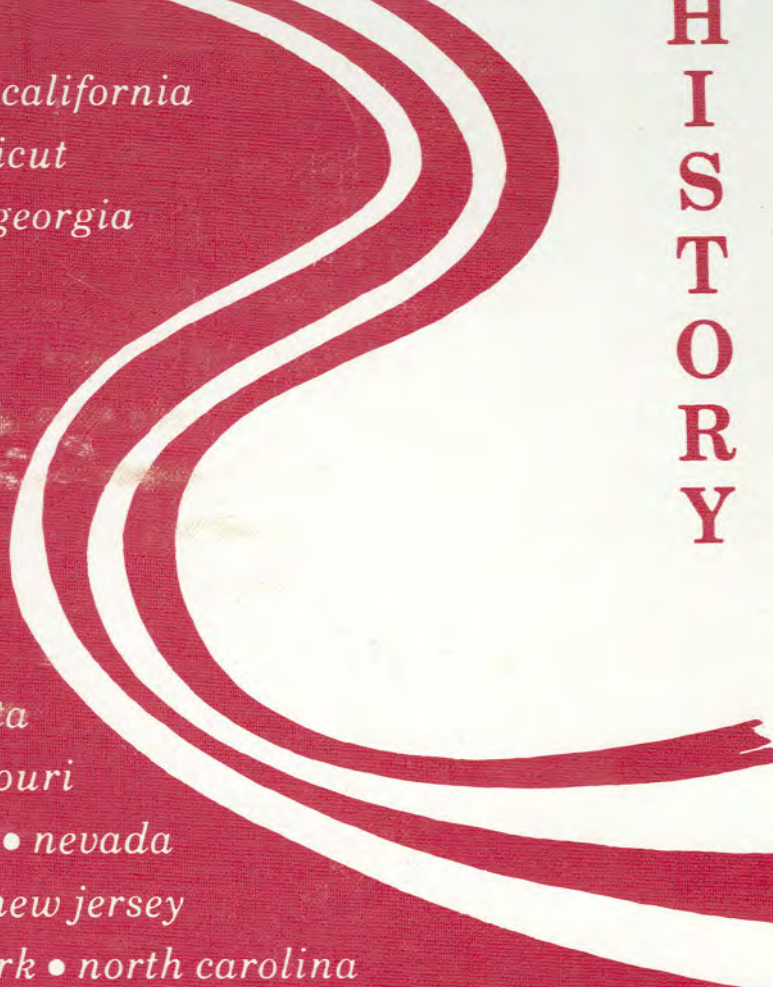


# THE STATE GEOLOGICAL SURVEYS •

## A H I S T O R Y



*alabama • alaska  
arizona • arkansas • california  
colorado • connecticut  
delaware • florida • georgia  
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illinois • indiana  
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tennessee • texas • utah • vermont • virginia • washington  
west virginia • wisconsin • wyoming*

# THE STATE GEOLOGICAL SURVEYS

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## A HISTORY

*Arthur A. Socolow, Editor*

*A project of the Association of American State Geologists*

1988



## PREFACE

In the early 1800's, as our fledgling nation expanded its borders and its appetite for raw materials, there arose a growing awareness that geological conditions and mineral resources play a major role in the development of our lands and the feedstock for our industries.

Thus it was that State Geological Surveys came into being. By 1860 some 30 State Geological Surveys had been established. Today, as many of those Surveys have celebrated their 150th anniversary, there are 50 functioning State Geological Surveys. While they are diverse in size, in name, and in detailed functions, each has the basic responsibility to delineate the geologic resources and conditions as they impact upon the economic and environmental well-being of the respective state.

In recognition of the important role which each State Geological Survey has played, the Association of American State Geologists presents this compilation of the histories of America's State Surveys. It is a record replete with scientific achievements, human drama, bureaucratic struggles, and most importantly, service to the public. Operating at the interface between science and the needs of the public, the State Geological Surveys are pleased to present the story of their development, their activities, and their aspirations.

Arthur A. Socolow, Editor

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of settlers grew to make Alabama "the Arsenal of the Confederacy" during the Civil War--and a prime military target. This fledgling industry was destroyed by the invading Federal foe but was later reestablished and gave birth to such cities as Birmingham, Anniston, and Bessemer in the latter part of the 19th century.

The mineral wealth of Alabama had been an object of curiosity since the age of DeSoto, but it was slow to be explored by the scientific community. The first naturalist of note known to have visited what is now Alabama was William Bartram in 1791, but he explored southern Alabama and was interested only in the flora. Johann David Schoepf (1787), in the first work on the geology of North America, defined the "fall line," which is one of the most dominant physiographic features of the state. The first geologic map showing Alabama was a map of the eastern United States published by William McClure in 1809. As far as is known, however, the first published geologic map of Alabama was by Timothy Abbott Conrad in 1835. Conrad, who later became State Paleontologist of New York, was in Alabama in 1833 and 1834 exploring the fossil locations of the southern part of the state, primarily at the bluff of Claiborne on the Alabama River above Mobile.

In the mid-1830's the University of Alabama appointed Richard T. Brumby as professor of chemistry, mineralogy and geology. In 1838, Brumby published the first and most extensive notice of the geology of the state. Brumby, by publishing letters in newspapers throughout Alabama, made the academic community, the legislature, and citizens aware of the importance of the geology of the state and the need for someone to survey the entire state.

In 1847, the President of the University of Alabama offered the chair of "Geology, Mineralogy and Agricultural Chemistry" to the prominent early American agriculturist, Edmund

Ruffin. Unable to accept the chair, Ruffin recommended Michael Tuomey, who was at the time State Geologist of South Carolina. Tuomey accepted.



Michael Tuomey (1805-57) was born in Cork, Ireland, was educated at Rensselaer Polytechnic Institute, and served as Alabama's first State Geologist (1848-57).

Michael Tuomey was a fateful choice for State Geologist. Within the few short years he served as a professor at the University of Alabama and as the first State Geologist of Alabama (1848 to 1857) he conducted the first systematic examination of the geology of Alabama and published the first reports on the geology of the entire state. Tuomey's articles on the geology of Alabama attracted the attention of the governor and the legislature. In 1848 he was appointed as the first State Geologist of Alabama, without salary. Tuomey published the First Biennial Report and Geologic Map of the State in just under 2 years of hard work. The legislature, impressed with the importance of Tuomey's work, made an appropriation of \$10,000 for the Geological

# ALABAMA

Geological Survey of Alabama, State of Alabama, P. O. Box O,  
Tuscaloosa, AL 35486-9780. Phone 205-349-2852.

## HISTORICAL SEQUENCE OF ORGANIZATIONAL NAME:

Geological Survey of Alabama, 1848-present

## NAMES AND TITLES OF ORGANIZATIONAL DIRECTORS AND DATES SERVED:

Michael Tuomey, State Geologist, 1848-57  
Eugene Allen Smith, State Geologist, 1873-1927  
Walter B. Jones, State Geologist, 1927-61  
Philip E. LaMoreaux, State Geologist, 1961-76  
Thomas J. Joiner, State Geologist, 1977-81  
Ernest A. Mancini, State Geologist, 1982-present

## THE GEOLOGICAL SURVEY OF ALABAMA--A SHORT HISTORY

By Alexander Sartwell, Historian

The Geological Survey of Alabama, during its 140-year history, has had only six State Geologists. These six State Geologists have seen Alabama go from an American horse-and-buggy frontier to the Space Age. In a large measure they have encouraged Alabama to grow from an agrarian society to a diversified economy. They have helped in exploration and development of Alabama's mineral wealth.

Before the coming of the Europeans, the native American Indians who occupied what is now Alabama used only a few of the area's mineral materials. The search for gold brought Hernando DeSoto through Alabama in 1540, but he found only a stone-age culture of no great wealth by European standards. By the late 1700's the southeastern native Americans were far removed from the stone-age peoples whom DeSoto had encountered. They used metal as extensively as the Europeans for cookwares, farm implements, and above all for firearms.

Among the first people the government of the young United States sent in

among the Indians were blacksmiths, who made the implements necessary for trade and agriculture. Tuomey, the first State Geologist, noted in his First Biennial Report of 1850 that the blacksmiths were "the first explorers of the coal beds" and "have been in all parts of the state."

Soldiers who had served with Andrew Jackson and who had passed through what is now Alabama on their way to fight the British at New Orleans returned after the war of 1812 and settled. They brought their families and other settlers, established blacksmith shops, and explored the hills of north Alabama, looking for iron ore and using the plentiful timber resources for charcoal. Initially, because charcoal was used in the making of iron, the vast coal resources of the Warrior, Cahaba, and Coosa coal fields were little known and used. The settlers, however, did export the coal by loading it on crude barges to wait for high water in late winter, when they would float over the numerous shoals to Mobile to sell the coal for fuel and for Mobile's gas plant.

An infant industry of bloomeries, furnaces, and rolling mills that made farm implements, ploughs, hinges, and cooking equipment for the great influx



Survey. Tuomey, now with adequate funds, devoted full time to field work and the production of the Second Biennial Report.

With delays by the State printer and Tuomey's sudden death in 1857, Tuomey's Second Biennial Report was not published until 1858. Seeing the report through to publication was completed by Tuomey's assistant, Dr. John William Mallet.

Dr. Mallet is important to the history of geology in Alabama for many reasons. His knowledge of the geology of Alabama, coupled with his knowledge of the chemistry of explosives, was useful to the Confederate government in making Alabama the "Arsenal of the Confederacy" during the Civil War. While he was a professor at the University of Alabama, he taught the young Eugene Allen Smith, who was later to become State Geologist. It is certain that Dr. Mallet influenced Smith to study in Germany under Mallet's own professor. Later, at the University of Virginia, Mallet taught Henry McCalley, who returned to the University of Alabama to be Smith's Assistant State Geologist. Mallet served as a thread of continuity from Tuomey through the difficult Civil War period and on to Smith.

After the death of Tuomey and the publishing of the Second Biennial Report, the Survey was nonexistent due to a lack of funding and the Civil War. However, Tuomey's investigations and Alabama's fledgling iron industry were fully utilized by General Josiah Gorgas and Dr. Mallet in the Ordnance Department of the Confederate government. With Alabama's mineral wealth, the Confederate Arsenal at Selma produced arms for the Confederacy. Although short-lived, the impetus caused by the war economy made people aware of the mineral reserves of north Alabama. In the spring of 1865, Alabama's furnaces, foundries, rolling mills, arsenals, the University of Ala-

bama, and the city of Selma were burned by the invading Federal Army.

In the midst of the turmoil of this period of Civil War and Reconstruction was young Eugene Allen Smith, Alabama's great geologist who became the second State Geologist in 1873. Smith, who was from Autauga County, Alabama, had studied under Mallet at the University of Alabama. Immediately after the war he went to Germany to study at Berlin, Gottingen, and Heidelberg, where, in 1868, he received his Ph.D. *summa cum laude*. He was appointed assistant professor of chemistry at the University of Mississippi, where he came under the influence of Dr. Eugene W. Hilgard. He served for a time as Assistant State Geologist under Dr. Hilgard. In 1871 he was made professor of chemistry and mineralogy at the University of Alabama, with instruction that he "spend as much of his time as could be spared from teaching in the investigation of the natural resources of the State." He was appointed State Geologist in 1873 with no salary but with an annual appropriation of \$500 for the expenses of the Survey.

For the next decade Dr. Smith spent his summers doing field work, receiving no compensation other than his expenses. In 1878 he was joined by Henry McCalley of the University of Alabama Chemistry Department, who worked as an unpaid assistant. Smith turned his attention to the economic geology of the state, working first in the Piedmont region. He then moved to the comparatively unknown Warrior coal field and published maps of those counties that were underlain by coal reserves.

In 1883 the legislature of the State, recognizing the value of the Survey and that more detailed work would be necessary before Alabama's great resources could be developed, increased the appropriation of the Survey to \$5,000 per annum and at last gave the State Geologist a salary. Again in 1891



Dr. Eugene Allen Smith (1841-1927), a native of Autauga County, Alabama, the State Geologist of Alabama (1873-1927) was the second longest serving State Geologist of any State Geologist.

appropriations by the legislature were increased. These increases made possible a staff of workers to aid Dr. Smith. The Cahaba, Coosa and Warrior coal fields were mapped, and the gold regions of the state were explored. Dr. Smith examined the Cretaceous and Tertiary formations of the Coastal Plain and, in 1895, published his monumental work on the Coastal Plain as Alabama Geological Survey Special Report 6.

Dr. Smith, in 1895, published the first geologic map of the state since Tuomey's. This map was perhaps Smith's most important accomplishment in the 19th century. Unlike

Tuomey's small and generalized map, Smith's was the first workable map of the state with accurate delineations of exposed formations. In the last part of the 19th century during the first half of Smith's term as State Geologist, the State of Alabama, because of its mineral resources, underwent dramatic changes in its economic structure. Alabama had had an agricultural economy that had been devastated by the war and the painful years of Reconstruction. In 1876 coke was used to make iron at Oxmoor furnaces near Birmingham, causing a boom in coal and iron ore. The cities of Birmingham, Anniston, and Bessemer



grew where mere villages or nothing at all had existed before the War. In a large part, the Geological Survey was responsible for the mining boom of the 1880's. The production of coal and iron increased nearly tenfold between 1880 and 1890, and the population in the principal cities involved in mining and manufacturing increased almost five times.

Henry McCalley, who began working with Smith as an unpaid assistant, became the first official Assistant State Geologist and served ably in that capacity until his early death in 1904. His last major contribution was Geological Survey Special Report 10, *Report on the Warrior Coal Basin*. As Walter B. Jones has said:

To Henry McCalley must go a large measure of credit for the full utilization of the coal deposits of the State. He carefully and accurately measured the seams,

mapped the location of outcrops, and made available good reliable analyses... this, the first Assistant State Geologist... certainly rendered magnificent service to his native state.

The Survey's research and publishing program in the early part of the 20th century covered a wide spectrum of subjects relating to the state's natural resources: streamflow records, the material and manufacture of Portland cement, underground water resources, roads and road building materials, natural gas, and the economic botany and plant life of the state. The climax of Dr. Smith's work as State Geologist was Geological Survey Special Report 14, *The Geology of Alabama* with a revised geologic map by George I. Adams, Charles Butts, L.W. Stephenson, and C. Wythe Cooke in 1926. This work, which was 20 years in preparation, was published a year before Dr. Smith died.



Dr. Eugene Allen Smith (on the right) on one of his many summer-long field trips into the Gulf Coastal Plain of south Alabama about 1900. Smith's son Merrill is the seated child.



Dr. Walter B. Jones (1895-1977) was born in Huntsville, Alabama. Known as "Doc Jones," he served as the third State Geologist of Alabama (1927-61) and was Alabama's first State Geologist to serve as Secretary to the State Oil and Gas Board.

The State of Alabama was fortunate that Dr. Smith had chosen as his successor and Assistant State Geologist Dr. Walter B. Jones, who, in 1927 became the third State Geologist. A man of spunk and wit, "Doc Jones" served his native state well for the next 34 years, through the Depression and two world wars.

On the very eve of Dr. Smith's death the state legislature had appropriated enough money for long-term projects and an increase in staff and materials. The task of preparing long-delayed reports on the different coal fields and ore deposits was undertaken. New reports on the petroleum possibilities of the state were prepared. Dr. Jones, through personal contacts, made the people of Alabama, the citizens, and the lawmakers aware that development of Alabama's natural resources meant more money in revenues for the State.

It was during Jones' tenure as State Geologist that, in February 1944, oil was discovered in Gilbertown, Choctaw County, Alabama. This discovery oil field was followed in May 1950 by the discovery of the South Carlton field in Clarke and Baldwin Counties, Alabama, and in January 1952 by the Pollard oil field in Escambia County, Alabama. In August 1955 Alabama's largest oil field was discovered. Known as the Citronelle oil field, at the time of its discovery it was the largest field in the world producing oil from below 10,000 feet.

The discovery of oil and gas in Alabama in the late 1940's and early 1950's and the establishment of the State Oil and Gas Board in 1945 has had a profound effect on the economy of the State. Dr. Jones, as the State Geologist, was named *ex officio* State Oil and Gas Supervisor. This dual function of State Geologist and State Oil and Gas Supervisor is maintained to the present. The potential for oil and gas had been recognized by Dr. Smith and encouraged by Dr. Jones who, in 1929, had issued Special Report 15 on the oil and gas possibilities of Alabama.

Dr. Stewart J. Lloyd, a native of Ontario, Canada, served "Doc Jones" as Assistant State Geologist. A man of consummate ability, much respected in the academic community, he organized the first Department of Chemical Engineering in the southeast at the University of Alabama and served as the first Dean of the University's School of Chemistry, Metallurgy and Ceramics. During Dr. Jones' several absences, first in the late 1930's to serve as the first Director of the State of Alabama Department of Conservation and later to serve in the Armed Services during World War II, Dr. Lloyd was Acting State Geologist. During World War II, the Geological Survey, under Dr. Lloyd's direction, participated in numerous mineral deposit studies with the U.S. Bureau of Mines, assessing



minerals of strategic interest in Alabama.

On Dr. Walter B. Jones' retirement, Philip E. LaMoreaux became the fourth State Geologist in 1961, and served for 15 years. LaMoreaux's tenure was a period of radical change and expansion for the Alabama Geological Survey and State Oil and Gas Board.



Philip E. LaMoreaux (1920- ), a native of Ohio, served as the fourth State Geologist of Alabama (1961-76) during a period of economic growth, drastic expansion of the number of staff and was the first State Geologist to occupy the present offices of the Survey, Walter Bryan Jones Hall.

For the first time in many years the principal staffs that were investigating Alabama's oil, water, minerals and biological resources were brought together under one roof. LaMoreaux established several divisions from the scattered Geological Survey and State Oil and Gas Board personnel. All offices and laboratories were relocated in the new Walter Bryan Jones Hall, which was completed in 1961. LaMoreaux also

developed the Geological Survey's extensive printing program by installing printing presses in Walter Bryan Jones Hall. The Survey then had the capability to produce a report from raw field data to finished product ready for public consumption.

The Survey under Philip LaMoreaux stressed the importance of energy, water, and mineral resources not only for Alabama but for the southeastern United States as well. The reports of the Survey of this period concentrated on county-wide hydrologic, mineral, and geologic reports. LaMoreaux envisioned use of the county geologic maps for the eventual preparation of an updated State Geologic Map. In addition, such subject areas as subsidence in limestone terranes, karst hydrology, deep-well disposal, acid mine drainage, offshore and estuarine areas, and hydrogeology of sanitary landfills were studied thoroughly. Philip LaMoreaux actively sought funding for research, in the process building one of the largest state geological surveys in the nation.

With the growing concern for the environment in the early 1970's the Geological Survey of Alabama, using the various geological disciplines, produced one of the first complete environmental studies of a specific area. The karst hydrology study by the Survey was one of the most complete studies by any state agency on the problems of karst areas. Alabama was one of the first states to use space-acquired data from the ERTS program in solving specific geologic and hydrologic problems.

The Geological Survey grew so quickly during the 15 years of the LaMoreaux Administration that in 1975 a new, three-story addition was added to Walter Bryan Jones Hall. The first two floors were designed to house the Survey's expanding printing program and the growing State Oil and

Gas Board functions. The top floor was left unfinished for later growth.

When Philip LaMoreaux resigned in August of 1976, the Assistant State Geologist Thomas J. Joiner became Acting State Geologist. In December 1977 Joiner was named the fifth State Geologist.

Markets for the State's oil and gas expanded during the Joiner years. A major pipeline from the Black Warrior basin was completed in 1977, establishing a market for previously shut-in gas wells. The most significant event of the Joiner era was the 1979 discovery of gas in State waters approximately 2 miles east of Dauphin Island in southern Mobile Bay. However, because of environmental concerns and economic considerations, it was almost 10 years before production in 1988.



Thomas J. Joiner (1932- ) served as Assistant State Geologist (1969-76) under Philip E. LaMoreaux before becoming Acting State Geologist (1976-77) and then Alabama's fifth State Geologist (1977-81).

This discovery of commercial quantities of natural gas in Mobile Bay

pointed out a need for more detailed information in the Alabama coastal area. In cooperation with other State agencies and various branches of the U.S. Government, the Alabama Survey compiled information on the geologic framework of the coastal area, studied the marine and estuarine environments, and delineated the area's wetland habitats.

When the scheduled sale of submerged State lands to be held in March 1981, was announced, most of the major petroleum companies examined the materials from the 1979 Mobile Bay discovery well, and drill cutting samples and core materials from onshore wells in surrounding counties, which were housed in the Sample and Core Library of the Survey and Board. This collection, unavailable elsewhere, helped the bidding companies determine the extent of their commitment and produced the State approximately \$449 million in bonus money.

During the Joiner years, the Geological Survey of Alabama continued work on a state geologic map that was started in previous administrations; emphasized studies on minerals mapping, mineral economics, water use, and water management; and accelerated efforts to describe and develop the energy resources of the State of Alabama.

In May 1981, Joiner, like LaMoreaux, left the Survey to go into private practice. An Acting State Geologist and Oil and Gas Supervisor, Richard Raymond, served until February 1982 when Dr. Ernest A. Mancini was named the sixth and present State Geologist.

The Mancini era began during a period of financial crisis, with prorated state funds and shrinking federal funding. Mancini's first priority was to put the finances of the Geological Survey and State Oil and Gas Board on solid footing. Mancini streamlined Survey and Board functions shifting the



Ernest A. Mancini (1947- ) has served as the sixth State Geologist of Alabama since 1982.

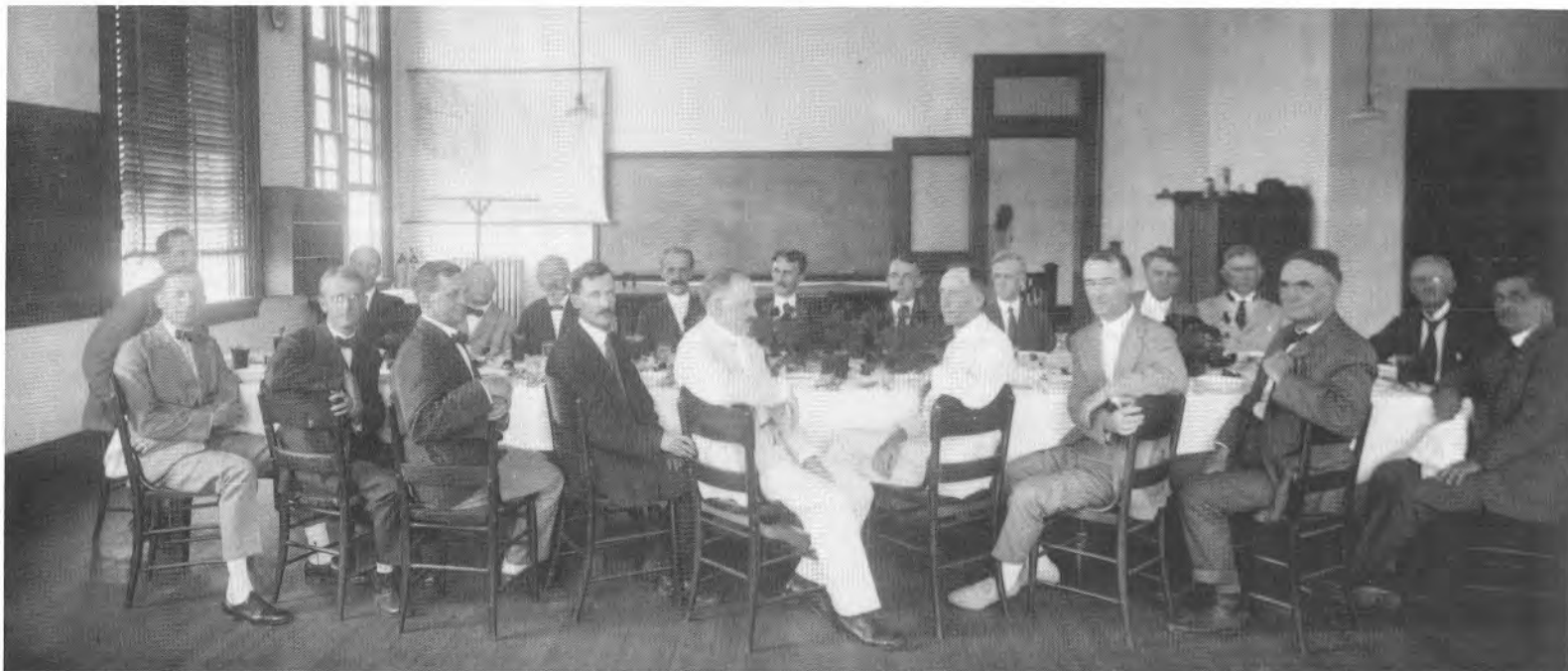
philosophy of the two agencies back to basics and the original legislative mandates. The environmental function of the Survey, in keeping with its mandate, was strengthened to include comprehensive biological investigations. An extensive network for monitoring changes in the quality and quantity of Alabama's surface- and ground-water supplies was established. The scope of the Energy Resources Division was expanded from its former concern with coal and lignite to include oil and gas and alternate energy sources such as coalbed methane, oil shale and tar sands. The Survey has undergone a reassessment of its information and data bases. Old data have been upgraded and computerized, and new data bases have been acquired. Mancini has emphasized comprehensive, multi-disciplinary investigations of the various mineral, energy, water and biological resources of the state. As a result, the Survey annually produces

summary reports and topical publications. A new state geologic map, long a goal of the Survey, was published in 1988.

Mancini has undertaken partial renovation and face-lifting of the offices and physical plant of the Survey and Board. The third floor of the new wing that was built in the final years of the LaMoreaux administration was finished as offices, conference rooms and a new hearings room for monthly State Oil and Gas Board meetings.

Throughout the tenures of the six State Geologists, in spite of the shortage of money, war-time conditions and economic depressions, the Geological Survey has prospered and grown. Michael Tuomey laid the ground work, producing the first accurate geologic map of the state; Eugene Allen Smith emphasized more intensive mapping, publishing geologic maps and reports of the state; and Walter B. Jones called attention to Alabama's varied resources, preparing the framework for the later expansion of the oil and gas industry. Under Philip E. LaMoreaux, the Survey grew in size, gaining an international reputation. During Thomas J. Joiner's term, the Survey and State Oil and Gas Board actively supported the orderly expansion of the oil and gas industry in the state. Under Ernest A. Mancini, both agencies have enhanced their abilities to provide timely support for economic development through expanded and automated data bases and the acquisition and utilization of sophisticated analytical instrumentation to provide support for economic development. As important mineral and fuel industries continue to grow in the coming years, the state geologist will encourage investigations and basic data support in anticipation of future developments as his predecessors have in the past.





Visiting State Geologists are entertained at a luncheon held at 2:00 p.m., September 6, 1919, in Smith Hall, then home of the Geological Survey of Alabama, on the campus of the University of Alabama in Tuscaloosa. The Geologists were attending a meeting of the American Association of State Geologists which was being held in Birmingham, Alabama, in September 1919. Only one of this group has been positively identified.

## ALASKA

Alaska Division of Geological and Geophysical Surveys,  
3700 Airport Way, Fairbanks, AK 99709. Phone 907-451-8760.

### HISTORICAL SEQUENCE OF ORGANIZATIONAL NAME:

Territorial Department of Mines, 1959  
Division of Mines and Minerals, 1959-66  
Division of Mines and Geology, 1966-70  
Division of Geological Survey, 1970-72  
Alaska Division of Geological and Geophysical Surveys, 1972-present

### NAMES AND TITLES OF ORGANIZATIONAL DIRECTORS AND DATES SERVED:

Jim Williams, 1959-71  
William Fackler, 1971-73  
Donald Hartman, 1973-75

Ross G. Schaff, 1975-86  
Robert B. Forbes, 1987-present

### THE ALASKA DIVISION OF GEOLOGICAL AND GEOPHYSICAL SURVEYS

By Ross G. Schaff and Robert B. Forbes

#### TERRITORIAL DAYS

The evolution and development of the Alaska Division of Geological and Geophysical Surveys (DGGs) are interwoven with the history of Alaska and the natural-resource issues that have affected Alaska and the nation since Alaska was purchased from Russia in 1867.

Although much has been written about the territorial history of Alaska and the many years of effort leading to statehood, insufficient acknowledgment has been given to the role played by the optimistic assessment of Alaska's natural-resource potential in convincing Congress and the executive branch that the territory of Alaska should be elevated to statehood status. In retrospect, we are still impressed by the fact that the statehood compact approved the addition of such an enormous and sparsely populated area (one-sixth the area of the United States)

with little economic and developmental infrastructure.

Longstanding concern about the geographical separation of Alaska from the conterminous states had been partially addressed during World War II by the construction of the Alaska Highway which provided a direct land transportation link between Alaska and the "lower 48," in addition to previously established marine and air supply routes. The real question, however, was whether Alaska could hold its own as an economic partner in the Union. Congressional questions were met by optimistic estimates of the state's high mineral and oil and gas potential, which were not well supported by the natural resource data available at that time. The issue of demonstratable economic vitality continued beyond the passage of the Statehood Act in 1959. The following paragraph taken from the 1959 annual report of the Division of Mines and Minerals (successor to the Territorial Department of Mines and predecessor to the Alaska State Division of Geological and Geophysical Surveys) was directed at this concern:

In view of the extreme need for increased mineral production in Alaska, the Division is exerting every effort within its means to obtain basic information on mineral deposits of possible commercial importance and to distribute this information to interested miners and venture capital. Much time is spent in all offices in giving advice and assistance to exploration parties, researchers, and engineers or geologists representing mining companies who are looking for mining or investment opportunities. Mining companies and investors outside of Alaska are contacted and urged to investigate Alaska's mineral possibilities. These efforts by the DM&M have helped create a marked increase of venture capital expenditures in Alaska in recent years. This increase has resulted in important discoveries. (Biennial Report, Division of Mines and Minerals, 1959, Jim Williams, Director)

### THE IMPACT OF STATEHOOD

A condition of the Alaska Statehood Act included the transfer of 104.3 million acres (an area about the size of California) from 365 million acres of federal land holdings to state ownership. A more thorough understanding of the geology and mineral and energy resource potential of the state was essential to the selection of state lands that would contain resources necessary for the development of a strong Alaska resource economy. In response to this need, the Division of Mines and Minerals was recast as the Division of Mines and Geology in 1966, and agency objectives were modified to include increased emphasis on geologic mapping and the definition of potential mineral terranes and oil and gas basins.

In 1970, the Division was renamed the Division of Geological Survey, and in 1971, William Fackler, formerly the Assistant Director for Minerals, became the Director. The addition of two petroleum geologists to the staff reflected a growing recognition of Alaska's petroleum potential. Detailed geologic mapping of the Brooks Range and reconnaissance surveys of the

Arctic National Wildlife Refuge were initiated under Fackler's leadership.

### STATUTORY FRAMEWORK

A rare event occurred in 1970, when John Sweet, an ARCO geologist, was elected to the Alaska State Legislature. Sweet introduced a bill that provided a statutory framework for the Survey and defined the responsibilities and duties of the State Geologist. This bill and the incorporated statutes became law on July 1, 1972. Shortly thereafter the agency name was changed to the Alaska Division of Geological and Geophysical Surveys. Donald Hartman, formerly with Texaco, was appointed State Geologist on April 5, 1973, by Governor William Egan, and the oil and gas section was strengthened with new staff appointments.

Another developmental stage in the history of DGGS was marked by the 1974 election of Governor Jay Hammond, the appointment of Guy Martin as Commissioner of Natural Resources, and the subsequent appointment of Ross Schaff as State Geologist and Director of the Survey in 1975. At this point, the Survey had evolved from an organization solely devoted to the promotion and development of the mining industry to a Division that also responded to a growing interest in Alaska's petroleum potential and was responsible for statewide programs in geologic hazards, industrial materials, and water resources.

With the election of Governor Hammond in 1974 and the serial appointments of Commissioners of Natural Resources Guy Martin, Robert LeResche, and John Katz, the role of State government in resource development and land use took a somewhat different course. While resource development was viewed as essential to the maintenance of Alaska's economic growth, the Hammond administration was characterized by a more cautious and deliberative approach to natural



resource and land-use issues, and the Survey's motto, "Acceleration of the mineral industry," was not very heartily endorsed.

In 1972, Congress enacted the Alaska Native Claims Settlement Act (ANCSA, 1972), which created 13 Regional Native Corporations that were authorized to select 40 million acres of federal land, including rights to the subsurface mineral resources. The same Act authorized the Secretary of Interior to set aside up to 80 million acres of conservation units (D-2 lands). From 1972 until 1981, when the Alaska National Interest Lands Act was passed by Congress, over 300 million acres of land and the subsurface resources were classified, traded, sold, or exchanged. These actions have placed additional constraints on natural resource development and open mineral entry.

#### RECENT DEVELOPMENTS

During the growth years, the Survey became the primary source of mineral resource information and analysis for the State. The Legislature enlarged the agency's statutory responsibilities to include water, geothermal, and seismic engineering data collection, and the Survey was also given the additional responsibility for coordinating the archaeology, forestry, and soil science field programs. In addition, a well-funded Geographic Information System was transferred into DGGS. Numerous cooperative agreements with federal agencies were established, and a geologic materials center was created and funded cooperatively with the U.S. Geological Survey, Bureau of Mines, and Minerals Management Service. The annual general fund budget reached a high of \$9.7 million in FY 1985, with a staff that included 115 full-time professionals, and 40 student interns.

In 1982, Bill Sheffield was elected Governor of Alaska, and a new Commissioner of Natural Resources (Esther Wunnicke) was appointed.

During Governor Sheffield's tenure, the decrease in the world market price of crude oil and the related decline in Alaska's petroleum revenues led to pervasive budget cuts that were also levied on DGGS. "Downsizing" and "belt tightening" were the guidelines, while the Sheffield administration and the Legislature labored with state priorities and program responsibilities and the short-term and projected long-term health of the Alaska economy. DGGS, beginning in 1982, was subjected to annual budget reductions of up to 25 percent per year up to FY 1988.

Governor Steve Cowper was elected to office in 1986, and in early 1987, the Governor reversed the recommendations of the previous administration by reinstating the Alaska Division of Geological and Geophysical Surveys as a separate division, rather than merging it with the Division of Mining. Judith Brady was appointed Commissioner of Natural Resources, and Robert Forbes, on recommendation of his professional colleagues, was appointed State Geologist.

Since that time, the DGGS budget and staff have stabilized at the FY 1988 level (\$3.1 million), with a small budget increase approved for FY 1989. Over the last few years, however, several programs, including funds and personnel, have been transferred to other Divisions within DNR, including the Cadastral Survey, Field Archaeological Studies, Oil and Gas Lease Sale Analysis, and the Geologic Information System. At present, the total Survey staff includes 69 professional and support personnel, plus seasonal student interns from Alaska universities.

Based on strong support from the current administration and the mining community and on improving trends, the Alaska Division of Geological and Geophysical Surveys anticipates a stable and productive future.

## ARIZONA

Arizona Geological Survey, 845 North Park Avenue, Tucson, AZ 85719.  
Phone 602-621-7906.

### HISTORICAL SEQUENCE OF ORGANIZATIONAL NAME:

Office of the Territorial Geologist, 1888-90, 1898-1912  
University of Arizona "Bureau of Mines," 1893-1915  
Arizona Bureau of Mines, 1915-77  
Arizona Bureau of Geology and Mineral Technology, 1977-88  
Arizona Geological Survey, 1988-present

### NAMES AND TITLES OF ORGANIZATIONAL DIRECTORS AND DATES SERVED:

John F. Blandy, Territorial Geologist, 1888-90  
Theodore B. Comstock, Director, 1893-95  
William P. Blake, Director, 1895-1905;  
Territorial Geologist, 1898-1904  
Cyrus F. Tolman, Territorial Geologist, 1911-12  
Charles F. Willis, Director, 1913-18  
Gurdon M. Butler, Director, 1918-40  
Thomas G. Chapman, Director, 1940-56  
James D. Forrester, Director, 1956-70  
William H. Drescher, Director, 1971-81  
Richard A. Swalin, Director, 1984-86  
Larry D. Fellows, State Geologist and  
Assistant Director, 1979-88

### ARIZONA GEOLOGICAL SURVEY

By Larry D. Fellows, State Geologist

#### INTRODUCTION

Recognition of the importance of mineral resources to the settlement and economy of Arizona led to the establishment, in 1915, of the Arizona Bureau of Mines, which was subsequently reorganized into the Arizona Bureau of Geology and Mineral Technology (1977) and the Arizona Geological Survey (1988). The Arizona Bureau of Mines consolidated functions performed by territorial geologists from 1888-1912 and research and service activities conducted by University of Arizona faculty from 1891-1915.

Although Arizona Territory was established by Congress in 1863,

settlement was delayed by the Civil War and did not begin in earnest until the 1870's, when a new wave of mining began. Many of the mines had been worked on a smaller scale by Spanish miners during the 1700's and by Indians even before then. By the early 1880's a number of mining camps were already active.

Little was known about the geology of Arizona Territory; information that was available was general and of little use to prospectors. Despite this dearth of information, prospectors were able to discover mineral deposits because vegetation was sparse and many deposits were exposed at the land surface (fig. 1). Because of the abundance of mineral deposits, Governor Trible, in 1883, requested that detailed geological surveys of the Territory be made.



Figure 1.--Prospector.

#### **TERRITORIAL GEOLOGIST: 1888-1912**

In 1888 Congress created the unpaid post of "Territorial Geologist," which was filled on an irregular basis until statehood in 1912. The first Territorial Geologist, John F. Blandy, who served until mid-1890, contributed short reports on geology and mineral resources that were included in annual reports Governor Lewis Wolfley and Acting Governor N. O. Murphy submitted to the Secretary of the Interior in 1889 and 1890, respectively. The Territorial Geologist position, abolished in 1890 because of lack of funds, was not reestablished until 1898. In that year Governor Murphy included a lengthy chapter by Dr. William P. Blake, Territorial Geologist, in his annual report. Although the title was not officially used between 1890 and 1898, the Territorial Geologist's duties were performed by Dr. Theodore B. Comstock (1891-94) (fig. 2) and Dr. Blake (1896-97), respectively, probably as a consequence of their official status

as Director of the University of Arizona School of Mines during those periods.

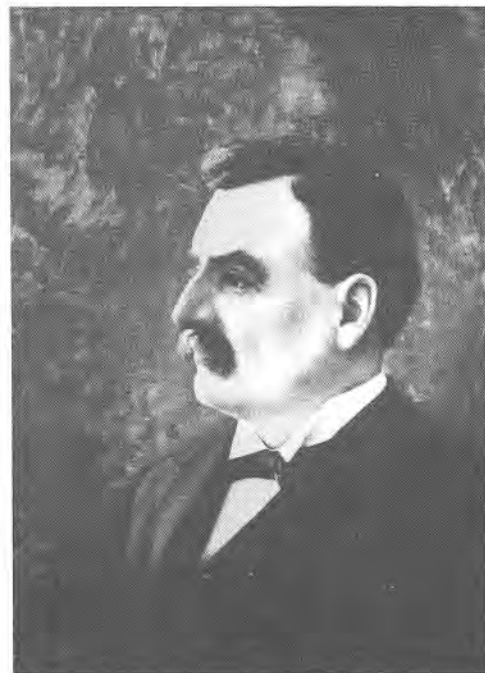


Figure 2.--Dr. Theodore B. Comstock.



After his comprehensive report in 1898, Blake made extensive annual contributions to governors' reports until 1904, when the position of Territorial Geologist again fell into disuse. In 1911, Dr. Cyrus F. Tolman, a professor of geology at the University, was given the title, but, with attainment of statehood in 1912, the post was officially abolished.

#### **UNIVERSITY BUREAU OF MINES: 1893-1915**

When it first opened in 1891, the University of Arizona was comprised of a School of Mines and a School of Agriculture. Dr. Comstock, Director of the School of Mines, established an assaying and ore-testing laboratory in 1893. The laboratory was variously known as "The University of Arizona Bureau of Mines," "University School of Mines Testing Laboratories," and the "Bureau of Mines of the Arizona School of Mines." Comstock directed the laboratory until 1895, when he became the first President of the University. Blake was Director from 1895 until he retired in 1905. Charles F. Willis (fig. 3), an instructor in geology and mining engineering, served as Director from 1913 to 1915. Willis wrote House Bill 53, the enabling legislation for the Arizona Bureau of Mines, which was introduced by Representative Sheldon A. Reed (Pima County), passed by the legislature, and signed by Governor George W. P. Hunt in 1915.

#### **ARIZONA BUREAU OF MINES: 1915-40**

The Arizona Bureau of Mines was established as an official state agency under authority of the Board of Regents of the University and State Colleges of Arizona. The enabling legislation specified that the new agency be administered as a Department of the University of Arizona and that its director be a mining engineer. Charles F. Willis, a mining engineer, became



Figure 3.--Charles F. Willis.

the first Director. The Arizona Bureau of Mines continued, essentially unchanged, the metallurgical services that had been offered by the "University Bureau of Mines" from 1893 to 1915.

Statutory duties of the Bureau were to collect, compile, and publish statistics relative to Arizona mining; maintain a library and bibliography of all literature pertaining to Arizona mining and geology; experiment, and publish results, on various mineral processing procedures; conduct qualitative analyses of rock and mineral samples; and collect geological and mineral specimens to constitute the museum of the State Mining Bureau. Under Willis' direction emphasis was placed on subjects such as mining safety and the welfare of the mining employee; numerous short bulletins were issued. Other bulletins were prepared on subjects such as sampling, field testing of minerals and metals, and specific mineral commodities.

In 1918, after directing the Bureau 3 years, Willis left the University for

private practice. Administration of the Bureau was then transferred to the College of Mines and Engineering, with the Director of the Bureau reporting to the Dean of the College. A few months later, the Dean and Directorship were combined. Dr. Gurdon M. Butler, Dean of the College, was asked to also serve as Director of the Bureau. He did so until 1940.

Under the direction of Dr. Butler, a geologist who had previously been on the Colorado Geological Survey, the Bureau began to undertake activities that were commonly done, in other states, by the state geological survey. Such activities included preparation of geologic maps and completion of reports on relationships between the geologic framework and ore deposits in major mining districts. This approach was necessary because major mineral deposits, which in earlier years had been relatively easy to discover because they were exposed at the land surface, were being depleted and new deposits were considerably more difficult to locate. In 1924 the first geologic map of Arizona was published, in cooperation with the U.S. Geological Survey.

#### **ARIZONA BUREAU OF MINES: 1940-77**

In 1940 the College of Mines and Engineering was divided into separate colleges, each supervised by a dean. Responsibility for the Bureau of Mines was assigned to the Dean of the College of Mines, Dr. Thomas G. Chapman, a metallurgist.

Activities of the Bureau during Chapman's first years as Director were greatly influenced by demands placed upon the minerals industries by World War II. Accelerated exploration programs, sponsored by the federal government, for critical minerals and metals involved the time of a major part of the Bureau's staff on a cooperative basis. Because the copper industry was faced with depletion of the major higher-

grade deposits, emphasis was given to large low-grade deposits. With this change in emphasis, many problems in ore-dressing were encountered. The Arizona Bureau of Mines played an important role in research and pilot-plant studies that led to design of ore concentrating facilities at five of the nine major low-grade copper deposits developed in Arizona from 1945-65.

When Dr. Chapman retired in 1956, he was succeeded as Director and Dean by Dr. James D. Forrester. Forrester, a geologist and mining engineer, came to the Bureau from the University of Idaho, where he was Dean of the College of Mines and Director of the Bureau of Mines and Geology, predecessor of the Idaho Geological Survey.

Work on a new geologic map of the State began in 1956, in cooperation with the U.S. Geological Survey. County geologic maps were released from 1957 to 1960; the state map was published in 1969. The first issue of *Fieldnotes*, the Bureau's quarterly information and research publication, was printed in 1971. Other items published included mineral commodity reports, indexes of mining properties, a geology guidebook series, and bibliographies of Arizona geology.

Dr. William H. Drescher succeeded Forrester as Director and Dean in 1971. Drescher, a metallurgical engineer, had extensive industrial experience in process metallurgy and ceramics. Recruited to be Dean of the College of Mines, Drescher was surprised when he arrived on the job and was informed that he was also "State Geologist." After participating in functions of the Association of American State Geologists for several years and discussing roles and responsibilities of state geological surveys with directors and state geologists from other states, Drescher realized that the Bureau of Mines' enabling act, in effect for 56 years since enactment in 1915, was outdated. He actively sought to modernize it by encouraging prepara-

tion of House Bill 2060. This bill, introduced by the majority of the House Committee on Natural Resources and Energy (C. W. "Bill" Lewis, Chairman), was passed by the Legislature and was signed by Governor Raul H. Castro in May 1977.

**ARIZONA BUREAU OF GEOLOGY  
AND MINERAL TECHNOLOGY:  
1977-88**

The new enabling act changed the Bureau of Mines to the Bureau of Geology and Mineral Technology and established two branches: the Geological Survey Branch, which was the State Geological Survey, and the Mineral Technology Branch, which continued most Bureau of Mines functions. The Director was to be a geologist or a geological, mining, or metallurgical engineer, registered by the State Board of Technical Registration. The Assistant Director in charge of the Geological Survey Branch was to carry the title "State Geologist" and was to be a geologist or a geological engineer, also registered by the State Board of Technical Registration. The new Bureau was established as a scientific, investigative, and information agency whose purpose was to conduct research and provide information. Provisions for a geological library and a repository for rock cuttings and cores were included. The new Bureau was, for the first time, also given responsibility for geologic hazards and limitations to land use.

The Bureau, which continued to function as a state agency, was organized as a Division of the University of Arizona, administered by the Board of Regents and supervised by the President of the University or his designate. Drescher was named Director of the Bureau. In February 1979, Dr. Larry D. Fellows was selected as Assistant Director and State Geologist. Fellows came to the Bureau from the Missouri Geological Survey. Under his

direction emphasis was given to detailed geologic mapping and structural geology in western Arizona, classification and description of metallic mineral districts, and identification of potential geologic hazards and limitations. An open-file report series was instituted to make information available to the public in a timely manner. The Arizona Geologic Information System, a computerized data base, was established.

Dr. Drescher resigned in 1981 and was succeeded as Director and Dean by Dr. R. A. Swalin in September 1984. Swalin, educated in materials science and metallurgy, came to the University from industry. Earlier in his career he had served at the University of Minnesota as Dean of the Institute of Technology, which included the Minnesota Geological Survey. In July 1985 the Colleges of Mines and Engineering were reunited as the College of Engineering and Mines. (They were previously together as the College of Mines and Engineering from 1918 to 1940.) Swalin, who was named Dean of the expanded college, continued as Director of the Bureau.

In September 1985, a legislative committee held hearings to consider merging several small natural-resource agencies, including the Department of Mineral Resources, Oil and Gas Conservation Commission, and the Bureau of Geology and Mineral Technology. The committee took no follow-up action relative to consolidation. Individual committee members, however, proceeded in other directions. Representative Doug Todd (Tempe) introduced House Bill 2460 in January 1986 to remove the Geological Survey Branch of the Bureau from administration by the University and make it an independent state agency. The bill, which transferred the Mineral Technology Branch to the University, passed both houses of the legislature but died in the Senate Appropriations Committee. In Septem-



ber 1986, Dean of the Faculty of Science, Dr. Edgar J. McCullough, Jr., was named Acting Director of the Bureau.

Todd, who was elected to the Arizona Senate in late 1986, reintroduced House Bill 2460 and Senate Bill 1102 in January 1987. The bill was subsequently passed by the Legislature and was signed by Governor Evan Mecham in April. Senate Bill 1102 established the Arizona Geological Survey as an independent state agency effective July 1, 1988, to be located in proximity to the University of Arizona in Tucson. Employees and equipment of the Mineral Technology Branch were transferred to the University of Arizona. The State Geologist, responsible for administration of the Arizona Geological Survey, would be appointed by and serve at the pleasure of, the Governor.

#### **ARIZONA GEOLOGICAL SURVEY: 1988-PRESENT**

The Arizona Geological Survey (AGS) inherited a tradition of research, publication, and excellence that was built by its predecessors over a 73-year period. Geologic investigations culminated in publication of 198 bulletins, 26 circulars, 6 special papers, and many maps. From 1980-88 an additional 130 open-file reports and maps were released.

This record of accomplishment reflects the dedication and commitment of Bureau staff. Although mention of individuals and their specific accomplishments has not been made in this summary, because of space limitations, several long-term employees played major roles in building the reputation and credibility of the Bureau: Dr. Eldred D. Wilson, a geologist employed 45 years from 1918-65; George H. Roseveare, who served as a metallurgist 31 years (1942-73); and Dr. H. Wesley

Peirce, geologist for 31 years from 1956-87.

As the 21st century approaches, the AGS will continue this legacy but must prepare for challenges and opportunities as well. Wise use of the State's land, water, and mineral resources will become increasingly more important because of substantial population growth. New residents will require additional land for development, earth materials for construction, and potable water. Information about distribution and characteristics of rock, surficial materials, and mineral resources, both at the surface and in the subsurface, will be needed. Potential hazards and limitations to development must be identified.

Population growth will result in generation of more wastes, including those that are hazardous, toxic, and radioactive. Disposal facilities must be sited and constructed with the regional and local geology in mind so as to not contaminate priceless ground-water resources. In addition, population growth will lead to greater demand for recreation areas, which must also be chosen with geology in mind.

The AGS and its predecessors have proudly served Arizona since 1888. We eagerly anticipate opportunities for continued service as a primary source of geologic information about Arizona.

#### **SELECTED REFERENCES**

- Dresher, W. H., 1973, Recommendations for the Arizona Bureau of Mines and the Arizona Department of Mineral Resources with regard to the proposed Arizona Department of Natural Resources: Arizona Bureau of Mines, unpublished report, p. 65.
- Moore, Richard T., 1971, The Arizona Bureau of Mines in origin and development of the state geological surveys: *Journal of the West*, v. X, no. 1, p. 136-141.

## ARKANSAS

Arkansas Geological Commission, Vardelle Parham Geology Center, 3815 West  
Roosevelt Road, Little Rock, AR 72204. Phone 501-371-1488 or 663-9714.

### HISTORICAL SEQUENCE OF ORGANIZATIONAL NAME:

First Survey (Owen's Survey), 1857-60  
 Second Survey (Reconstruction Survey), 1871-75  
 Branner Survey, 1887-93  
 Geological Survey of Arkansas, 1923-45  
 Division of Geology, Arkansas Resources and Development Commission, 1945-55  
 Arkansas Geological and Conservation Commission, 1955-63  
 Arkansas Geological Commission, 1963-present

### NAMES AND TITLES OF ORGANIZATIONAL DIRECTORS AND DATES SERVED:

David Dale Owen, State Geologist, 1857-60  
 W. F. Roberts, Sr., State Geologist, 1871-73  
 George Haddock, State Geologist, 1873-74  
 William Hazeldine, State Geologist, January-June 1874  
 Arnold Syberg, State Geologist, June 1874-January 1875  
 John C. Branner, State Geologist, 1887-93  
 George C. Branner, State Geologist, 1923-42  
 Richard J. Anderson, Acting State Geologist, 1942-43  
 Joe W. Kimzey, State Geologist, 1943-45  
 Harold B. Foxhall, Director and State Geologist, 1945-51  
 Norman F. Williams, Director and State Geologist, 1951-55; Director and  
 State Geologist, 1955-63; Director and State Geologist, 1963-present

Note: From 1907-23 The Professor of Geology, University of Arkansas, acted *ex officio* as part-time State Geologist. Office holders were A. H. Purdue, N. H. Drake, and G. H. Cady.

### ARKANSAS GEOLOGICAL SURVEY

#### HISTORY

The beginning of a state geological survey in Arkansas was in 1857 and was known as the "First Survey" or "Owen's Survey." In 1857-58, the first geological survey of Arkansas was conducted by Dr. David Dale Owen. Two reports were published as a result of his work, the *First Geological Reconnaissance of Arkansas* and the *Second Geological Reconnaissance of Arkansas*. The first report was published in 1858 and then in 1859 the

Legislature made an appropriation to continue the work. Dr. Owen died in 1860 and his brother, Richard Owen, and his assistant, Edward T. Cox, edited the second report and had it published in 1861. These two volumes remain as the foundation to the present day State Geological Survey of Arkansas. It should also be noted that this work was done at a cost to the state of \$16,800.

For the next 10 years no geological surveys were conducted because of the Civil War and the period of reconstruction following the war. Activity resumed in 1871 when the State legislature enacted legislation to form a geological survey. W. F. Roberts was

appointed as State Geologist, and Dr. George Haddock was hired as his assistant. At this time they started a geological reconnaissance survey in western Arkansas. From 1873 through 1874 Dr. George Haddock, William C. Hazeldine, and Arnold Syberg held the office of State Geologist. During the 4 years (1871-74), no official reports were published, only a 63-page pamphlet by George Haddock in 1873. This period is known as the "Second Survey" or "Reconstruction Survey." Dr. John C. Branner was quoted in an Arkansas Gazette article in 1919 about the surveys of Owen's time and the period in the early 1870's.

It is to be noted regarding these surveys that they cover a period of seven years, that they cost the state \$51,428, but that, with the exception of Dr. Owen's reports, the work was of no value.

It was not until 1887 that the State had another state geological survey. At that time Dr. John Casper Branner was appointed State Geologist and remained in that position until 1893. He was an outstanding geologist of his time and was highly regarded by his colleagues. It was the excitement of the possibility of gold and silver in Garland and Montgomery Counties that sparked interest in establishing a new geological survey. The fight was led by Colonel Elias W. Rector of Hot Springs, a member of the Lower House. Over this 7-year period, Dr. Branner's survey produced some monumental economic geology reports which led to a much better understanding of the overall geologic relationships within the state. As a result of his work, nineteen volumes of his reports were published. During this period, one of Dr. Branner's assistants was Herbert Hoover, who later became President of the United States. Since the main reason for the reestablishment of the survey was to ascertain the potential for gold and silver in western Arkansas, it was essential that this be one of the

investigations conducted. Dr. Branner's staff made an evaluation of the gold and silver prospects open at that time and showed that at least in the case of the mines then open, there was no validity in claims being made about the gold possibilities. This so irritated some people in the State that funding for the geological survey was withdrawn, not to be reestablished until 1923.

From 1907 until 1923, the Legislature appropriated a small amount of money for the Department of Geology at the University of Arkansas to conduct geologic surveys. The geological work was to be conducted under the direction of a commission composed of the Governor, the President of the University, and the Commissioner of Mines, Manufactures, and Agriculture. The professor of geology at the University was to designate a small portion of his time to survey work. The work at this time was done by Professor A. H. Purdue, Professor A. A. Steel, and Dr. N. F. Drake. The most notable contributions published during this period were on the slates of Arkansas and the coal fields in the Arkansas Valley.

In 1923 the Geological Survey of Arkansas was once again established and has continued to the present. George C. Branner, son of John Branner, was appointed State Geologist and held that position until 1942. George Branner was not a geologist by training, and the amount of new work performed in the 18 years he headed the survey was only a fraction of what his father had accomplished in less than a third of the time. George Branner served as State Geologist until the beginning of World War II, when he served as a Colonel in the Army. During this period very little was added to the knowledge of the geology of the State. Richard J. Anderson served as Acting State Geologist in 1942-43 and Joe W. Kimzey was State Geologist from 1943 to 1945.

The end of the war brought about a reorganization of State government and placed the Geological Survey in the Arkansas Resources and Development Commission as its Division of Geology. This reorganization took place in 1945 and Harold B. Foxhall served as the Director and State Geologist until 1951. During this period, the Division of Geology experienced some growth. In 1947, a young geologist from Oklahoma came to work for the survey, his name was Norman F. (Bill) Williams.

In 1951, N. F. Williams was appointed Director and State Geologist of Arkansas and holds that position today. Since the reorganization after World War II, the survey has experienced several name changes and reorganizations. In 1955, under a reorganization, the geological survey was called the Arkansas Geological and Conservation Commission. In 1963, this Commission was designated as the Arkansas Geological Commission. In 1977, State government was reorganized into twelve major departments. The Arkansas Geological Commission was placed in the Department of Commerce. In 1983, the Legislature abolished the Department of Commerce and again the Arkansas Geological Commission became a separate entity in state government.

In the early years, the Survey was housed in the State Capitol Building. It was not until 1966 that it moved out of the Capitol to temporary quarters west of the Capitol while plans were being made for a dedicated building. In 1970, the Survey moved into its current building and named it the Vardelle Parham Geology Center in honor of Vardelle Parham, a long-time Chairman of the Arkansas Geological Commission.

In 1977, the State Land Survey Division was added to the Arkansas Geological Commission. Thus today, the Arkansas Geological Commission is made up of the Geology Division and

the Land Survey Division. The number of employees has grown to 32, including 11 full-time geologists.

## ORGANIZATION

The Arkansas Geological Commission has a staff of 32 and consists of the Geology and Land Survey Divisions. The agency has a Board of Commissioners consisting of seven members with contiguous terms of 7 years. They are appointed by the Governor with the advice and consent of the Senate, and each staggered district must be represented by membership on the Commission.

The Land Survey Division, created in 1973 as part of the Office of the State Land Commissioner, was transferred to the Arkansas Geological Commission in 1977. The State Surveyor serves under the authority, direction, and approval of the State Geologist. The Land Survey Division has an Advisory Board composed of seven members who assist the State Surveyor in developing policies and regulations to establish uniform standards for professional surveying and mapping methods in the state.

### Geology Division

The primary purpose of the Arkansas Geological Commission is to increase the knowledge of the geology of the State and to stimulate the orderly development and utilization of the State's mineral resources. The Geology Division is organized into three sections: Administrative Services, Information Services, and Technical Services, all of which are under the direct supervision of the State Geologist.

The Administrative Services section consists of administrative, accounting, and secretarial services, and provides all administrative support of the agency. Specific activities include preparing budgets and operation plans, monitoring and processing expenditures, typing and reproducing letters and reports, maintaining an agency



filing system, maintaining buildings, and purchasing and inventorying supplies and equipment.

The Information Services Section's primary function is the distribution of information prepared and maintained by the Geology Division. This is accomplished through four offices: Maps and Publications Sales, Geological Library, Print Shop, and Cartographic Information Center. Maps and Publications Sales office has available for sale all available U.S. Geological Survey topographic and planimetric maps of Arkansas and publications relating to the geology and hydrology of the State prepared by the Geology Division. This office also provides general information to the public and operates the agency's reception and telephone services. The Geological Library maintains more than 35,000 references relating to the geology of Arkansas, other states, and various parts of the world. This library is used extensively by Arkansas Geological Commission geologists, by other government agencies, universities, and the general public. It is also a repository for government documents prepared by the U.S. Geological Survey and the U.S. Bureau of Mines. The agency's print shop maintains an inventory of publications prepared by the Arkansas Geological Commission. The Arkansas Affiliate of the National Cartographic Information Center operates on a cooperative agreement between the U.S. Geological Survey and the Arkansas Geological Commission. The USGS provides a listing on microfiche of all cartographic data available for the United States, with particular emphasis on Arkansas.

The Technical Services Section is composed of the geologic staff and technical support personnel. Its primary responsibilities are (1) to encourage the orderly development of the State's mineral, oil and gas, and water resources; (2) to maintain current geologic and topographic map coverage

of the State; (3) to study and report on the geologic factors affecting the State's environment; and (4) provide a public source of geologic information. Technical Services is divided into five major activities: Economic Geology, Environmental and Areal Geology, Hydrology and Subsurface Geology, Mineral Exploration and Lignite Investigation, and the Technical Support Group.

The Economic Geology and the Mineral Exploration and Lignite Investigation activities are responsible for the development of information on the mineral resources of the State. Included in this program is the agency's drilling operation, which is used extensively in evaluating mineral resources.

The Hydrology and Subsurface Geology activity is responsible for studies of the State's oil and gas potential, ground-water investigations, and geologic investigations of the subsurface derived primarily from examination of rock cuttings, core materials, and geophysical logs throughout the State.

The Environmental and Areal Geology activity is responsible for the development of surface geologic maps in the State and the study of geologic factors affecting the environment. A good geologic map is a prerequisite for most geologic programs; the search for oil and gas and other minerals, the protection of the environment, and the conservation of mineral and water resources. Therefore, the geologic mapping program is a continuing one. The Commission's environmental program is geared to deal with specific urban areas, the resolution of individual environmental problems, or geohazards. These studies can provide general information on the geology, help solve construction problems caused by geologic factors, evaluate flood hazards, ascertain problems on quantity and quality of water, and provide natural resource information.

Because many areas of traditional geologic interest have come to the forefront of the public eye, geologic educational programs have become a significant activity in recent years.

All of the above Technical Services activities are supported by a Technical Support Group, which consists of the Chemical Laboratory, Sample Library, and the Cartographic Section. The Chemical Laboratory is an important adjunct of the mineral resources program. Its primary purpose is to provide the staff with chemical analyses on the wide variety of mineral and rock samples collected for various projects. The results of these chemical tests are critical to the evaluation of mineral deposits. The Sample Library maintains cuttings and cores of selected wells in Arkansas. These samples are critical to the expansion of our knowledge of the subsurface geology, development of the State's oil and gas resources, development of mineral resources, and ground-water data. Currently, the repository contains cuttings for over 2,800 wells and more than 300,000 feet of drill hole core from selected areas in Arkansas. The samples are used extensively by the Arkansas Geological Commission staff and are frequently used by company geologists and graduate students in geology. The Cartography Section supports the Technical staff by displaying information from geologic projects on maps, charts, and figures for publication. All of the programs of the technical staff interact and are flexible to meet current trends.

In addition to the major activities in the Technical Services Section, the Agency has several ongoing cooperative projects with the Geology Division of the U.S. Geological Survey. In addition, the Arkansas Geological Commission has three cooperative programs with the Water Resources Division of the U.S. Geological Survey: the Ground-water Survey, Stream Gauging

Program (surface water), and Water Quality Program. Each of these is a 50-50 cooperative program in which the costs are split but with the majority of the work done by USGS personnel using their equipment and facilities.

The Arkansas Geological Commission also has a 50-50 cooperative topographic mapping program with the Mid-Continent Mapping Center of the U.S. Geological Survey. These funds provide for the preparation and publication of topographic maps in Arkansas and for the revision of existing maps.

In addition to the ongoing cooperative programs, the Geological Commission has been involved in many short term cooperative projects with the USGS. Examples of these are the State Geologic Map of 1976, COGEMAP project in the Ouachita Mountains of Arkansas and Oklahoma, the CUSMAP project in northern Arkansas and southern Missouri, and the Strategic/Critical Minerals Program. The Commission has enjoyed an excellent relationship with the USGS over the years and anticipates many more years of cooperation.

#### **Land Survey Division**

The Land Survey Division is divided into three sections: Administrative Section, Records Repository Section, and the Corner Restoration Section. The Administrative Section provides for the administration of the Division and management of the physical plant; it also plans, develops, and implements overall programs. And finally, the Administrative Section develops and prescribes the necessary land surveying standards in order to promote uniformity and quality in land surveying practices throughout the State. The Records Repository Section establishes, maintains, and provides safe storage facilities for survey data concerning all monuments established by the United States Public Land

Survey and other monuments placed by surveyors. It also furnishes, upon request, copies of records created and maintained by the division.

The Corner Restoration Section's objectives are to restore, maintain, and preserve the Land Survey monuments established by the United States Public Land Survey and to provide a sufficient number of geologic control stations to permit statewide use of the State Plane Coordinate System.

### **SIGNIFICANT LANDMARKS AND ACCOMPLISHMENTS**

One of the principal activities of the Arkansas Geological Commission (AGC) is to provide information on the State's mineral resources to both prospective and existing industries. Many of these mineral resources have been found as a result of investigations by the staff of the AGC. Some of these have had a major impact on the economy of the State and Nation.

(1) Bauxite was first identified by Dr. John Branner, State Geologist, from a sample brought in by a local contractor, Ed Weigel, who was using it to pave roads near Little Rock. Eventually this led to the discovery of the largest bauxite deposit in the United States and has resulted in over 80 million tons of bauxite being mined in Arkansas since 1898.

(2) The barite deposits in Hot Spring County were described in a published report of the AGC about 10 years prior to the mining operations. Within another 10 years, the Chamberlain Creek barite deposit was furnishing over half the Nation's supply.

(3) The first successful gas well in the state was sited by Dr. John Branner.

(4) The mining of vanadium, chalk, and clay and the production of bromine has led to the development of several major industries in the State. Geological data compiled over the years

by research and investigations of the AGC staff have been the primary source of information used in the development of these resources.

Another primary function of the Arkansas Geological Commission is the preparation and updating of geologic maps and reports on Arkansas. Numerous maps and publications would qualify as significant contributions to the advancement of geologic information of the State, but only a few can be considered as landmarks.

- ▶ Geologic Map of Arkansas, 1929.
- ▶ Geologic Map of Arkansas, 1976.
- ▶ First Geological Reconnaissance of Arkansas.
- ▶ Second Geological Reconnaissance of Arkansas.
- ▶ The 19 reports published under the direction of Dr. John Branner (1887-93).

### **MAJOR PERSONALITY FEATURES**

The classic work of David Dale Owen was a fine beginning for geologic studies in the State. John Casper Branner's great ability as a geologist and organizer was a giant step forward. Branner had on his staff R. A. F. Penrose and J. Francis Williams as well as Herbert Hoover and others who made substantial contributions to our understanding of the geology of the state and an appreciation of its mineral potential.

In the 1960's and 1970's Hugh Dinsmore Miser had a great influence on the work of the AGC staff, especially in the Ouachita Mountains. It was also through the influence of Mr. Miser that Charles Milton started his classic studies of the mineralogy of igneous rocks within the State, a study which is continuing.

### FUTURE PROJECTIONS

The Arkansas Geological Commission plans to continue making available the best geologic information of the State of Arkansas with the funds appropriated. As always the geologic map is one of the best products to display and disseminate this information. Currently, the AGC is involved in COGEOMAP and CUSMAP projects, each of which have an emphasis on

geologic mapping. Another area that will be expanded is the conversion of information in paper files to a computerized data base system.

Over the years the AGC has collected over 300,000 feet of core and cuttings from approximately 2,800 wells in the state. It is our goal to provide a facility to house and conduct research for these materials.



## CALIFORNIA

Resources Agency, Department of Conservation, Division of Mines and Geology,  
1416 Ninth Street, Rm. 1341, Sacramento, CA 95814. Phone: 916-445-1923

### HISTORICAL SEQUENCE OF ORGANIZATIONAL NAME:

California State Mining Bureau, 1880-1926  
Division of Mines and Mining [within the Department of Natural Resources], 1927  
Division of Mines [within the Department of Natural Resources], 1928-60  
Division of Mines and Geology [within the Resources Agency, Department of Conservation], 1961-present

### NAMES AND TITLES OF ORGANIZATIONAL DIRECTORS AND DATES SERVED:

#### State Mineralogists

Henry G. Hanks, 1880-86	Lloyd Root, 1923-28
William Ireland, Jr., 1886-92	Walter W. Bradley, 1928-46
J. J. Crawford, 1892-96	W. Burling Tucker, 1946-47
Augustus S. Cooper, 1896-1901	Olaf P. Jenkins, 1947-58
Lewis E. Aubury, 1902-11	Gordon B. Oakeshott, Interim, 1958
William H. Storms, 1911-13	Ian Campbell, 1958-61
Fletcher M. Hamilton, 1913-23	

#### State Geologists

Ian Campbell, 1961-69	Thomas E. Gay, Jr., 1975-78
Wesley G. Bruer, 1970-73	James F. Davis, 1978-87
James E. Slosson, 1973-75	Brian E. Tucker, Acting, 1987- present

### HISTORY OF THE CALIFORNIA DIVISION OF MINES AND GEOLOGY

#### THE EARLY YEARS: 1850-80

Although it was not until 1880 that the California State Mining Bureau, predecessor to the Division of Mines and Geology, was established, the "roots" of California's state geological survey date to an earlier time. As might be expected for a State that owed its existence to the gold rush of 1849, the State Legislature recognized that geologists could produce valuable information.

In 1851, only 1 year after California was admitted to the Union, John B. Trask of the California Academy of Sciences in San Francisco was named Honorary State Geologist. In 1853,

Trask was given a budget of \$2,000. Although the activities of the survey under Trask ceased in 1856 due to lack of funding, Trask had impressed the Legislature by publishing four geological reports that were highly valued.

In 1860, the Legislature appropriated \$20,000 for a new State Geological Survey to provide information on where gold could be found and to make a complete and accurate survey of the geology of the state. Josiah D. Whitney was appointed as State Geologist. Whitney hired several competent staff members, including Clarence King, who later became the first Director of the U.S. Geological Survey. In 1874, the Legislature abolished the Geological Survey.

### 1880-1928

On April 16, 1880, the State Mining Bureau was established by the State Legislature. The bill provided for a State Mining Bureau and a State Mineralogist to be located in San Francisco, the center of local and international mining interests and corporations. The establishment of the Bureau was a direct action in response to the need for information on the occurrence, mining, and processing of gold in the state.

According to the Act of 1880, the State Mineralogist was appointed by and reported directly to the Governor. The Act provided for an analytical laboratory, establishment of a library, the display of mine models, a museum of mineralogical and geological specimens (especially those of economic value), and the publication and dissemi-

nation of information to the citizens of the state. The authorizing legislation made no mention of any geological survey of the state. The Mining Bureau activities were to be funded entirely by a tax on mining and milling corporations.

### THE STATE MINING BUREAU: 1880-1927

The first State Mineralogist was Henry G. Hanks (1880-86). Under Hanks' direction publications consisted of the Annual Report of the State Mineralogist series and the Special Publication series. The former included many technical articles; the latter mostly consisted of catalogues of items in the museum and library.

In 1886, the Sixth Annual Report mentioned, for the first time, the Trustees of the State Mining Bureau,



Henry G. Hanks  
(1880-86)

advisory board appointed to advise the State Mineralogist. In that Annual Report, the Trustees stated that the purpose of the Bureau was "to encourage the development of the great mineral resources of California." This purpose was steadfastly pursued by Hanks and most of his successors. The emphasis of the minerals program, the Bureau's only program until the 1930's, was on broad-scale recognition of the potential mineral wealth and the use of modern mining technology.

From 1880 to 1898 the Bureau occupied office space in various locations in San Francisco.

Hanks was succeeded as State Mineralogist by William Ireland, Jr. (1886-92). It is curious that the Bureau's first major technical publication did not deal with minerals at all. Bulletin No. 1, *A description of the desiccated human remains in the California State Mining Bureau*, was published in 1888. It appears that Ireland may have had a broader perspective than did the Board of Trustees. For example, in the Annual Report for 1890, Ireland wrote, "We are in need of a geological survey . . ." so that investors may use the information to guide their investments, for educational purposes, to guide settlers to suitable farming land, and for use in exploring for minerals. The next year, Ireland published the first geologic map of the state (approximate scale 1:760,000) showing eight stratigraphic units in color, along with numerous blank areas where information was lacking.

This map was the largest scale map (1 inch=12 miles) at that time. In the early years, preparation of state geologic maps was recognized by all to be a major activity of the Bureau, and it is still a major activity of DMG today.

Ireland was succeeded by several State Mineralogists who pursued programs much more in line with the desires of the Board of Trustees. J. J. Crawford (1892-96) published eight

more bulletins covering mine timbering techniques, the cyanide process, gold mill practices, oil and gas yielding formations, mineral production statistics, a catalog of California fossils, and a bibliography of California geology. The museum was gaining popularity, and in 1894, 65,985 persons visited the Mining Bureau Museum; 2,070 specimens were identified for the public; and 10,000 inquiries for information were answered.

From 1896-1901, Augustus S. Cooper was State Mineralogist. In 1899 the Bureau moved into offices in the newly constructed Ferry Building at the foot of Market Street in San Francisco. The Division occupied office space there until August 1984, when the office was moved to Pleasant Hill in Contra Costa County.

Cooper was succeeded by Lewis Aubury (1902-11) and William H. Storms (1911-13).

State Mineralogist Fletcher M. Hamilton (1913-23) published a second colored geologic map of the state (scale 1 inch=12 miles) in 1916. The map showed 21 stratigraphic units and was accompanied by an explanatory volume (Bulletin 72, *Geologic Formations of California*) explaining the units. Hamilton had Professor J. P. Smith of Stanford University compile the map. Olaf P. Jenkins, one of Smith's students, worked on this map, which became known as the J. P. Smith map. The entire area of the state was colored in, although the geology of many large areas of the state was then unknown.

In 1915, the Bureau was given responsibility for the oil and gas operations in California, and the office of Oil and Gas Supervisor was created.

In 1919, four geographical divisions were designated and district field offices were established at Redding, Auburn, San Francisco, and Los Angeles. In 1923, the Redding and Auburn districts and field offices were consolidated and moved to Sacramento.

Under Hamilton and his successor, Lloyd Root (1923-28), the Bureau began a series of mineral commodity reports. These publications, which began with the efforts of mining engineers Clarence A. Logan and Walter W. Bradley, marked the start of the Bureau's transition from a record-keeping and reporting agency to a more sophisticated geological survey.

### THE DIVISION OF MINES AND MINING: 1927-29

Until 1927, California State government was small enough that agency chiefs reported directly to the Governor. In 1927, for administrative reasons, the reporting relationship changed. The Department of Natural Resources was established, and the Bureau became the Division of Mines and Mining, one of four divisions within the department.

In 1928, Walter W. Bradley (1928-46) became the State Mineralogist. Bradley, who was hired in 1912 as a Junior Mining Engineer, also had served as the State Mining Bureau statistician, curator, and librarian, before he was appointed State Mineralogist.

In 1928, Bradley employed geologist Olaf P. Jenkins to prepare a state geological map. Jenkins' working title was Chief Geologist. At that time he was the only state employee classified as a geologist. As the official Geological Branch of the Division of Mines, the branch was given civil service sanction by examination in 1933.

In the 1930's, the Board of Trustees was replaced by a State Mining Board, appointed by the Governor. The board served in an advisory capacity to the Director of Natural Resources and the Division of Mines until 1961, when a new board, the State Mining and Geology Board, was established.

In the early 1930's state civil service was established and Bradley was the last employee of the Division to be appointed by the Governor.

As Chief Geologist, Jenkins began the compilation of a new 1:500,000-scale geologic map utilizing volunteer workers. Some funds were obtained from the Public Works Administration (Works Progress Administration or WPA as it later was called). The map was published in 1938.

Jenkins also began preparation of Bulletin 118, *Geologic formations and economic development of oil and gas fields in California*, which was published in 1943. This monumental work contained articles by 126 leading petroleum geologists. The Bulletin included much information that had been considered proprietary by most oil companies. Other notable works under Bradley included Solon Shedd's bibliographies of California geology to 1936 (inclusive).

Walter Bradley reached mandatory retirement age in 1946, and W. Burling Tucker, a mining engineer, served as State Mineralogist for 5 months while the first civil service examination for the position was held. In February 1947, after the results were announced, Olaf P. Jenkins was appointed State Mineralogist.

### THE OLAF P. JENKINS YEARS: 1947-58

As State Mineralogist, Jenkins developed the concept of the Division as a state geological survey, establishing two well-defined administratively-equal branches: the Mining Engineering Branch and the Geology Branch. Within 2 years, Jenkins hired Parker W. Trask (who left the next year), Gordon B. Oakeshott, Charles W. Chesterman, Lauren A. Wright, and Oliver E. Bowen, Jr., as geologists. Chesterman was a volcanologist; Wright became an expert on talc and a lifelong student of Death Valley geology; and Bowen specialized in studying limestone resources.

In 1947, Jenkins began publication of *Mineral Information Service* (MIS) on



a monthly basis. Jenkins also immediately changed the name of the *Annual Report of the State Mineralogist* to the *Journal of Mines and Geology*. The Division began processing numerous geologic quadrangle maps and reports for publication.

In 1952, the Division began its first earthquake investigation effort. Gordon Oakeshott was given responsibility to edit a comprehensive report about the 1952 Arvin-Tehachapi earthquake and aftershocks, and he later made several field studies of surface faulting for the Division. Until this time, the Division and its Mining Bureau predecessor seemed to pay little attention to earthquakes. For example, although the headquarters of the State Mining Bureau was located in San Francisco at the time of the 1906 earthquake, the only mention of the event in any Division publication was a short paragraph reporting that about \$1,500 in damage was sustained by the Bureau's facilities!

In 1951, Charles Kundert began compiling a new series of 1:250,000-scale geologic maps using the Army Map Service bases that were available at the time. In 1956, vastly improved 1 degree by 2 degrees USGS base maps were made available, and these enabled Kundert's successor, Charles W. Jennings, to oversee the compilation of much more accurate maps of the entire state.

In February 1958, Jenkins retired. In that year, the first full color 1:250,000-scale map sheet of the Geologic Atlas of California (a 27-sheet series) was published. The new map series was published as the *Olaf P. Jenkins Edition* in honor of Jenkins' 29 years of continuous service with the Division.

#### **THE IAN CAMPBELL YEARS: 1958-69**

In 1958, while the search for a new State Mineralogist was conducted,

Gordon B. Oakeshott served as Interim State Mineralogist.

Late in 1958, Dr. Ian Campbell, professor of geology at the California Institute of Technology, became the State Mineralogist.

He introduced the Division's geologic hazards program by starting experimental projects on urban geologic mapping in cooperation with Los Angeles and San Diego Counties. He worked toward legislation which changed the name of the Division of Mines to Division of Mines and Geology, and the change in designation from State Mineralogist to State Geologist in 1961; established serpentine as the official state rock, gold as the official state mineral, and the saber-toothed tiger as the official state fossil. He was a leader in the move to enhance the status of geologists through registration.

The 1960's were years of development of new programs and modernization of long-standing programs.

A highlight of the decade was the completion in 1966 of the geologic mapping program--the initial 27-sheet coverage of the state on the lithographed, colored sheets of the Olaf P. Jenkins edition of the State Geologic Map (scale 1:250,000). Revision and updating of these sheets continued to be a major activity of the Division. Quadrangle mapping (15-minute and 7.5-minute sheets) continued but was tapering off at the end of the 1960's as the Division entered very strongly into geologic hazards studies.

Dr. Campbell reached mandatory retirement age in December 1969.

#### **LEGISLATED PROGRAMS: 1970-PRESENT**

Early in 1970 the Division Headquarters office was moved to Sacramento.

In September 1970, Wesley G. Bruer, a geologist from Bakersfield, California, became the State Geologist. Bruer supervised the Division as a full-



Ian Campbell  
(1958-69)

time administrator. Bruer was succeeded by James E. Slosson (1973-75), Thomas E. Gay, Jr. (1975-78), and James F. David (1978-87). The current Acting State Geologist is Brian E. Tucker (1987-present).

From the early 1970's to the present, Division programs have expanded, often due to the passage of legislation. Current programs emphasize the accurate understanding of nonrenewable natural resources, their extent and distribution; the identification and delineation of geologic hazards to protect California citizens from such hazards; and effective communication of technical geological information to state and local decision makers.

The name of the Division's monthly magazine was changed to *California Geology* in January 1971 to reflect the

direction toward geologic hazards investigations.

The 1971 damaging San Fernando earthquake (M=6.4) of February 9 in the densely populated metropolitan Los Angeles area brought about legislation designed to mitigate the dangers of earthquakes.

In 1971 the Strong Motion Instrumentation Program (SMIP) of the Division was established to obtain statewide records of the response of rock and soil units and of engineered structures to ground motion generated by earthquakes.

In 1972 the Alquist-Priolo Special Studies Zones Act was passed. This act mandates the State Geologist to delineate traces of potentially and recently active faults that constitute a potential hazard to structures from surface rupture. Local agencies use this

information to ensure that structures for human occupancy would not be sited in areas subject to the hazard of surface fault rupture.

In 1973 the Hospital Safety Act was passed and is now administered by the Department of Public Health. DMG reviews geologic/seismic reports on the potential of earthquake damage to hospital sites. The Division also reviews the geologic/seismic reports on school sites.

In 1975, the Surface Mining and Reclamation Act (SMARA) was passed by the State Legislature. This program is to ensure that significant mineral deposits are identified and protected when land-use policies and decisions are made concerning the development of areas where nonrenewable mineral resources exist.

In 1983, the Landslide Hazard Identification Act was passed. This act mandates the Division to develop and carry out a statewide landslide hazard mapping and technical advisory program in urban and urbanizing areas to assist cities and counties in fulfilling their responsibilities for protecting public health and safety. The maps show landslide and debris flow susceptibility and other data to assist local agencies in land-use decisions.

The Division's ongoing programs continue to provide geotechnical information for a comprehensive analysis of California's geologic hazards and mineral resources for the protection and benefit of the citizens of the state.

## COLORADO

Colorado Geological Survey, Department of Natural Resources, 715 State Centennial, 1313 Sherman Street, Denver, CO 80203. Phone 303-866-2611.

### HISTORICAL SEQUENCE OF ORGANIZATIONAL NAME:

"The First Survey," Colorado Geological Survey, 1907-27  
 "The Second Survey," Colorado Geological Survey, 1967-present

### NAMES AND TITLES OF ORGANIZATIONAL DIRECTORS AND DATES SERVED:

#### Director and State Geologist

Russell D. George, 1907-27  
 John W. Rold, 1969-present

### HISTORY OF THE COLORADO GEOLOGICAL SURVEY\* (1872-1988)

John W. Rold, Director and State Geologist, and Stephen D. Schwochow, Colorado School of Mines

#### TERRITORIAL AND EARLY STATE GEOLOGISTS

The discovery of gold at Idaho Springs in 1859 marked the beginning of what for Colorado has become a billion-dollar mineral industry. Rich strikes in the 1860's hailed an era of boom towns, prosperity, and great personal triumphs and failures. Even before Colorado statehood, the territorial legislature realized the importance and potential of this emerging industry. An official government representative was needed to assist and advise the fledgling industry and to begin the monumental task of identifying and evaluating the territory's mineral wealth. On February 9, 1872, the legislature empowered the Governor to appoint a

Territorial Geologist who was to reside in the territory and serve a 2-year term. Because neither salary nor expenses were budgeted, the early Territorial Geologists made their livings essentially by consulting for the mining industry, and their public contributions were severely limited.

In 1874, J. Alden Smith was appointed as Colorado's first Territorial Geologist and served until 1883 and again from 1885 to 1887. Smith was born in Maine in 1830, and after completing his formal education at age 14, worked in such areas as printing, wool manufacturing, stone cutting, and finally back to newspaper printing. His early fascination with rocks and minerals led to tutored studies in geology and mineralogy. By 1864 his expertise had brought him to Gilpin County where his reputation as a consultant and assayer grew quickly. Smith's most notable work was the first detailed list of Colorado's minerals and gem stones. After its publication in *Black Hawk* in 1865, it appeared in Ovando Hollister's 1867 classic

\*The first portion of this was largely adapted from an article written by Stephen Schwochow entitled "History and Activities of Your State Survey" in *Colorado Miner*, March/April 1980, Volume 2, No. 2, published by the Colorado Mining Association. The last portion was adapted and updated from an article entitled "15 Years of Progress and Problems" by John Rold in the March 1984 issue of *The Outcrop*, the newsletter of the Rocky Mountain Association of Geologists.



historical work, *Mines of Colorado*, and was republished in 1870 and 1880. He is also recognized for several telluride gold discoveries and for donating his valuable mineral collection to the University of Colorado. Six competent and highly regarded men succeeded Smith as Territorial Geologist--Ernest Le Neve Foster (1883-85), F. G. Bulkley (1887-89), George E. Kedzie (1889-95), Thomas A. Rickard, a prominent mining editor and prolific author (1895-1901), John Wellington Finch, who later became director of the U.S. Bureau of Mines (1901-05), and B. A. Langridge (1906-07).

### THE FIRST SURVEY

So that more formal investigations of the state's resources could be made, the legislature created the Colorado Geological Survey on April 24, 1907. Among the eight objectives, one dealt specifically with mineral resources:

A study of the geological formations of the state with special reference to its economic mineral resources, namely: the gold, silver, lead, copper, iron and other metallic ores; the clays, coals, oil, gas, building materials, cement materials, artesian and mineral waters and other mineral substances.

Although metals dominated Colorado's mining industry at that time, specific mention was made of nonmetallics, mineral fuels, and water resources. Provisions also were made for a comprehensive bibliography of geology and resources, the publication and distribution of maps and reports, the collection and distribution of mineral specimens, and most importantly--a budget. The act appropriated the State Geologist's salary of \$500, and \$8 per diem, and an operating fund of \$5,000 for fiscal years 1907 and 1908.

By virtue of his chairmanship at the University of Colorado Department of Geology, Russell D. George became State Geologist and first director of the Survey. Born in 1866, George was raised and educated in Ontario,

Canada. Following graduation from McMaster University (Toronto) in 1897, he served as an instructor at the University of Chicago, where he earned his Ph.D., and then at the University of Iowa. In 1903 he came to the University of Colorado where he built up the young and ill-equipped Geology Department. His affinity for the mining industry's problems soon established his eminence in the consulting field. For 20 years George and his limited but highly proficient staff produced a series of comprehensive bulletins on the geology and ore deposits of a number of mining districts, along with the first complete bibliography and inventories of molybdenum, clay, manganese, fluorspar, oil shale, and mineral waters. Horace B. Patton, P. G. Worcester, R. D. Crawford, Harry Aurand, and Junius Henderson were among the Survey's noted authors. R. C. Coffin's 1921 report on uranium and radium is still an often cited reference. Between 1910 and 1925, the Survey published 31 bulletins. Another major accomplishment was a revision of the then 30-year-old state geologic map originally compiled during the Hayden Survey (1876-81).

Besides emphasizing the resources and pure scientific contribution, the legislature intended the new Survey to contribute directly to education:

The Survey shall...[prepare]...bulletins on the geology, geography and natural resources of Colorado suitable for use in the Schools of the State.

The Survey also was empowered to borrow freely upon the geology faculty at the state's colleges; indeed, many of the Survey's staff also taught at the University of Colorado and at Colorado School of Mines.

People-related problems were first hinted at in the second legislated objective:

An examination of the topography and physical features of the State with reference to their practical bearing upon the occupations of the people.

Although that early Survey published many excellent bulletins and contributed extensively to original geologic mapping of the state, it failed the survival test. Its last publication was issued in 1925. Records and files of that time were lost or destroyed. Old timers have hinted of political intrigue, funding limitations, and rivalry with the Colorado Metal Mining Fund Board, which had been created in 1921 to collect taxes on metal mining properties in order to "... make such investigations regarding the prospecting for, mining, production, transportation, buying, selling, treatment or reduction of metalliferous ores..." It may well have been a classic conflict between perceived pure research and geological investigations on one hand and the claimed practical value of finding, producing, and selling ore on the other.

In 1927, the Metal Mining Fund was given statutory authority to contract with the U.S. Geological Survey (USGS) for the completion of geologic and topographic mapping. Even though a statute enacted in 1929 placed the Survey under the control of a Geological Survey Board, no records indicate any activity, and no publications were issued. The USGS Colorado Geologic Map, published in 1935, credits "cooperation of the Colorado Geological Survey and the Colorado Metal Mining Fund." Neither USGS nor state records indicate the nature, extent, or timing of that cooperation. It may well represent mapping done by the state survey years earlier.

The exact reasons for or time of the first survey's demise will probably never be known. Although the law remained on the books, activity ceased and the Colorado Geological Survey died of "fiscal malnutrition" sometime in the late 1920's.

## THE SECOND SURVEY

Records show that the interim boards and agencies dealing with geologic problems from the 1930's into the 1960's were beset with perennial financial problems, outside political pressures, and internal conflicts. Perhaps as crucial as these problems was their apparent failure to recognize changing attitudes and needs. During the 1960's, the local geological community clearly saw the need for a formal state agency to deal not only with mineral and water resources in general but also with "people" problems and the geological and engineering aspects of construction, development, and land use.

In 1965 Representative George Fentress, a geologist in the state legislature, began working toward the reestablishment of the Colorado Geological Survey by collecting background information and gaining the support of other state surveys as well as the Association of American State Geologists. The first reorganization attempts outside the legislature came in 1966 when the Rocky Mountain Association of Geologists and American Institute of Professional Geologists formed a joint committee with representation from the Colorado Scientific Society and local chapters of the Association of Engineering Geologists and Society of Exploration Geophysicists. The committee evaluated the laws and sought from the other 47 state geologists advice in writing a meaningful statute. Through the efforts of the RMAG-AIPG committee, chaired by Robert D. Brace, and Representative Fentress, state statutes were amended by House Bill 1282 (1973), C.R.S. 34-1-101, et seq., and on June 9, 1967, the Colorado Geological Survey was recreated. The enabling act set forth the following general purpose:

... to coordinate and encourage... the full development of the state's natural resources, as [they] are related to the geological processes that affect realistic development of human and mineral utilization and conservation practices and needs in the state of Colorado, all of which are designed to result in an ultimate benefit to the citizens of the state.

The bill placed the Survey within the newly formed Department of Natural Resources and also provided for at least four operational specialties-- mineral deposits, hydrology, mineral fuels, and engineering geology. More importantly nine specific objectives were cited:

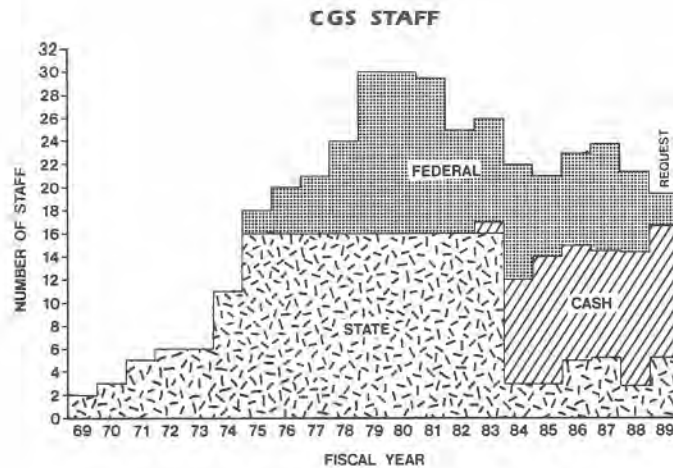
- (1) Assist, consult with, and advise existing state and local governmental agencies on geologic problems;
- (2) promote economic development of mineral resources;
- (3) conduct studies to develop geologic information;
- (4) inventory and analyze the state's mineral resources as to quantity, chemical composition, physical properties, location, and possible use;
- (5) collect and preserve geologic information;
- (6) advise the state and act as liaison agency on transactions dealing with natural resources between state agencies and with other states and the federal government on common problems and studies;
- (7) evaluate the physical features of Colorado with reference to present and potential human and animal use;
- (8) prepare, publish, and distribute reports, maps and bulletins when necessary to achieve these purposes;
- (9) determine areas of natural geologic hazards that could affect the safety of or economic loss to the citizens of Colorado.

Funding was not appropriated until 1968, and the agency did not begin official operations until February 1, 1969, with the hiring of the new Director and State Geologist, John W. Rold. Born in 1927 in Kirkman, Iowa, John Rold was raised on a ranch near Salida, Colorado. After active service in the U.S. Naval Reserves, he attended the University of Colorado from which

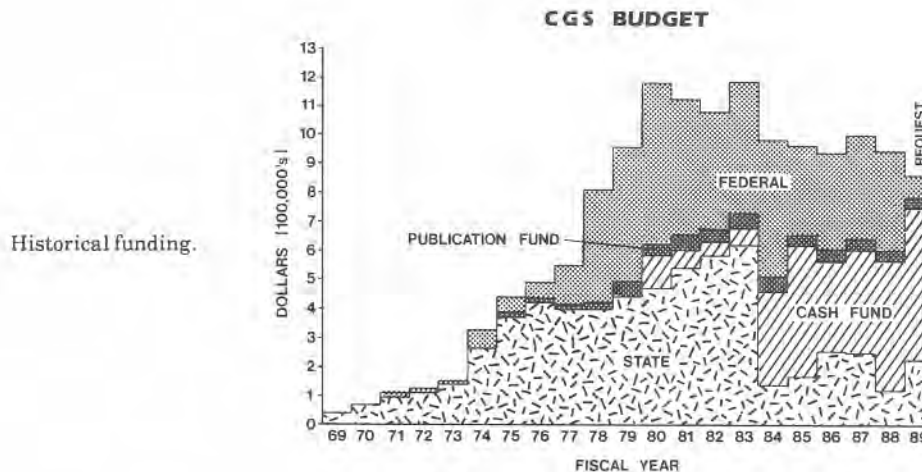
he received A.B. and M.S. degrees in geology in 1948 and 1950. His 19 years of experience with Chevron Oil Company earned him the positions of Area Geologist and finally District Geologist. An active member and officer of a number of local and national geological associations, John has also served on many panels and commissions in his position as State Geologist and has published numerous papers on geological, mineral resource, and land-use problems in Colorado.

After evaluating the many growing geological problems of the state in light of his limited fiscal and staff resources, Rold established an overall goal "to ensure the utilization of adequate geologic information in the state's public and private decision making." He often characterized the fledgling agency's role as being "like the yeast in bread dough." The Survey relied heavily on the many active geological societies in the area and on the U.S. Geological Survey and U.S. Bureau of Mines in attempting to achieve that goal.

Growing problems of oil-shale development, underground nuclear detonations, landslides, swelling soils, burgeoning ski area developments and subdivisions in hazardous areas, geologically related construction problems, and environmental controversies nearly engulfed the new one-man agency. Fortunately, attempts to address and mitigate these serious problems resulted in much-needed state-funded staffing increases from one in 1969 to 16 (11 geologists and 5 support staff) by 1975. That number remained static at 16 through 1983. Lack of increased state-funding support since 1975 forced the implementation of federal grants and contracts to better address many of the state's critical resource- and hazard-investigation needs. State funding of \$632,000 in 1983 was drastically reduced to \$139,000 in 1984. Accordingly, state-funded staff was reduced from 16 to only 3, but 10



Historical staffing patterns.



Historical funding.

positions were authorized by cash funding--if sufficient fees could be generated to cover their salaries and expenses. To date, the Survey has been marginally successful in replacing those state funds with cash income generated from other sources.

### ACCOMPLISHMENTS AND ACTIVITIES

One of the Survey's most noteworthy long-term contributions was insuring that geologic factors were addressed in Colorado's numerous land-use laws passed in the early 1970's. The first of these, Senate Bill 35, (1972), C.R.S. 30-28-101, et seq., the

subdivision law, sets minimum standards for all subdivision of lands in unincorporated areas of the state. Specifically, it requires investigation of geologic factors that would impact the proposed land use and requires review and recommendations for those subdivisions by the Colorado Survey. House Bill 1041, (1974), C.R.S. 24-65.1-101, et seq., legally defines geologic hazards and authorizes cities and counties to identify, designate, and manage activities in geologic hazard and mineral resource areas. House Bill 1034, (1975), C.R.S. 29-20-101, et seq., empowers cities and counties to consider geologic hazards when regulating



development and activities within their jurisdictions. House Bill 1529, (1973), C.R.S. 34-1-301, et seq., requires consideration of mineral resource values in zoning decisions and essentially constrains development over commercial sand and gravel deposits in the populous Front Range counties. Other provisions in HB-1529 provided the nation's first statewide reclamation law affecting all mineral resource development. House Bill 1574, (1973), C.R.S. 34-1-201 and 202, et seq., legally defines the practice of geology and professional geologists.

Two later laws addressed school construction and residential swelling soil problems. House Bill 1045, (1984), C.R.S. 22-32-124, et seq., requires that:

Prior to the acquisition of land for school building sites or construction of any building thereon, the board of education also shall consult with the Colorado geological survey regarding potential swelling soil, mine subsidence and other geologic hazards and to determine the geologic suitability of the site for its proposed use.

Senate Bill 13, (1984), C.R.S. 6-6.5-101, requires every seller of a new home to at least 14 days prior to closing the sale provide the buyer a "summary report of the (hazard) analysis and the site recommendations" and "for those sites in which significant expansive soils is recognized, the builder shall supply each buyer with a copy of a publication detailing the problems with such soils, the building methods to address these problems during construction, and suggestions for care and maintenance to address such problems." The preceding statutory language describes the Colorado Survey Special Publication 14 which is sold in quantity to home builders for distribution to home buyers. This law provided a windfall for publication sales and over 40,000 copies have been sold and distributed to date.

## GEOLOGIC HAZARDS

Robert B. Sennett, the first engineering geologist hired by the Survey, began the first geologic hazards investigations in 1970. After Sennett left the Survey, William P. "Pat" Rogers was hired in June 1971. He developed the program and the Engineering and Environmental Section, which he still directs. Early important contributors to engineering geology and hazards programs were Walter Rahe Junge, Stephen S. Hart, Lewis R. Ladwig, Arthur I. Mears, David C. Shelton, and James M. Soule. Somewhat later Timothy D. Bowen, Susan H. Cannon, Jeffrey L. Hynes, Candace L. Jochim, Robert M. Kirkham, Julia E. Turney, and Bruce K. Stover joined the organization and made important contributions to the understanding of and mitigation of geologic hazards.

The study and mapping of geologic hazards has captured much of the state Survey's interest throughout its existence. Under the impetus of HB-1041 several county-wide or regional hazards mapping projects were completed by either Colorado Survey staff or contracted consultants. Topical research and mapping has addressed swelling soils, snow avalanches, landslides, mine subsidence, earthquakes, rockfalls, debris flows, and hazardous canyons. Marble, Vail, Crested Butte, Big Thompson, Muddy Creek, Castle Rock, and Telluride Airport were sites of newsworthy hazard investigations.

Geologic review of projects constitutes a major portion of the extensive hazard-mitigation program. In fact, since 1972 the Survey has reviewed nearly 12,000 SB-35 projects. To our knowledge, no significant geologic hazard problems, other than those from swelling soils, have developed in any of those 12,000 subdivisions that were approved and constructed on the basis of the geologic

recommendations. The geologic-review system has proved so worthwhile that cities and towns have voluntarily submitted over 700 subdivisions for the Survey's geologic review. Over 900 other major developments--ranging from dams to large mines and large construction projects--were reviewed to ensure that potential geologic problems were addressed. Preconstruction geologic review of state building activities is estimated to have saved the state an average of \$500,000 in annual construction, repair, and maintenance costs.

Although numerous earthquakes had occurred in the Denver area in the 1960's, they were linked to injection disposal in a deep well at the Rocky Mountain Arsenal and even area professionals seemed little concerned with statewide seismicity. In 1980, with USGS funding, Pat Rogers and Bob Kirkham began an extensive evaluation of the state's seismic hazards. Their work and the resulting publications defined the problem and raised public and professional consciousness. Now developers of major dam and construction projects commonly evaluate and design for seismic risk.

Natural radioactivity is legally defined as a geologic hazard, consequently, in 1986 the Colorado Survey cooperated with the Colorado Department of Health and then carried out the EPA-sponsored statewide radon survey. Needed follow-up research and area evaluations have been stymied by lack of funds.

One of the later significant contributions of the Engineering and Environmental Section was site selection and geologic and geotechnical characterization of a proposed Superconducting Supercollider site in north-eastern Colorado. The quality of the site and the geologic analysis have won high praise from outside reviewers and have gained Colorado a place on the select

list of the nation's six most favorable sites.

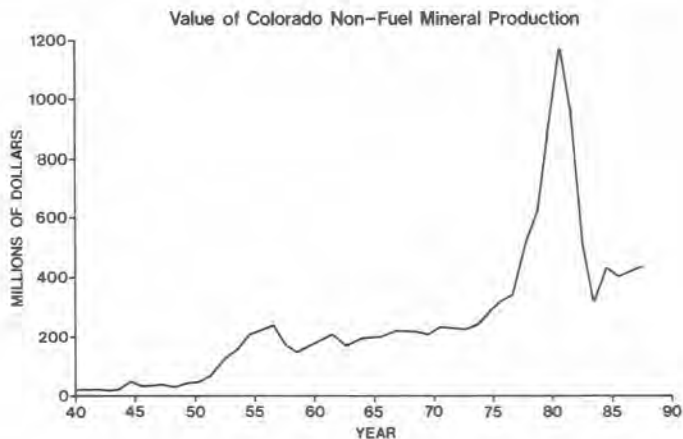
### MINERAL RESOURCES

Mr. Allison L. Hornbaker came from the Kansas Geological Survey in 1970 and headed the Mineral Resources section until his retirement in 1985. He was ably assisted for 11 of those years by Stephen D. Schwochow. Donna B. Collins and James Nelson-Moore also made important contributions. After Hornbaker's retirement, Mark W. Davis was hired to direct the Mineral Resources program.

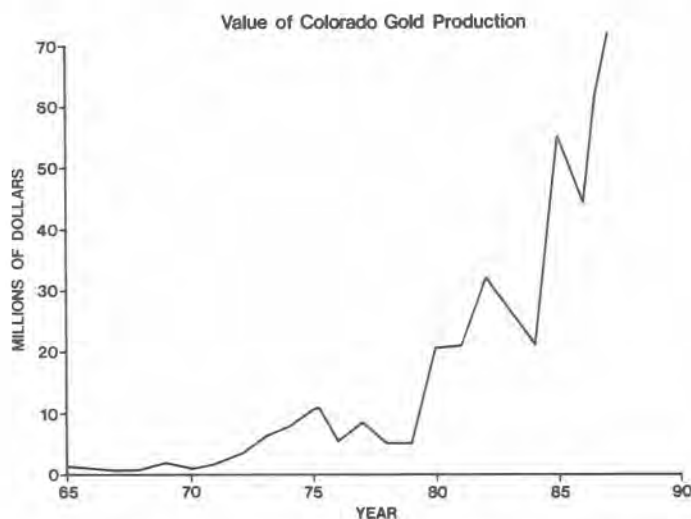
HB-1529 in 1973 required the Colorado Survey to map the sand and gravel deposits in the ten populous Front Range counties. The 213 maps generated by this project became part of the documentation for county planning processes. Other mineral resource maps and reports subsequently were completed for Mesa, Moffat, and Routt Counties. A major comprehensive inventory of radioactive mineral occurrences and producing areas in the state was published in 1978 at the height of the exploration boom and sold out within 10 weeks. Information about metallic mineral occurrences and mines compiled for the U.S. Geological Survey's Computerized Resource Information Base (CRIB), provides a wealth of basic data and historical information for both research and exploration. A statewide map and directory of operating metal mines has proved its value to industry and the public. Numerous smaller investigations of the state's various industrial minerals answered specific resource questions in local areas. The geology and resource potential of strategic minerals in Colorado were evaluated in a 1984 publication.

### MINERAL FUELS

Mr. D. Keith Murray was hired in 1973 to develop a mineral fuels program and direct that section. Major



Except for a dramatic peak at 1980 due to high molybdenum production and prices, the curve shows a steady increase in total nonfuel mineral production value.



The dramatic increase in gold production may be doubled by current exploration and proposed development projects.

contributors to that program since then have included Wynn Eakins, Steven M. Goolsby, Bruce S. Kelso, Peter Rushworth, Ann H. Scanlon, and Carol M. Tremain. Lew Ladwig became section head in 1979 and directed the program until he became Minerals Director for the Colorado Board of Land Commissioners in 1987. Administrative duties of the section subsequently were assigned to Mark Davis.

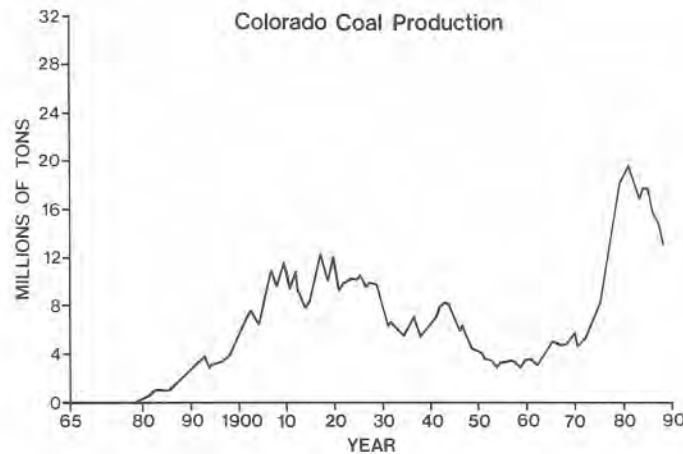
Little up-to-date information existed on Colorado's coal resources, which were being extracted at a rate of only 5 million tons per year in 1969. Because no state funds could be obtained, a major data-acquisition program was initiated through U.S.

Bureau of Mines, USGS, and Department of Energy grants. The numerous coal-resource investigations resulting from the grants now portray the depth, quality, quantity, and distribution of much of the state's 129-billion-ton coal resource. Thirty-nine formal publications and 30 open-file reports have contributed not only to an increase in coal production to over 19 million tons in 1982 but also to a better understanding of coal-development problems. In the early 1970's staff contributed considerably toward addressing the environmental, economic, and technical aspects of oil shale development and to the successful promulgation of the federal leasing

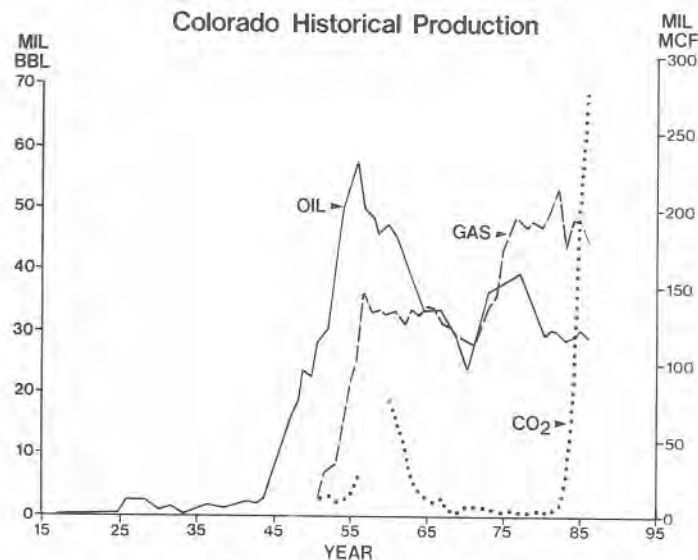
program. A widely used statistical summary and map of Colorado's oil and gas fields resulted from a contract with the Colorado Oil and Gas Conservation Commission. Pioneering investigations of the potential for development of coalbed methane depicted and estimated a resource of over 100 trillion cubic feet and helped spawn a significant coalbed methane industry in the state.

## GROUND WATER INVESTIGATIONS

This program was developed by Richard H. Pearl, who in 1970 came from the Water Resources Division of USGS. He directed the program until major budget cuts in 1983 eliminated the section. Important contributors to the ground-water and geothermal programs were made by Barbara A. Coe, Jay D. Dick, Michael J. Galloway,



Though declining since 1980, production is still high by historical comparison.



Production responded dramatically to markets, pricing, exploration, development and field decline.



Robert M. Kirkham, and Ted G. Zacharakis.

Water resources investigations of Boulder County and the mountainous portion of Jefferson County, done in cooperation with USGS, have helped home buyers, developers, and those local governments understand and address problems associated with this critical resource in the Front Range region. A study of the Denver Metro sewage-sludge-disposal site and Lowry landfill by the same cooperator was the first indicator of Lowry's pollution problems. A water quality atlas and water temperature maps of the state provide valuable background data for water users, industry, and government. Hundreds of shorter investigations of ground-water resources and ground-water pollution addressed problems of homeowners, small businesses, and local governments.

### GEOTHERMAL RESOURCES

A major federally funded program to define and evaluate Colorado's geothermal resources resulted in 26 publications and 9 open-file reports addressing that potential. Investigators mapped and analyzed 56 thermal areas. The geology and geothermal potential of 14 of these areas were investigated for possible local commercialization. In addition, the feasibility of geothermal heating of state buildings in several areas of the state was investigated.

### WASTE DISPOSAL

The Colorado Geological Survey was a forerunner in the development of geologic criteria for the safe long-term disposal of hazardous wastes and the evaluation of sites for the disposal of toxic waste and low-level radioactive waste, as well as uranium mill tailings and landfills.

### GENERAL CONTRIBUTIONS

Several major compilations released by the CGS have facilitated research and mineral exploration by others in the geological profession. A bibliography and index of all Colorado geological publications from 1875 through 1975 was published in 1976. This volume, the first of AGI's state compilations through GeoRef, and later supplements are widely used in research and mineral exploration. Through the Colorado Survey's encouragement and partial funding, USGS compiled and published a new revised geologic map of Colorado in 1979, as well as statewide gravity and aeromagnetic maps.

The Colorado Survey addressed the public understanding of geology with two major popular contributions. *Prairie, Peak and Plateau* was written on contract by John and Halka Chronic. Its continued appeal is reflected by sales of 48,000 copies. *Nature's Building Codes* explains in cartoons, sequential diagrams, and laymen's language the impacts of geologic factors on construction in Colorado. Subsequent publications prepared especially for the homeowner explained and addressed the problems of swelling soil and mine subsidence.

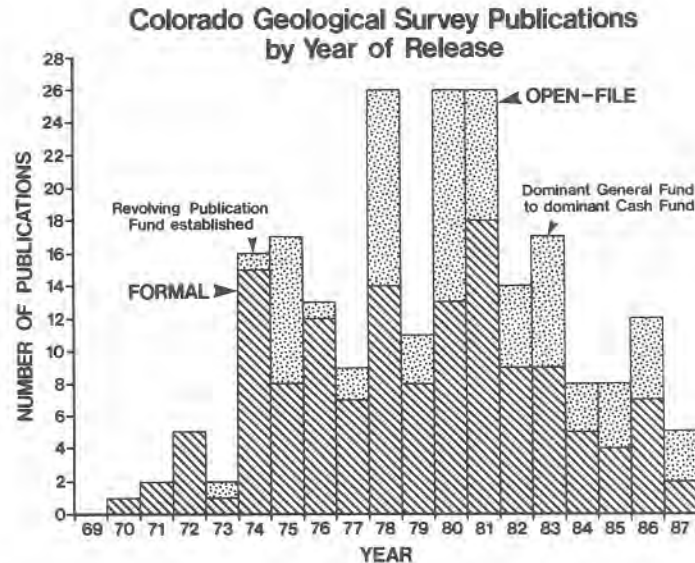
The Colorado Survey figured prominently in establishing a State Mapping Advisory Committee, the Rocky Mountain Groundwater Symposium, the Rocky Mountain Coal Geology Symposia, and the Governor's Environmental Geology Conferences. It cohosted the state's first Geothermal Symposium, a Seismicity Symposium, the 15th Industrial Minerals Forum, a Mine Subsidence Symposium, and the National Highway Geology Symposium. It has hosted numerous workshops and training sessions for geologists, planners, engineers, and government

officials on geological hazards, geologic factors in land use, and mineral resources. Staff has presented more than 1,000 talks ranging from technical papers for scientific societies to lectures and educational presentations to schools, colleges, and service clubs throughout the state.

In 19 years the Colorado Geological Survey's investigations have resulted in 142 formal publications and 92 open-file reports. Over 147,000 separate publications whose printing and distribution were paid for by more than \$470,000 in sales were sold and distributed. Staff contributed numerous articles on Colorado's geologic problems to scientific journals and other outside publications. Thousands of minor investigations and evaluations conducted for state and local governmental agencies and private individuals resulted in less formal responses in the

form of letters or short unpublished reports. Prior to July 1, 1983, CGS responded each year to thousands of informal geologic inquiries from the general public, local officials, geologic and engineering practitioners, and industry on a wide variety of geology-related subjects. The current level of state funding has drastically curtailed this important activity.

One of the more important actions to affect the Survey in recent years was the appointment in October 1987 by Governor Roy Romer of a Geological Survey Task Force. The Task Force was ably chaired by Stanley Dempsey, President of Royal Gold, Inc., and formerly an executive with AMAX. The charge to this group of 16 people representing the state's mineral industry, business, academic, local and federal government agencies, legislative and public communities was to



Shows the dramatic increase in formal publications when the Joint Budget Committee initiated a revolving publication fund in 1974 and the marked decline in 1984 after the change from dominantly general funding to predominantly cash funding. The decline would be even more dramatic except for the fact that several projects commenced under general funding were stalled and could not be completed and published until later years. The Survey since 1970 has sold and distributed a total of over 247,000 separate publications.

investigate the geologic needs of the state and to examine, evaluate, and strengthen the Colorado Geological Survey and its mission.

The Executive Summary of their report completed in February 1988 follows:

After lapsing for several decades owing to lack of funds, the Colorado Geological Survey (CGS or Survey), was reestablished in 1967 by legislative action, following recommendations by geologists and legislators. The newly formed Survey was to encourage resource development while mitigating geologic hazards and environmental concerns. Less than a decade ago, the CGS was among the country's top state geological surveys and served as a role model for the surveys of other states. The CGS produced important documents in mineral and energy resources and aided the legislature in formulating some of the most innovative and effective land use legislation anywhere.

Currently, however, the CGS is unable to meet Colorado's geological services needs. In 1983, responding to a directive to cut direct state government spending, the legislature reduced general fund support to many agencies, including the CGS. The legislature also provided for more reliance on cash funding of agency projects. Since then, a majority of the Survey's operating expenses have been derived from fees it charges for its services.

Although the Survey has done well at developing its cash-funded program, the overall change in funding has had a dramatic effect on the Survey staff. From 1975 until 1983, the CGS received an allotment for 16 full-time professionals. The average general-funded staff for the past five years has been four. Moreover, because only four people remain of that nationally recognized core, the leadership of a few years ago has been diminished.

The Survey's focus has shifted as well. The organizational structure is decidedly weighted toward short-term responses. This arrangement also allows the users to dictate the priorities and focus of the CGS. The majority of the Survey's current workload is geared toward engineering and environmental services and away from encouraging economic development of mineral resources and mineral fuels, industries experiencing a cyclical slump.

Another effect of reduced general fund support has been that CGS no longer has the resources to initiate joint, mutually beneficial projects with federal agencies.

Similarly, the funding negotiation process has made working for other state agencies difficult, and in turn, caused other agencies to staff their own geoscientists.

Regardless of the reasons for the current situation, the mission and responsibilities of the CGS to the economic, environmental and social well being of Colorado are too important to neglect. The Task Force makes the following recommendations to improve the value and viability of the Survey.

1. No changes are needed in the CGS's enabling legislation.
2. The Governor should create a permanent CGS advisory board that would aid in long range planning, aid in setting state geological priorities and provide continuity of direction and planning.
3. The CGS with assistance from the recommended Advisory Committee should establish a clearly defined research program involving the CGS, local universities and federal projects.
4. The CGS, to best promote the economic development of the state and its mineral resources, should step up the development, production and distribution of maps, publications and presentations for the economic geology community.
5. The CGS should collect, store and make available to the public basic geological, geophysical and geochemical data, and physical specimens of geologic value such as significant drill cores and cuttings.
6. The CGS should resume sponsorship of educational and technical programs, conferences and workshops on geological and mineral resource topics of significance to Colorado.
7. The CGS should be general funded to the necessary level to provide services to other Colorado agencies.
8. The CGS should be general funded to the necessary level to provide emergency response and short-term consultation services to local governments.
9. The CGS should be allotted general funds to support a cadre of personnel sufficient to meet its statutory

responsibilities and the activities recommended in this report.

10. The CGS should continue to seek cash funding to the extent that it meets the intent of the agency's mission and does not infringe on private consultants.
11. The USGS and CGS should continue their cooperative efforts and intensify their goal of setting mutual priorities on geological mapping and research.
12. The CGS should continue to cooperate with and seek funding from other federal agencies that have missions consistent with CGS efforts.

As a result of the Task Force efforts, the legislature, even in 1988's climate of severe general budget restrictions, funded one additional geologist for the Survey staff.

### AVALANCHE FORECASTING

In May 1987, the administration of the cash-funded Colorado Avalanche Information Center was transferred to the Colorado Survey from the Executive Director's Office of the Department of Natural Resources. Avalanches are a legally defined geologic hazard. The Colorado Survey has been involved with avalanche mapping since 1975. This transfer expands the Survey's hazard mitigation program to include temporal prediction as well as spatial. The four person Avalanche Center, officed with the National Weather Service, combines weather conditions and forecasts with snow conditions and the reports of 30 field observers to make daily avalanche hazard forecasts. These forecasts are routinely disseminated with radio and television weather reports. Daily recorded forecasts are available on local telephone hotlines throughout the state.

### SUMMARY

The past 19 years have been truly a time of significant progress and serious problems. Marked progress has been made towards achieving the overall goal of ensuring the utilization of adequate geologic information in both

public and private decision-making. The Survey has succeeded in encouraging the public and private sectors to utilize geologic information in land use, waste disposal, and construction decisions throughout the state. A majority of builders, developers, and governmental officials at both local and state levels have come to realize that geologic factors contribute significantly to many of their major everyday problems. They also now realize that geologic information can contribute towards solving those problems and that geologic information can provide better, cost-effective, long-term solutions to many problems.

In those 19 years the Survey has markedly improved and increased the quantity, quality, availability, and utility of publicly available geologic information. Geologists, engineers, and planners now better understand the location, distribution, and the causal bases for the occurrence of Colorado's many geologic processes that may react adversely to human activities. Together they are learning how to avoid and mitigate geologic hazards and how better to utilize the state's land resources. Improved understanding of the location, quantity, quality, and potential development impacts of Colorado's plentiful and varied mineral resources has aided geologists, industry, government agencies, and the general public.

Despite these accomplishments, problems and frustrations still abound. Seldom has adequate staff or funding been available to address, let alone solve, many of our growing geology or resource problems. Many developers and governmental officials still fail to realize that moneys spent on geologic investigations in the early stages of project development represent a cost-effective investment that ultimately saves money in construction, repairs, and long-term maintenance costs.



Looking to the future, it is hoped that the value of past and current work by the Survey will become more apparent and decision-makers will

come to realize that geological investigations and information are a worthwhile investment in Colorado's future.



John W. Rold, Director, Colorado Geological Survey,  
1969-present.

## CONNECTICUT

State Geological and Natural History Survey of Connecticut,  
Natural Resources Center, Department of Environmental Protection,  
165 Capitol Avenue, Hartford, CT 06106. Phone 203-566-3540.

### HISTORICAL SEQUENCE OF ORGANIZATIONAL NAME:

State Geological and Natural History Survey of Connecticut

### NAMES AND TITLES OF ORGANIZATIONAL DIRECTORS AND DATES SERVED:

William North Rice, 1903-16  
Herbert Ernest Gregory, 1916-21  
Henry Hollister Robinson, 1921-25  
Wilton Everett Britton, 1925-39

Edward Leffinwell Troxell, 1939-54  
John Becker Lucke, 1954-60  
Joe Webb Peoples, 1960-74  
Hugo Frederick Thomas, 1974-present

### A HISTORY OF THE STATE GEOLOGICAL AND NATURAL HISTORY SURVEY OF CONNECTICUT

By Robert J. Altamura

#### FOUNDATIONS OF THE SURVEY

There was a growing interest in geology in the early part of the 19th century, not only in Connecticut, but elsewhere. By that time, James Hutton, the founder of modern geology, had presented his epoch-making *Theory of the Earth* to the Royal Society of Edinburgh in 1785. Europeans, who had studied the natural sciences for some time, continued to pursue the subject of geology. Here in the United States, foreign literature stimulated interest in natural science, including geology and biology, and people were becoming increasingly aware of the natural world.

In 1802, the President of Yale College in New Haven, Connecticut, hired Benjamin Silliman, who just had completed his training in law, to head a department and offer courses in science. Before he began teaching, Silliman attended lectures in chemistry at a medical school in Philadelphia and had studied natural science in Europe. By

1806, Silliman had published a sketch of the mineralogy of New Haven and in 1818 he founded *The American Journal of Science*. The early volumes of *Silliman's Journal*, as it was then known, contained a number of papers on Connecticut mineralogy and geology, many by Silliman himself.

Silliman's students carried their knowledge to other parts of the country. In 1824, Denison Olmsted went to head the North Carolina Survey. Edward Hitchcock went to Amherst College in Massachusetts and conducted the geological survey of that state beginning in 1830, which inspired and stimulated other states to get surveys under way. Amos Eaton went to Williams College in Massachusetts and later to Rensselaer Polytechnic Institute in Troy, New York, where he worked on a geological survey in eastern New York, and James Gates Percival stayed in Connecticut to lead the state's first systematic geological survey.

In the United States, the period from 1830-80 has been referred to as the "Era of the State Surveys" (Merrill, 1924). William W. Mather, who taught at Wesleyan University in Middletown, Connecticut from 1833-34, was one of four state geologists who mapped New

York State from 1836-42, and in 1841 Edward Hitchcock completed the geological survey of Massachusetts.

The first systematic study of the geology of Connecticut was made when a survey of the state was authorized by the Legislature on June 15, 1835. James Gates Percival was placed in charge of the geology and Charles Upham Shepard, the mineralogy. A passage from the Annual Message of 1835 from Governor Henry Edwards may provide insight into the thinking of the times, which led to the birth of that first geological survey of the state.

The mineralogical treasures which have been developed within a few years and which are constantly coming to light in different parts of our country, give us reason to believe, that we have not as yet availed ourselves to the extent that we might of this source of wealth, and suggests the expediency of a more systematic examination than has hitherto taken place . . . (from Shepard, 1837).

Shepard's *A Report of the Geological Survey of Connecticut* was published in 1837, but it wasn't until 1842 that Percival published his *Report on the Geology of the State of Connecticut*, which was a comprehensive geological investigation. By 1841, Percival (fig. 1) had surveyed the entire state in E-W traverses at 2-mile intervals, which means that he touched every square mile of the state. By the time Percival accomplished this task, the Legislature and new governor William Ellsworth became impatient for a final report. Requests for further appropriations were denied, and Percival was forced to report his work in "a hasty outline" of 495 pages with a map (the first state geological map, scale 1:250,000).

Percival's report on the geology of Connecticut delineates all the major rock types with particular attention to detail. His observations are descriptive with little interpretative bias. Geologic boundaries key to some of the modern interpretations as shown on the most recent state map were delineated on Percival's 1842 map. As an example of



Figure 1.--James Gates Percival--student of Benjamin Silliman and author of the first geological map of Connecticut, which was published in 1842.

the value of Percival's observations, in preparing the 1985 *Bedrock Geological Map of Connecticut*, John Rodgers of Yale used Percival's map to help resolve conflicts.

From 1842 to 1903, the State initiated no new geological investigations. However, studies were conducted by various university and federal geologists. In the last half of the 19th century, instruction and investigations in geology were conducted primarily at three Connecticut universities. At Yale, Benjamin Silliman, James Dwight Dana, his son Edward S. Dana, and George Brush, made early contributions to the geology and mineralogy of the state. At the Peabody Museum of Yale, Othniel C. Marsh made collections of dinosaur bones from the western United States, competing with Edward

Drinkwater Cope of the Academy of Natural Sciences in Philadelphia. Also at this time, geological instruction and investigations were under way by John Johnston and William North Rice at Wesleyan. Rice had received a Ph.D. from Yale in 1867. This was the first Ph.D. in geology given by an American university. The title of his dissertation was *The Darwinian Theory of the Origin of Species*. Rice, a graduate of Wesleyan in 1865, returned to become professor of geology and in 1903 became the first Superintendent of the State Geological and Natural History Survey of Connecticut. Rice was also an ordained minister. Charles Upham Shepard taught and conducted numerous investigations at Washington College (later to become Trinity College) in Hartford during this time. Key contributions to Connecticut geology and mineralogy appeared in *The American Journal of Science*.

Shortly after its formation in 1879, the U.S. Geological Survey (USGS) began work in Connecticut. William Morris Davis, who was a professor at Harvard and also worked for the USGS, studied and mapped the Mesozoic rocks of Connecticut. Davis accomplished part of this work by leading the Harvard College summer geology school to the Meriden area for geological mapping. Later, Davis worked with S. Ward Loper, a farmer who later became curator of the geology museum at Wesleyan. Loper helped confirm Davis' structural models for block faulting in the Connecticut valley by locating specific fossil fish and fossil plant marker horizons.

One of Davis' geological assistants was William North Rice (fig. 2). Another was Lewis Gardner Westgate, also a graduate of Wesleyan, who did considerable mapping in the crystalline rocks near Middletown.

In 1891, W. F. Hillebrand, a chemist with the USGS, studied uraninite (essentially  $UO_2$ ) from Portland, Connecticut, and noticed during the

preparation for analysis that a gas was being emitted. Several years later, helium was isolated as a stable decay product of uranium. In 1904, Ernest Rutherford of McGill University presented ideas on how progressive accumulation of daughter products might be used to measure geologic time. Those ideas were put to use by Bertram B. Boltwood of Yale, who, in 1906, following a suggestion made by Rutherford, looked at analyses of uranium minerals, including Hillebrand's uraninite analyses, and made the first radiometric age determinations. Radiometric age dating indicated that the expanse of geologic time was much greater than geologists previously thought.

Around the turn of the century, William H. Hobbs of the USGS conducted pioneering lineament studies in Connecticut, a field that today receives a significant amount of attention.

During the 19th century, people in Connecticut also turned their attention to biology. For example, around the time of Percival and Shepard, Eli Ives of Yale, a professor of botany and medicine, published three papers on plants in *Silliman's Journal*. Ives later made a list that included the names of more than a thousand plants growing near New Haven (Troxell, unpub. ms.). Troxell also reports that Amos Eaton and John Pierce Brace pursued similar interests. Brace later studied plant life in the Litchfield, Connecticut, region, and his herbarium was donated to Williams College.

About 1856, professor Daniel Cady Eaton and other members of the Sheffield Scientific School of Yale produced a catalog of the higher plants found in the vicinity of New Haven, listing about 1,230 species (Troxell, unpub. ms.). In 1885, James W. Bishop presented a catalog of plants for all of Connecticut which included contributions from many naturalists throughout the state.





Figure 2.--William North Rice (first Superintendent of the Connecticut Geological and Natural History Survey) (left) and William Morris Davis of the U.S. Geological Survey (right) "toast" in the field. (Department of Earth and Environmental Sciences, Wesleyan University.)

In 1903, the Connecticut Botanical Society was founded, and a goal was to catalog all the higher plants growing naturally in the state. That same year the State Geological and Natural History Survey of Connecticut (also referred to as the Connecticut Geological and Natural History Survey) was founded.

#### FORMATION OF THE CONNECTICUT GEOLOGICAL AND NATURAL HISTORY SURVEY

The Act establishing the State Geological and Natural History Survey was approved by the Legislature on June 3, 1903. The Commissioners, under whose direction the Survey was placed

by the terms of the Act, appointed William North Rice (fig. 3), Professor of Geology at Wesleyan, to be Superintendent of the Survey.

The first Biennial Report of the Commissioners states that equal attention be paid "both to the rocky framework of the state and to its vegetable and animal life--both to the Geology of the state and to its Botany and Zoology." The report also states that the Survey has three distinct aims. These are:

First the advancement of our knowledge of the geology, botany, and zoology of the state as a matter of pure science; second, the acquisition and publication of such knowledge of the resources and products of the state as will serve its industrial and economic interest; third, the presentation of the results of investigation in such form as to



Figure 3.--William North Rice--First Superintendent of the Connecticut Geological and Natural History Survey and Professor of Geology at Wesleyan. (Wesleyan University Archives.)

be useful in the educational work carried on in the various schools of the state. These three aims, the purely scientific, the economic, and the educational, we have endeavored constantly to keep in mind in all plans which have been made.

It may have been Professor Herbert Ernest Gregory of Yale and also of the U.S. Geological Survey who eventually brought the elements together to form the Survey. Troxell (unpub. ms.) implies that Gregory, who took many trips back and forth to Hartford, was the main organizer. Gregory met frequently with other scientists, with administrative officers, and with politicians whose final consent needed to be won.

On the occasion of the 25th anniversary of the Connecticut Survey, Gregory wrote a letter, dated December 30, 1927, in which he states that his deep and continuing interests made him feel that the time he gave to the Survey's organization, along with its administration and scientific studies, was profitably spent. He further states, "My reason for urging the establishment of the Survey was the belief that such an organization would fill a useful place in the educational system of the state." Education may have been Gregory's primary incentive.

### Practical Organization

The Connecticut Survey consisted of a board of commissioners, who were made up of the presidents of the state's principal colleges. These institutions were the Connecticut Agricultural College (later to become the University of Connecticut) in Storrs, Trinity College in Hartford, Wesleyan University in Middletown, and Yale University in New Haven. Later Connecticut College in New London was represented on the Commission. The Governor was an *ex officio* member of the board. A Superintendent, who was a scientist and not necessarily a college president, was appointed by the Commission to direct the work of the Survey.

The organization of the Survey was intended to be simple and, following this reasoning, the Commissioners decided that no promises of position or support would be implied beyond the current biennial term. The exception to this rule was the Superintendent, who was appointed by the Commission to serve until removed for valid reason. The Survey's office was based at the institution where the Superintendent was employed.

The initial biennial appropriation for the Connecticut Survey was \$3,000. "Scientific men" employed to investigate specific subjects and to prepare reports were paid a sum when their report was

accepted. The Commission, in addition, would allocate funds for travel expenses, services of stenographers and other assistants, and to purchase materials as needed. Only the Superintendent was paid a regular salary, and this was provided in quarterly installments. In the early years, the Superintendent's annual salary was \$400.

Once under way, the Survey quickly undertook several studies in the fields of geology, botany, and zoology.

### Publication

Each report was published as a separate bulletin in paper cover. When several bulletins were completed, bound volumes were then prepared. The distribution and exchange of publications was conducted by the State Librarian, a function now provided by the Natural Resources Center. Publications received from other geological surveys "and from various learned societies and scientific institutions" were deposited in the State Library.

From the beginning, the Survey had to deal with inadequate means for publishing. At the time the Connecticut Survey was founded, the general law of the State limited the editions of printed matter to 1,375 copies. The Survey immediately saw the need to acquire agreement for larger printing runs of 3,000 to 8,000 copies. At the recommendation of the Survey, the General Assembly adopted a resolution authorizing the printing of the necessary number of copies.

Every 2 years, Biennial Reports dutifully cited work undertaken, accomplished, and proposed for the future. Superintendent Rice suggested that these reports include proposed future work, so that members of the General Assembly would be "better prepared to reach wise conclusions in regard to the continuation of appropriation for the Survey." The Legislature appropriated funds on a biennial basis.

### ERA OF COLLEGE PRESIDENTS AS COMMISSIONERS: 1903-45

During the first 42 years of the Geological and Natural History Survey, scientific research in the geological and biological sciences was undertaken and reports written at a remarkable pace and quality.

Generally, the Survey encouraged work on the geology and biology of the state through the support and/or publication of work conducted by university faculty and graduate students. Where need was determined to exist, selected studies were strongly urged and researchers sought for those projects. Appropriations were applied to projects where the need was judged to be greatest and where there was the likelihood of the greatest success.

### Geology

The first geological work undertaken included a manual on the geology of the state. Since the publication of Percival's *Report on the Geology of the State of Connecticut* in 1842, a good deal of geological work was done partly by the U.S. Geological Survey, and partly by those working at universities. The results of these studies were scattered in various publications. Rice (1904) recognizing this wrote,

In this condition they are almost inaccessible to the great number of teachers in our high schools and other intelligent people in the state, who are not geologists by profession, but who desire to know something of the geological structure and history of the state.

Superintendent Rice and Professor Gregory (second Superintendent of the Connecticut Survey) undertook the responsibility for the *Manual of the Geology of Connecticut* which was published as Bulletin No. 6 in 1906. In additional work, Professors Gregory and Henry Hollister Robinson (also of Yale and third Superintendent of the Survey) prepared the second state geological map, which was in color and at the scale of 1:250,000. An investigation called *The*

*Clays and Clay Industries of Connecticut* by Gerald Francis Loughlin was published in 1905. Joseph Barrell and Loughlin wrote *The Lithology of Connecticut* (1910), and Barrell prepared *Central Connecticut in the Geologic Past* (1915) (fig. 4).

Aside from Rice and Gregory's manual of geology, which rapidly went out of print, one of the most widely read geologic reports was published in 1929--Bulletin No. 47, *The Glacial Geology of Connecticut* by Richard Foster Flint. This comprehensive and popular bulletin includes many landscape photographs plus the first glacial geologic map of the state, which is in color at 1:125,000 scale. Flint, in putting

together the report and map, synthesized much information about the glacial geology of the state and developed many of his ideas about glacial processes.

In addition, the Survey's *List of Publications* for this period includes reports on fossil fishes and other Mesozoic life, a physical history of Connecticut's shoreline, the mineralogy of the state, an investigation on the marbles of Connecticut, and various other studies of both regional and local nature.

### Natural History

One of the first botanical works undertaken by the Connecticut Survey was an annotated list of the state's

## STRUCTURE SECTIONS of CENTRAL CONNECTICUT

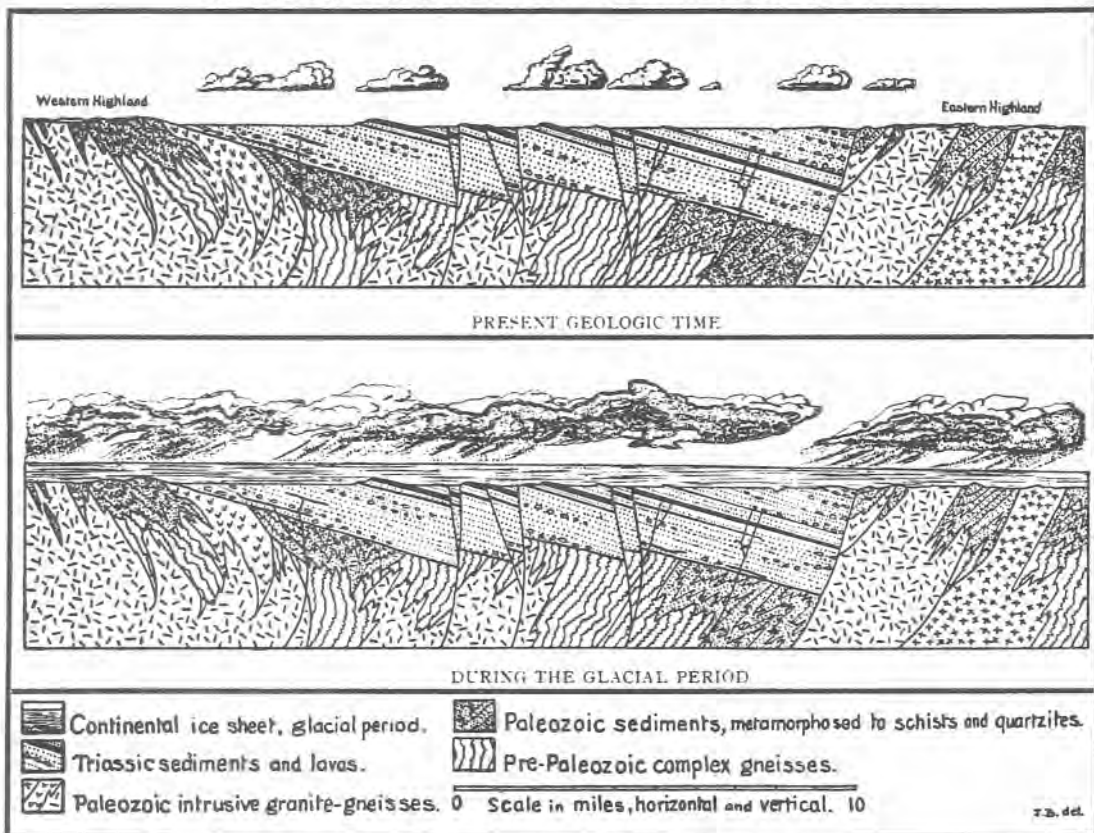


Figure 4.--Structural sections across central Connecticut showing the Mesozoic age Hartford basin (Newark Supergroup). These and other sections appeared in Survey Bulletin No. 23, *Central Connecticut in the Geologic Past* by Joseph Barrell (1915).



vascular flora. The Commissioners believed that having such a list was in the interest of pure science. One of the criteria for the report was to give attention to the economic relation of plants "valued for their beauty or for their useful products, and to those which are troublesome weeds, or which possess poisonous or other injurious properties." Such a work already was begun by the Connecticut Botanical Society, which responded "most cordially" to a suggestion that the Survey act as the vehicle to publish the work (Rice, 1904). Subsequently, this list was published as Bulletin No. 14, *Catalogue of the Flowering Plants and Ferns of Connecticut, Growing Without Cultivation* by C.B. Graves, E.H. Eames, C.H. Bissel, L. Andrews, E.B. Harger, and C.A. Weatherby (see fig. 5) in 1910 and added to in 1926 as Bulletin No. 48, *Additions to the Flora of Connecticut*.

Concurrently, reports on certain groups of fungi in Connecticut were undertaken by Professor E. A. White of the Connecticut Agricultural College and G. P. Clinton of the Connecticut Agricultural Experiment Station. Clinton's report on smuts had economic importance, because among them are many plant diseases caused by fungi that destroy agricultural crops.

During this era, botanical reports also were published concerning fresh-water algae, bryophytes (mosses and liverworts), and lichens.

In the field of vertebrate zoology, the Survey's first undertaking was a list of Connecticut's birds. "Their migration, their food, and other matters bearing on their economic relations" were of interest to the Survey. John S. Sage, a banker and early member of the American Ornithologists' Union and Dr. L. B. Bishop of New Haven were the investigators, and in 1913, they published *The Birds of Connecticut* as Bulletin No. 20.

Planned in the first Biennial Report was a systematic study of the micro-

scopic life of the fresh waters of the state. The study satisfied all the scientific, educational, and economic aims of the Survey. Considered economically important, the study explored the possibility of contamination of reservoirs by "injurious or disagreeable organisms." The investigation was undertaken by Professor Henry William Conn of Wesleyan and published as Bulletin No. 2, *A Preliminary Report on the Protozoa of the Fresh Waters of Connecticut*. It marked the first scientific investigation published by the Survey.

Other zoological work during this period included initiation of an entire series (9 fascicles) on insects, publication of reports on shrimp- and sowbug-like invertebrates, fish, amphibians, reptiles, and mammals.

Of the zoological work, perhaps the publication *The Birds of Connecticut* by Sage and Bishop is significant enough to be singled out. The information included in this long-awaited document was carefully collected. Sage and Bishop, using a method common for ornithologists of that time, shot the specimens to make a "bird in hand" identification.

In addition, the series of guides to the insects of the state, which has continued to the present, has been particularly responsive to people's needs. For example, after World War I, a study of mosquitoes was done with attention to diseases that might be transmitted by returning soldiers.

The Survey's *List of Publications* grew rapidly, and by 1945, more than 68 bulletins had been published.

### Early U.S. Geological Survey Cooperatives

In the 1890's, prior to the founding of the Connecticut Geological and Natural History Survey, the State of Connecticut cooperated with the relatively newly formed USGS to create a 15-minute series of topographic maps of the state. In 1893, the first state topographic map



Figure 5.--Charles Burr Graves, Una F. Weatherby, and Charles Alfred Weatherby pose in front of a large oak tree in Ledyard, Connecticut. C. Weatherby and Graves collaborated with others in the publication of Bulletin 14, *Catalogue of the Flowering Plants and Ferns of Connecticut, Growing Without Cultivation* in 1910.

was compiled at a scale of 1:125,000. The popular topographical atlas of the state (a book made from the 1:62,500 scale 15-minute quadrangle sheets) was out of print by 1908, and the State Legislature ruled that the Survey was responsible for supplying bound copies of the atlas. This was an early example of the State

Legislature relying on the Survey to provide map information.

The Biennial Report for 1927-28 (Bulletin No. 45) states that the Survey had proposed new topographical surveys for funding by the State Legislature as the obsolescence of the 1890's map series had been recognized for some time. A revised 1:125,000 scale map was needed

for the glacial geology by Flint, who finally had to use the 1893 map. The proposal for new mapping was submitted biennium after biennium without receiving favorable action. New surveys were indeed needed, but it wasn't until the late 1940's that new 7.5-minute topographic mapping at a scale of 1:31,680 (later changed to 1:24,000) began under a USGS cooperative agreement.

During the Survey's early years scientific investigation proceeded in many directions. In 1911, the State Geological and Natural History Survey entered into a cooperative agreement with the USGS to study the water resources of Connecticut under the direction of George Otis Smith, Director of the USGS and William North Rice, Superintendent of the State Survey. Professor Gregory was placed in charge of the USGS effort. The agreement, made and entered on May 31, 1911, is reported to be the first cooperative agreement between the USGS and a state geological survey. The project was successful and produced a number of USGS Water-Supply Papers that focused on ground water and included the occurrence of water in crystalline rocks and the study of coastal ground water.

Some fundamental ideas concerning salt water intrusion came from the coastal ground-water work by John S. Brown of the USGS, who was assisted by Harold T. Stearns, a former student of Rice, and Wilber G. Foye at Wesleyan.

Another type of cooperation occurred in 1911-12 when T. Nelson Dale of the USGS was assisted by Gregory in writing a chapter for a book on granites in Connecticut. Gregory wrote about the geology of the state and Dale focused on the more utilitarian aspects of quarry rock, operations, and products. The report was published as USGS Bulletin No. 484 in 1911. Dale prepared a report on the commercial granites of New England some years later.

This era of the Connecticut Survey experienced two world wars. From 1917-18, the Survey assisted the Council on National Defense through the National Research Council by taking the responsibility of providing reliable information regarding earth materials for road making and fortification construction along the Atlantic seaboard. During World War II, work was directed along three lines: forest study, search for strategic minerals (primarily mica and some beryl), and areal geology and field work in southern Connecticut. General Survey work was hampered by very limited appropriations during the Depression and World War II.

Following World War II, a change was made to switch the appointment of Commissioners of the Survey from college presidents to scientists who were on the faculties of the respective colleges. The Survey's character changed, and its activities evolved to move forward into a new era.

#### ERA OF SCIENTISTS AS COMMISSIONERS: 1945-71

During this period, the Commission was composed of members selected from the science faculties by their college presidents, together with the Superintendent, and Governor, who served *ex officio*.

Troxell (unpub. ms.), Superintendent of the Survey from 1939-54, wrote that the spirit and attitude of the Survey changed with the transition from college presidents to scientists as Commissioners--a move that inspired and invigorated. One example of the change is that individual members of the Commission frequently visited investigators in the field, not merely to check on progress, but to lend assistance in solving difficult problems.

Troxell lists the personnel of the Survey at that time (circa 1953) as: the Commissioners; the Director (the title Superintendent had been changed to Director--apparently by Troxell's usage);

the professional specialists or researchers; the State Librarian; and an editor, a new position at the time.

### Natural History

During the era of scientists as Commissioners, publications in natural history included 5 fascicles (primarily on flies) in the series *Guide to the Insects of Connecticut*; a bulletin on *The Flora of Windham County: A Check List*; bulletins on the fresh water and salt water fishes of the state, and the first publication with color photographic plates--*Connecticut's Venomous Snakes*.

In addition, *Spiders of Connecticut* by Benjamin J. Kastin was published in 1948 (see fig. 6) and a revised edition published in 1981. This 1,020 page monograph is considered one of the most authoritative references on spiders of eastern North America. *The Climate of Connecticut*, (Bulletin No. 99) written by Joseph J. Brumbach and published in 1965, shows the diversity of publications in natural history.

In 1962, William Niering and Commissioner Richard Goodwin of Connecticut College, conducted and published pioneering studies on natural areas which stimulated public interest. Later, in 1965, a new series, *The Vegetation of Connecticut Natural Areas*, published reports by Frank E. Egler and

William Niering documenting the results of vegetation studies of selected habitats in the state. This series has been expanded to include a greater diversity of habitats such as trap rock ridges.

### Geology

Around 1948, it became apparent that a long-range, statewide program for mapping geology was needed. At the urging of Commissioner Goodwin, the Connecticut Survey and the Yale University Department of Geology sponsored a conference in New Haven on May 8, 1948. All who were "apt to have a real interest in the geology of Connecticut were invited to review the geology of the state; to clarify ideas on outstanding problems and discuss how to attack them; and to lay the groundwork for a program which would result in a revised modern bulletin of the geology of the state." This was an important meeting, which provided new direction for geologic mapping in the state. The resolutions developed at the meeting had far-reaching effects in future geological work.

The meeting had 54 registered delegates and passed the following resolutions: that geological mapping of the state on 7.5-minute quadrangles should be conducted; that publishing

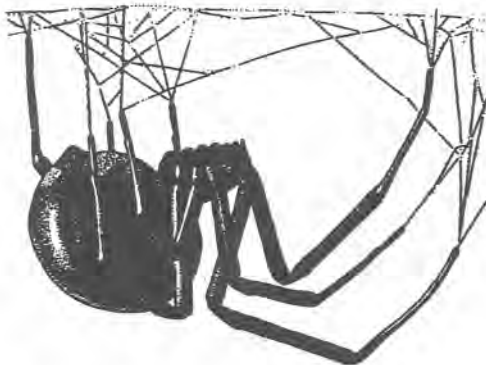


Figure 6.--*Latrodectus mactans* (Fabricius) [black widow spider]. This figure is part of a plate from Benjamin J. Kastin's *Spiders of Connecticut* (Connecticut Geological and Natural History Survey Bulletin No. 70) published in 1948 and revised in 1981.



these maps and reports was important and the necessary publication funds should be sought; and that southwestern Connecticut should have new topographic maps prepared. Earlier maps of southwestern Connecticut, which were made during World War II by private contractors, were inaccurate and below the high standards of the USGS.

Because of his strong interest in Connecticut geology and in the proposed mapping program, Professor John Rodgers of Yale was regularly invited to attend the meetings of the Survey, although he was not a Commissioner at that time. In the early 1960's, Rodgers was made a Commissioner. Another interested party was Robert Gates of the University of Wisconsin, who, along with his students, began mapping geology in western Connecticut as early as 1948.

Delays, unfortunately, forced a landmark piece of work in sedimentology to be published later than it might have been. *Petrology, Stratigraphy, and Origin of the Triassic Sedimentary Rocks of Connecticut* by Paul D. Krynine was printed by the Survey in 1950, nearly 14 years after the study had been completed as a dissertation for a Ph.D. at Yale. This paper remains a classic in the field of sedimentary petrography, in paleoclimatology, and in redbed studies. The work shows careful assembly of data (often from diverse sources), drawn together in an exciting, forceful style, and directed toward support of his argument on a controversial issue, the origin of redbeds.

At this time, the Connecticut Survey also published posthumously a report by Wilber G. Foye of Wesleyan, *The Geology of Eastern Connecticut*. This, like Krynine's paper, had been delayed. In addition, the catalog of minerals of Connecticut was updated, and Richard Swann Lull of the Yale Peabody Museum revised his classic work, *Triassic Life of the Connecticut Valley* nearly 36 years after its initial

publication (Lull cites Krynine's ideas on Mesozoic climate as an impetus for the revision).

The 50th anniversary of the Connecticut Geological and Natural History Survey (1953) occurred during this period. To celebrate, the American Association of State Geologists (AASG) held a special meeting at Trinity College in Hartford. This was also to honor Dr. Troxell, who had been President of the AASG. The meeting was marked by a number of geological field trips throughout the state. Also, a biological symposium was held at Connecticut College in New London in recognition of the anniversary.

Publication formats other than the State Survey Bulletin were developed to allow for more varied types of reports and maps. The new formats included a Report of Investigation series, which covered less comprehensive studies than Bulletins; Guidebooks; a series on the Vegetation of Connecticut Natural Areas; and a Miscellaneous Series.

Shortly after the Connecticut Survey marked its 50th year, systematic geologic mapping on 7.5-minute quadrangles was initiated with the help of the USGS. Robert Gates was the author of the first quadrangle geologic map, which carried forward the thrust of the Yale meeting of 1948. This work, *The Bedrock Geology of the Litchfield Quadrangle* was published in 1951 under the Miscellaneous Series. Five years later, a preliminary state geologic map (1:253,440 scale) and text were prepared by Rodgers, Gates, and others, which helped to focus the statewide quadrangle mapping. Also in 1956, under a cooperative agreement, the USGS began systematic geologic quadrangle mapping.

The Connecticut Geological and Natural History Survey at first published quadrangle maps with reports under the Miscellaneous Series, and later under a new specialized series--the Quadrangle Report (QR). Maps were published by the USGS under the

Geologic Quadrangle Map (GQ) series. For the most part, two maps were prepared for each quadrangle--one delineating the bedrock geology and the other the surficial geology. In some cases, both bedrock and surficial geology are shown on the same map. During this era of scientists as Commissioners, more than 100 7.5-minute geologic quadrangle maps were published and mapping was started on many others.

By 1968, both Rodgers and Flint had state compilations at the scale of 1:125,000 under way. These compilations used a 1:125,000 scale topographic base map. This base map had been prepared by the USGS as a result of efforts by Director Peoples, who successfully gained appropriations for its preparation from the State Legislature. The base map has been used to present a variety of information (e.g. regional geology and ground-water availability) published under the Natural Resources Atlas Series. In 1988, there are ten maps in this series.

In addition to the bedrock and surficial maps, other geological products prepared during this time were aeromagnetic maps (1:24,000; 1:125,000 scales), a gravity map (1:125,000), along with an aeroradioactivity map (1:250,000), and one of the first examples of side-looking airborne radar imagery (1:500,000). Some of these products were developed using advances in geophysical technology developed during World War II.

In 1959, reorganization of State agencies placed the Survey within the newly organized Department of Agriculture and Natural Resources. The administrative structure of the Survey remained essentially the same, but now came under the authority of a new department. A representative from the Department of Agriculture and Natural Resources would frequently attend the Survey Commissioners' meetings.

During the 1960's and 1970's, when geologic quadrangle mapping was particularly active, important changes

were taking place in geologic science that would profoundly affect the later quadrangle mapping and especially the state bedrock and surficial map compilations. In bedrock geology, the development of the theory of plate tectonics brought new significance to the structure and stratigraphy of Connecticut, as it lies in the center of the Appalachian orogen. The state bedrock map, published in 1985, used a plate tectonics conceptual model.

In surficial geology, work in New England that was led in part by USGS geologists resulted in a new conceptual model for regional deglaciation. The new model, termed "stagnation zone retreat," differed significantly from Flint's model of "regional stagnation." Flint's compilation work of the state surficial map was halted by his death in 1976. Subsequent work by USGS personnel on a new state surficial compilation is based on the new model of glacial retreat.

During this period of increased activity, Joe Webb Peoples was Director of the Survey (1960-74). He conducted annual summer field conferences in Middletown to allow geologists to meet to discuss common issues and future plans, and to resolve correlation problems (especially at quadrangle boundaries). At the conferences, reports and compilations were presented informally. These events, which were well-established by the mid-1960's, are fondly remembered by those who participated in both the technical conference and the evening comradery that followed at Director Peoples' home overlooking the Connecticut River in Middle Haddam.

In time, the summer conferences were attended by other interested people, including planners, water resource managers, soil scientists and topographic mappers. As a result, participants recognized the need for interdisciplinary cooperation in the earth sciences, and in 1969 with the help of Harold Bannerman, a consultant for the Survey who was retired from the

USGS, the Connecticut Geology-Soils Task Force was developed. Bannerman convened the Geology-Soils Task Force to bring the appropriate branches of science together to address how geoscience information could best be applied in land- and water-use planning. The Task Force included John Baker of the Water Resources Division of the USGS, David Hill of the Connecticut Agricultural Experiment Station, and Hugo Thomas of the University of Connecticut.

A major result of the work of the Task Force was the publication of a report by Hill and Thomas: *Use of Natural Resource Data in Land and Water Planning*. The report discusses how separately mapped resource parameters (e.g. surficial geology; bedrock geology; slope; drainage; soils; depth to ground water, . . . or what they called "single factor maps") could be used to improve land and water use analysis and decision making.

They presented, as an example, plans for a hypothetical solid waste disposal site in a trial map area. The need for the standardization of map scales and map units was clearly identified. Their suggested land- and water-use analysis process began to identify which were the most important pieces of geologic resource information for modern society.

Also during the later part of this era, the State Survey acquired its first full-time geologist. Until that time, work had been conducted for the Survey through part-time employment and volunteer efforts. The appointment came after an unusual set of circumstances which increased the responsibilities of the Survey and necessitated the creation of the position.

In 1966, during excavation for the foundation and basement of a Highway Department testing laboratory on a site in the central lowlands, a bulldozer operator recognized dinosaur tracks in rocks several feet below the natural

surface of the ground. Because of the extent and number of tracks, Governor John Dempsey announced that the site would be set aside as a state park. Investigations by scientists from the Peabody Museum (Yale), the Survey, the University of Connecticut, and Willimantic State College (now Eastern Connecticut State University) had established the significance of the area. Dinosaur State Park today is a very popular educational site for natural sciences.

The government agencies responded quickly to a situation requiring rapid decision-making. They delayed and ultimately halted the construction of the Highway Department building and dedicated the area as an educational site. Much of the credit for this was due to the skill and determination of Director Peoples (fig. 7). Sidney Quarrier was completing a master's degree in earth science education at Wesleyan, when he was assigned to work at the Park. As the Survey's first full-time employee, Quarrier helped to initiate a new direction for the agency, and this included entering public education, increasing public awareness of the geology of the state, and maintaining contact with other State departments. The Park was extensively used by schools in the area, and programs were designed as such. By 1970, the Survey hired current Park manager Richard Krueger as geologist. Krueger ran the Park, relieving Quarrier to perform other Survey work. In 1971, the Parks and Forests division of the State took over all Park operations.

The 34th Biennial Report (1969-71) (Bulletin No. 104) outlined a cooperative agreement with the U.S. Geological Survey in which the Connecticut valley is chosen for an interdisciplinary study to develop new ways to present geoscience data to be used by planners, engineers, and the general public. The concept of the project must, with little doubt, have been influenced by the



Figure 7.--Joe Webb Peoples, Professor of Geology at Wesleyan University and seventh Director of the Connecticut Geological and Natural History Survey, shows colleagues the extent of the dinosaur footprint track-way near the town of Rocky Hill at the site that is now Dinosaur State Park. Tracks of the dinosaur *Eubrontes* appear in the foreground. (From left to right: Joe Webb Peoples, Lawrence Frankel of the University of Connecticut, Elwyn Simons of the Peabody Museum of Yale University, and Hugo F. Thomas of the University of Connecticut and current State Geologist.) (Photo by John Howard.)

summer conferences and the Geology-Soils Task Force. This project, directed by Frederick Pessl of the USGS, came under the heading of the Connecticut Valley Urban Area Project (CVUAP). Members of the Geology-Soils Task Force and CVUAP worked closely as a cooperative spirit existed between the various groups of geologists and hydrologists.

The project began developing and producing applied geologic quadrangle scale products for a one hundred quadrangle area of Connecticut and Massachusetts. Among the innovative products created by this project were individual maps at the scale of 1:125,000, showing textures of unconsolidated materials, thickness of fine-grained deposits, slopes, and ground-



water availability. A surficial materials map (a derivative from the glacial geological map), a depth to bedrock map and a standardized quadrangle drainage area map were produced for many 7.5-minute quadrangles in the project area.

### Economic Geology

As shown over the Connecticut Survey's 85-year existence, economics played an important role in many aspects of the scientific investigations. Loughlin reported on clays and clay industries in Bulletin No. 4 in 1905, a work still prized by one of the two remaining clay-mining operations in the state. Also, Gregory and Nelson reported on *The Granites of Connecticut*, while Fred Holmsley Moore, a graduate student at Yale, investigated *Marbles and Limestones of Connecticut*, which was published as Bulletin No. 56 in 1935.

Although Connecticut is not thought of as a mining state, it ranked number eight in the country in 1986 for dollar value of nonfuel mineral production per square mile. The State Survey has given attention to economic geology in quadrangle reports and GQs, which typically discuss or note mines or quarries of both historic and current interest, especially on surficial maps.

In some cases, papers on Connecticut economic geology published elsewhere have been outgrowths of work conducted for the Survey. For example, Crawford Fritts reported on the barite deposits that occur near the town of Cheshire within the Mount Carmel quadrangle, which he had mapped as part of the quadrangle mapping project.

As part of a strategic minerals investigation of the nation during World War II, State and Federal surveys investigated the occurrence of mica and beryl within some of the granitic pegmatites in Connecticut, particularly within the Middletown Pegmatite District. Connecticut investigations are

reported in USGS Professional Paper No. 255.

Today, the Connecticut Survey under the Natural Resources Center regularly cooperates with the U.S. Bureau of Mines (USBM) to prepare *The Mineral Industry of Connecticut*, which is published in the USBM Minerals Yearbook. Recently, as part of its Atlas Series, the Natural Resources Center published a map, *Bedrock Mines and Quarries of Connecticut*, which locates and identifies the more than 600 historic and active mines and quarries. The Center also keeps records of active operations and regularly responds to inquiries concerning the mining industry in the state.

The era of the scientists as Commissioners is brought to a close by another change for the State Survey. As part of a State agency reorganization, the Survey joined the newly formed Department of Environmental Protection (DEP).

### DEP AND THE NATURAL RESOURCES CENTER YEARS: 1971-PRESENT

During the 1960's, as a result of concern about the environment, a number of state governments reorganized their offices to more efficiently manage land, water, and air resources. Many states created departments of environmental conservation and environmental protection and the federal government formed the Environmental Protection Agency. The State Legislature passed the Act creating Connecticut's Department of Environmental Protection in 1971, and in 1972, the new department began setting up shop.

DEP absorbed about 15 different boards and commissions. The State Geological and Natural History Survey, which had been part of the former Department of Agriculture and Natural Resources, was included in the new DEP. Survey Director Peoples became an employee of the DEP, and the other

Commissioners of the Survey were asked to serve in an advisory capacity.

DEP's first Commissioner, Daniel Lufkin, was responsible for developing the new department and coordinating the many separate elements from which his agency was formed. He was particularly interested in the Geological and Natural History Survey's record of collecting and publishing natural science information. He and his staff recognized that geology, hydrology, and biology had a vital role in environmental management.

The State Survey had been involved in two projects that were significant at this point, the Connecticut Geology-Soils Task Force and the Connecticut Valley Urban Area Project (CVUAP). Both projects used resource information. The CVUAP developed new, more usable formats for geological and hydrological information, and the Geology-Soils Task Force developed the methodology to use resource information for environmental decision-making. The Task Force publication, *Use of Natural Resource Data in Land and Water Planning*, had provided new direction for methods of environmental management (fig. 8).

Commissioner Lufkin saw the value of, and need for, such resource information in his new Department. He arranged to have Hugo Thomas, a member of the Geology-Soils Task Force, develop a central office within DEP to coordinate collection, interpretation and publication of natural resources information. This central office, called the Natural Resources Center, started with a staff of several geologists and hydrologists.

The Natural Resources Center began to function as a repository and clearing house for information on earth sciences and biology. Early on, the Center's staff became involved in the DEP's environmental management activities, providing technical advice to the DEP and to local town governments.

The Survey provided much of the basic information for the thrust of the Natural Resources Center. Work in DEP soon became a focus of the Survey's activities. In 1974, the State Geological and Natural History Survey and the Natural Resources Center were officially merged. The State Survey office at Wesleyan was moved to the DEP offices in Hartford and Survey staff was transferred to the Natural Resources Center. The State Geological and Natural History Survey became the technical resources investigation arm of the Center. At this time, Dr. Peoples retired and Dr. Thomas, Director of the Center, became the State Geologist.

As the Natural Resources Center began to function, several goals were developed, and these included managing comprehensive basic data collection programs in earth sciences and biology; establishing a working reference library serving users of resource maps and information; developing methods of applying resource information to land- and water-use planning and environmental management decisions; and providing technical assistance to DEP and local governments in the use of resources information in their planning and decision-making.

The Natural Resources Center expanded its programs and staff to more uniformly address topics in geology, hydrology, and biology as well as to develop applied methodologies for use of resource data for planning and management. A major effort was made to centralize the management of USGS cooperative programs for topographic mapping, water resources, and geology. In the related area of soils mapping, the Legislature approved a 6-year appropriation for DEP to support completion of detailed soils mapping of the state by the U.S. Department of Agriculture, Soil Conservation Service. Among other things, this provided maps for the DEP's inland wetlands program. In biology, a program was initiated to

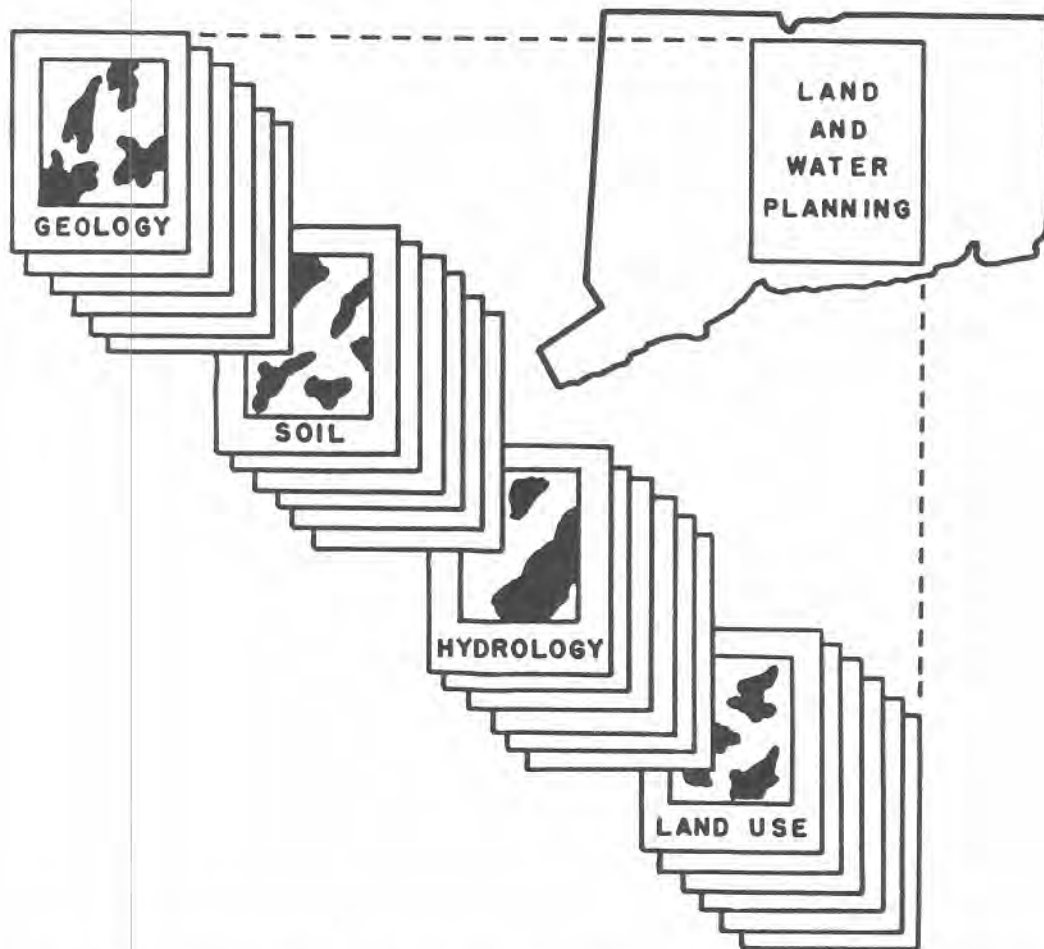


Figure 8.--Separately mapped resource parameters or "single factor maps" for land- and water-use analysis became a theme for the Natural Resources Center. Figure is from *Use of Natural Resources Data in Land and Water Planning* by Hill and Thomas, which was published in 1972 as Connecticut Agricultural Experiment Station Bulletin 733.

collect information on rare and endangered species. The state low-altitude air photo flights were conducted by the Center on a regular 5-year basis. An important step was to standardize map scales at 1:24,000, 1:50,000 and 1:125,000 for all types of mapped resource information.

Eventually, the Center added a sales office. This function formerly was carried out at the State Library. At this new sales office, anyone could buy maps and publications and get information and technical assistance about the

meaning and use of the resource information.

The Center began to provide technical assistance to regulatory and management units of DEP on topics such as water resources, waste disposal, ecological habitats, and earth materials. These units of DEP became increasingly aware of their need for trained technical staff. They rapidly began to hire technical staff, some of whom were initially trainees at the Center. DEP units began to use more natural resources information, and the demand for additional coverage and new

information mounted, driving forward the Center's data collection program. The Natural Resources Center quickly brought the value of resource information, concepts, and resource staff out of the academic institutions and into the forefront of the decision-making process of a state government department.

Through the late 1970's, environmental management in Connecticut passed from merely using resource information, to basing long-term environmental management on "resource system concepts." For example, DEP's water management programs changed from the previous method of simply using hydrologic information as one technical element of water management, to newly designed programs managing ground and surface water of each drainage basin. This more comprehensive and integrated approach to resource management was based on sound hydrologic principles and on understanding of the water resource system for each basin.

Interaction between the Center's staff and scientists and planners continued at the federal, state, and local levels. The emphasis was on interdisciplinary involvement. This was the theme of the Geology-Soils Task Force and CVUAP. The Natural Resources Center played a leadership role in coordinating the collection, dissemination, and use of the resource information.

The period since 1974, when the Geological and Natural History Survey was combined with the Natural Resources Center, has been especially productive. Programs of longstanding interest to the Survey have been pursued, and a number of new programs have been initiated. The following selection gives highlights for this period and gives an overview of the Survey's current program.

### Earth Sciences

Statewide low-altitude aerial photo surveys are conducted on a regular 5-year schedule, and an air photo lending library that contains all 5-year flights has been established.

The Natural Resources Center manages a USGS cooperative to produce revised 7.5-minute topographic quadrangle maps and to routinely update regional and state base maps. Recently acquired digital 1:24,000 scale quadrangle data will be used for a statewide geographic information system (GIS).

The Center also has been cooperating with the U.S. Department of Agriculture's Soil Conservation Service to complete detailed statewide soil mapping. A project has been initiated to rectify and digitize detailed soils maps for inclusion in the DEP's geographic information system (GIS).

In the field of geology, several projects continued during this period including management of the cooperative geologic mapping program with the USGS. This included the quadrangle mapping that started in the 1950's and completion of the compilations of the state bedrock and surficial maps. The state bedrock compilation by John Rodgers (fig. 9) was published in 1985 at a scale of 1:125,000. Both Rodgers' map and *The Face of Connecticut: People, Geology, and the Land*, a general introduction to the geology of the state by Michael Bell, were prepared for the 77th annual meeting (1985) of the American Association of State Geologists in Mystic, Connecticut. Compilation for the state bedrock and surficial maps has produced a complete set of 7.5-minute bedrock and surficial quadrangle sheets with consistent map units. This quadrangle scale geologic information is being entered in the GIS. In addition, a 10-year program to study the marine geology of Long Island Sound is under way.





**Figure 9.**--John Rodgers, Professor of Geology at Yale University and former Commissioner of the Survey, working on a draft of the state bedrock geological map of Connecticut. The published map was first presented to the geological community at the annual meeting of the American Association of State Geologists in 1985 at Mystic, Connecticut. (Photo by T. Charles Erikson.)

In the field of hydrology, a cooperative water resources investigation program with the USGS Water Resources Division continues. As a result, inventories of the state's surface and ground-water inventories have been completed. The Center continues to operate an integrated ground- and surface-water quality monitoring network. A statewide map showing stratified drift aquifers, compiled by Daniel Meade, was published in 1978. In addition, detailed mapping of drainage basins has been completed delineating basins with drainage areas greater than one square mile. This information has been published on a state map, and entered in the GIS. The data has allowed DEP to develop a statewide water quality classification and management system.

### Biology

A major part of the biology program is the Natural Diversity Data Base, a computer inventory of the occurrence and distribution of critical biological resources, including both species and habitats. The Data Base is used to guide biological protection programs and to evaluate potential negative impacts to biota during land-use change or development. Systematic mapping of critical habitat information is being prepared for the GIS. Bulletin No. 70, *Spiders of Connecticut* has been revised and reprinted.

### Geographic Information System (GIS)

A statewide computer mapping system for natural resources and related data is being completed. The interactive system will permit spatial analysis of

resource data bases. Data sets being compiled at 1:24,000 include: USGS quadrangle bases, surficial and bedrock geology, drainage basins, public water supply sources and distribution systems, waste water discharges and water pollution sources, soils, land use and land cover, zoning, open space lands and selected biological information. The DEP uses the GIS for environmental planning and management.

### **Publications and Outreach**

All in-print maps and other publications can be bought at the Center's sales office. This office serves as a resources center where the Center's staff is available to assist people in understanding and using the information. Regular educational workshops are run for local town officials to train them to use the information.

## **GEOLOGICAL AND NATURAL HISTORY SURVEY AND NATURAL RESOURCES CENTER**

### **85 Years of Natural Science Service to the State of Connecticut**

The Natural Resources Center serves as a central office for collecting and distributing information about the state's physical and biological resources. The Center also develops methods of using resource information for environmental management. These activities compare favorably with the three goals set out for the State Geological and Natural History Survey in the first Biennial Report (1904)--to advance knowledge for pure science; to serve economic needs, and to educate.

The data collection movement of Percival and Shepard (1835-42) has grown into something larger and more directly functional to the State than perhaps could have been imagined by the Survey founders. The State Geological and Natural History Survey of 1903 to 1974 became part of a natural

resources center for an environmental protection department.

In 1903, there was only one regular employee of the Survey--Superintendent Rice--who worked only part-time along with the voluntary Commissioners. Eighty-five years later, in 1988, the Natural Resources Center employs about 30 people in all fields of natural resources investigations and applications.

### **Acknowledgments**

A number of people and sources provided information and assistance during the preparation of this manuscript. Joe Webb Peoples took a particular interest in the project and provided much information about the Survey, its work with the local universities, and with the U.S. Geological Survey. An unpublished manuscript and notes on the Survey's history by E. L. Troxell was an invaluable resource. Sidney Quarrier provided direction, encouragement, and assistance throughout the project. Richard Hyde, Leslie Mehrhoff, Joe Webb Peoples, Sidney Quarrier, John Rodgers, and Hugo Thomas read the manuscript and provided helpful comments. Elizabeth Swaim provided access to information on William North Rice from the Wesleyan archives. Linda Rancourt worked with patience and skill to edit the manuscript.

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## DELAWARE

Delaware Geological Survey, University of Delaware, Newark, DE 19716.  
Phone 302-451-2833

### HISTORICAL SEQUENCE OF ORGANIZATIONAL NAME:

Geological and Mineralogical Survey, 1837-41  
Delaware Geological Survey, 1951-present

### NAMES AND TITLES OF ORGANIZATIONAL DIRECTORS AND DATES SERVED:

James C. Booth, State Geologist, 1837-41  
Johan J. Groot, State Geologist, 1951-69  
Robert R. Jordan, State Geologist, 1969-present

### DELAWARE GEOLOGICAL SURVEY

By Thomas E. Pickett

On February 18, 1837, the Delaware Legislature passed an act "to procure to make a geological and mineralogical survey of the State." Three commissioners, one from each county, were named to hire a geologist: Thomas Stockton, Jonathan Jenkins, and Dr. Henry F. Hall. The commissioners were also to spend some time in the field with the geologist. Stockton spent 40 days; Hall, 28; and Jenkins, 11. They were paid \$3 a day.

On June 1, 1837, they hired James Curtis Booth (1810-88), a Philadelphia chemist-mineralogist, as the Delaware State Geologist at a salary of \$1,200 a year. He was paid at this rate for 2 years. Booth was educated at the University of Pennsylvania, under Amos Eaton at Rennselaer and was probably the first American to study analytical chemistry in Germany. In addition to the requirements of the act of the Legislature, Booth agreed to give information on any useful discovery to the owner of the land and to collect and deposit with the commissioners specimens of all minerals he found. The

location of these samples is unknown today.

Booth started his field work in the summer of 1837. In the winter of 1837-38, he analyzed samples he had taken. He returned in the field season of 1838 with an auger capable of drilling up to 20 feet, which he used for greensand evaluation. He was assisted by John F. Frazer, his former co-investigator in the Pennsylvania Survey (1836). The field work was apparently concluded by the fall of 1838. Booth analyzed more samples, becoming more oriented toward geology for agricultural purposes as he realized that most of Delaware's mineral wealth was in the soil, suitable for crops.

In 1839-40, he wrote his Memoir of the Geological Survey of Delaware, including the Application of the Geological Observations to Agriculture, which he formally submitted to the Legislature on May 4, 1841.

In a letter with his report, Booth concluded that there was no formation of special value except some "excellent clay," which modern tests have confirmed; that there was a "moderate amount of iron ore" (mostly bog iron); and "that the 2,000 square miles of Delaware should be devoted to agriculture, because the whole state is peculiarly well adapted to it, and



because there is no other general object to which it is as well adapted." Booth saw his main purpose, during his field investigations, as "a traveling instructor in agriculture, without exhibiting the formality of teacher among the people to be taught."

Geologic formations delineated by Booth in his 1841 report were divided into (1) Primary (modern Piedmont crystalline rocks), (2) Upper Secondary (modern Cretaceous formations and lower Tertiary greensands), (3) Tertiary (modern Miocene), and (4) Recent (modern Quaternary). This was the first effort in describing Delaware's stratigraphy.

Booth's colleague, John Frazer, constructed a geologic map of Delaware to go with the survey based on "an old but excellent map of the state by Mr. Varley." However, Booth declined to publish the map, saying that the minute descriptions of the survey alleviated the need somewhat, and recommending that Maryland, Delaware, and Virginia cooperate in publishing a map of the Delmarva Peninsula, since the entire area contained similar geologic formations. The General Assembly also felt that the map would be too expensive to publish. The Commissioner's report on the survey to Charles Marin, Secretary of State, said that the "map that was to accompany the Memoir is still in the hands of Mr. Booth, but will be forwarded to you in a few days." A search by the author and others revealed no trace of this map, which could be very useful in locating some of Booth's outcrops that are now obscure. Perhaps it was never completed.

Of great value to the modern Delaware Geological Survey are his outcrop descriptions and analyses. Natural outcrops are rare in Delaware's Coastal Plain; therefore Booth's report is a useful guide to rediscovering long lost outcrops. This has had direct application to the Geologic Quadrangle Mapping Program. Other state surveys may find

it useful to study carefully the original surveys of their states.

In his Memoir, Booth revealed his great interest in promoting the use of greensand (glauconite) as a natural source of potash for fertilizer. He devoted many pages to this subject and to chemical analyses of Delaware greensands. The modern Delaware Geological Survey has had a grant from the United States Bureau of Mines to investigate the interesting ability of greensand to remove objectionable metallic ions from waste water. Delaware has one of the purest glauconite deposits in the United States.

The origin of the Delaware Piedmont crystalline rocks is today viewed as enigmatic. Booth reasoned that they are, at least in part, sedimentary in origin because of the sedimentary structures he observed in the weathered rocks. Booth's reasoning coincides more with the ideas of modern geologists than it does with the ideas of geologists of the intervening years between 1841 and now. Booth wrote:

... the value of the splendid Bay and Ocean Front, directly contributing food to man, of the best quality, in ample supply, and through all the time, only needing proper legislative influence to regulate it, for the welfare of the citizens of the State.

Thus, it seems that Booth was ahead of his time in calling for legislative regulation of Delaware's important coastal wetlands. Delaware was one of the first states to do this, long after Booth's time. The Delaware Coastal Zone Act was passed in 1971.

In 1986, the University of Delaware Library acquired a collection of over 3,000 items of Booth's family archives. This includes letters and field notebooks and provides documentation of the unique involvement in 19th century science by Booth. Booth was melter and refiner of the U.S. Mint in Philadelphia from 1849 until his death in 1888. In the 110 years from Booth's Memoir in 1841 until the establishment of the modern

Delaware Geological Survey in 1951, Delaware geology was largely overlooked because there was no Delaware State Survey, and the geologists of adjacent Maryland and New Jersey ventured into Delaware only occasionally. F. D. Chester, a faculty member at Delaware College (now University of Delaware) attempted to be named State Geologist in the mid-1880's but could not convince the General Assembly. Delaware geology was usually mentioned in passing or in connection with a special note about

fossils from the Chesapeake and Delaware Canal.

In 1951, Delaware passed legislation establishing the present Geological Survey as a unit of the University of Delaware. Johan J. Groot was installed as State Geologist. Upon his retirement in 1969 Robert R. Jordan was promoted from Assistant State Geologist to State Geologist.

The Delaware Geological Survey plans to publish its history from 1951-69 by Johan Groot.

## FLORIDA

Florida Geological Survey, Bureau of Geology, Florida Department of Natural Resources, 903 West Tennessee Street, Tallahassee, FL 32304-7795.  
Phone 904-488-4191.

### HISTORICAL SEQUENCE OF ORGANIZATIONAL NAME:

Office of State Engineer and Geologist, 1852-55  
State Geologist, 1886-87  
Florida Geological Survey, 1907-71  
Florida Bureau of Geology, 1971-83  
Florida Geological Survey, 1983-present

### NAMES AND TITLES OF ORGANIZATIONAL DIRECTORS AND DATES SERVED:

#### State Engineer and Geologist

Francis L. Dancy, 1852-55

#### State Geologists

John Kost, 1886-87  
E. H. Sellards, 1907-19  
Herman Gunter, 1919-58

Robert O. Vernon, 1958-71  
Charles W. Hendry, Jr., 1971-88  
Walter Schmidt, 1988-present

### HISTORY OF THE FLORIDA GEOLOGICAL SURVEY

The origin of the Florida Geological Survey can be traced to the year 1852, when the office of State Engineer and Geologist was authorized by the legislature. "General" Francis L. Dancy, a former militia officer and mayor of St. Augustine, was chosen to head this office. Although Dancy did not have geological training, his extensive experience in engineering was useful to his office's responsibility to drain lowlands for agricultural development. In November 1855, Dancy requested \$500 to do soil tests in various parts of the state, whereupon the legislature abolished his post.

The discovery in the 1880's of commercially valuable phosphate deposits in Florida prompted Governor E. A. Perry to appoint Dr. John Kost, a medical doctor and amateur geologist, as State Geologist in 1886. Dr. Kost completed studies of phosphate and

other minerals in 1887. Dr. Kost's request to the legislature to extend his tenure and duties met the same fate as his predecessor's.

In 1907 enabling legislation was passed creating an autonomous, permanent Florida Geological Survey, and an office of State Geologist, with four support staff positions. The new Survey was given latitude to formulate its own choice of studies and research.

A reorganization of state government in 1933 placed the Florida Geological Survey under the newly-formed State Board of Conservation. The Survey remained essentially autonomous. State government was reorganized again in 1971. The Florida Geological Survey was placed in the Department of Natural Resources and its name changed to the Bureau of Geology. In 1983 the legislature reestablished the name of Florida Geological Survey, leaving unchanged its position in the department's hierarchy. Significantly during fiscal

year 1986-87 the Florida Geological Survey celebrated its 78th year of service to the state. It is the oldest state agency functioning under both its original establishing legislative statute and its original title.

### STATE GEOLOGISTS

#### E. H. Sellards: 1907-19

Since passage of the 1907 law, there have been five state geologists. The first was Dr. Elias Sellards, who for 2 years was Assistant Paleontologist with the Kansas Geological Survey. He received his B.A. and M.A. degrees from the University of Kansas and his Ph.D. from Yale University. He taught geology and mineralogy at Rutgers University and, in 1904, became an instructor at the University of Florida.



Elias H. Sellards (1907-19)

While at the University of Florida, Sellards devoted a considerable amount of time to the study of Florida's underground water resources, a subject of special concern to the state's

agricultural interests. Water resources studies subsequently became a primary focus of the early work done by the survey staff. These early investigations, which included the underground water supply of central Florida and a survey of road materials, were directed toward serving Florida's economic needs. In later years, the emphasis became more academic and expanded to include paleontology and general Florida geology.

Under Sellards' guidance, the Geological Survey continued as a permanent part of state government. After Sellards' resignation in April of 1919, he joined the Bureau of Economic Geology of the State of Texas. His former student and staff assistant, Herman Gunter, assumed the position of State Geologist.

#### Herman Gunter: 1919-58

Herman Gunter's association with the Florida Geological Survey spanned almost 52 years--a length of service unmatched by any other Florida State Geologist. Gunter graduated from the University of Florida with a B.S. degree in 1907 and in that same year joined the Survey staff. His advancement to director in 1919 ensured that the position was staffed by someone well versed in Florida geology.

As the Geological Survey's second director, he changed the survey's emphasis somewhat by making its reports more diverse and less academic in outlook and by more closely relating the Geological Survey's work to the needs of state government. In his role as administrator, Gunter encouraged cooperation with the state's public schools and enlarged the Geological Survey's museum and library. Gunter acted on the belief that a primary purpose of the Florida Geological Survey was to serve as a highly accessible source of information on Florida geology.

Under Gunter's direction, the Florida Geological Survey initiated a





Herman Gunter (1919-58)

conservation campaign aimed at exposing the gross damage being done to the state's underground and surface water supplies by careless drilling practices and misuse of water. His interest in the preservation of the water resources of Florida also propelled him to the forefront as an opponent of the Cross Florida Barge Canal (originally conceived as a sea level ship canal across Florida).

Gunter also began work on the investigation of Florida's mineral resources. He sought and obtained funding for a cooperative venture with the U.S. Geological Survey to complete topographic mapping of the state.

It was also largely through his efforts that the legislature authorized and funded the construction of a geologic center comprised of the Florida State University's Department of Geology and the Florida Geological Survey. The proximity of these entities, which are housed next to each other on the campus of Florida State University, has provided for a cooperative use of scientific

equipment and library facilities and has encouraged an open and stimulating exchange of ideas between the university and the survey over the years. This relationship has enhanced opportunities for student employment at the Florida Geological Survey and has benefited the survey staff by supplying skilled, knowledgeable graduate students to assist in areas involving practical geological research.

Gunter's contributions to geologic research were formally recognized by the University of Florida in 1944, when he was awarded an honorary Doctorate of Science. His accomplishments laid a firm foundation for the future. In recognition of his service, the Florida Geological Survey building on the campus of Florida State University was named the Gunter Building.

#### **Robert O. Vernon: 1958-71**

Herman Gunter's successor was Robert O. Vernon, who joined the survey as an Assistant State Geologist in 1941. Vernon received his B.S. from Birmingham Southern College, his M.S. from the University of Iowa, and his Ph.D. from Louisiana State University.

Emphasizing geologic research, Vernon conducted or participated in a large number of investigations concerning Florida geology. Part of his research emphasis resulted in the expansion of the cooperative program in water resource investigations between the Florida Geological Survey and the U.S. Geological Survey.

Recognizing the need for conservation of Florida's limited water resources, much of his time was spent informing the public about Florida geology and hydrology through numerous publications, public forums, and presentations to schools and civic organizations. The Florida statutes relating to conservation of water resources are principally the direct result of Vernon's efforts.



**Robert O. Vernon (1958-71)**

In November 1971, Vernon resigned as State Geologist and accepted the position of Director of the Division of Interior Resources in the Department of Natural Resources. Robert Vernon is remembered as a dedicated professional who devoted many years of effort to Florida geology.

**Charles W. Hendry, Jr.: 1971-88**

Upon Vernon's resignation in 1971, Charles W. "Bud" Hendry, Jr., assumed the post of State Geologist. An employee of the Florida Geological Survey since 1949, Hendry held a number of positions including draftsman, stratigrapher, director of water resources investigations, and Assistant State Geologist. In addition to earning his B.S. from Florida State University, Hendry had the distinction of receiving the first M.S. degree in geology awarded by the Florida State University.

Under Hendry's direction the Oil and Gas Section significantly upgraded Florida's oil and gas regulations,



**Charles W. Hendry, Jr. (1971-88)**

providing better protection for the environment and conserving oil reserves. Seeing a state-wide need for geologic data to assist planners, Hendry had an environmental geology map series completed.

**Walter Schmidt: 1988-Present**

In 1985 Walter Schmidt was appointed Chief of the Florida Geological Survey and assumed the post of State Geologist in March 1988, upon Hendry's retirement. Schmidt did his undergraduate work at Florida Institute of Technology and the University of South Florida. His masters and doctoral work were carried out at Florida State University, with his doctoral dissertation specifically dealing with Florida Neogene stratigraphy.

One of his first acts as Chief of the Florida Geological Survey was to create a Mineral Resources and Environmental Geology Section. This program is designed to provide interpreted geologic data to the planning community as Florida's population continues to grow.



Walter Schmidt (1988-present)

As a supplement to maintaining the basic geologic repositories, one goal is to computerize all data and to upgrade the Survey's computer capabilities, providing better data management and graphic displays.

The State's oil and gas rules have been extensively rewritten, responding to Florida law changes, the constant technological changes in industry, and the environmental awareness of Florida's citizens.

### FLORIDA GEOLOGICAL SURVEY PROGRAMS

Ranking first in the nation in the production of phosphate rock and titanium concentrates, second in fuller's earth, crushed stone, and peat, as well as nineteenth in oil production in 1985, Florida's natural resources contribute about \$2 billion annually to the state's economy.

The Florida Geological Survey has had, since its inception, two basic objectives. The first is to collect, interpret, report on, store and maintain

geologic data. These data are used by governmental agencies, industry, and the public, and contributes to the responsible use and understanding of Florida's natural resources including groundwater. The second objective is to conserve Florida's oil and gas resources and minimize environmental impacts during exploration and production. The Survey has responded to these needs by establishing three sections: the Geological Investigations Section, the Mineral Resources and Environmental Geology Section, and the Oil and Gas Section.

The Survey maintains a geologic core and well cuttings depository of over 16,000 wells. It also operates a trailer-mounted auger rig and a full-time core drilling rig to acquire geological samples for projects. A depository of geophysical wire line logs contains over 4,800 logs from throughout the state.

The Survey's geologic data base is further strengthened by its paleontological invertebrate fossil depository, containing over 20,000 specimens of macrofossils and over 10,000 microfossil specimens. The collections of Florida typical and/or guide fossils consist of mollusks, echinoids, ostracodes, foraminifers, bryozoans, corals, nannofossils, and diatoms.

An integral part of the Survey's research capabilities is its library, with its special collections of geological, industrial mineral, and petroleum industry publications. Its holdings include over 15,000 maps and aerial photographs, 11,000 government documents, 2,300 technical books, and lengthy runs of 35 scientific periodicals. It has access to GEOREF, a national computer-based information retrieval system, which significantly increases its value for research.

#### Geological Investigations Section

The Geological Investigations Section carries out primary applied

geological research throughout the state. Current projects include revising the geologic map of Florida, county hydrogeologic reports, a summary of the state's economic minerals, and a study of the phosphate-bearing, Miocene age Hawthorn Group sediments.

This section also acts as a technical consultant for other governmental agencies regarding aquifer contamination and recharge, geologic hazards, minerals mapping, and community development and planning. Wells and cores on file are worked and analyzed with the information being added to the Survey's computer-coded data base, currently containing nearly 5,000 well logs. These data and associated computer programs are used by other governmental agencies and private firms.

#### **Mineral Resources and Environmental Geology Section**

This group maintains contact with the mineral industry in Florida and publishes biannual status reports. The state legislature recently required all counties to prepare comprehensive growth plans. This section is assisting the counties with the identification of

their mineral resources by preparing mineral resource reports. These reports contain geologic data which are needed to make sound planning decisions. In addition, environmental geology reports are being prepared for several metropolitan areas. These studies will provide a document for land-use planners which will focus on the physical environment, and mineral and groundwater resources.

#### **Oil and Gas Section**

This section regulates exploration and production of oil and gas in Florida through a system of permits and inspections. The section's main office is located in Tallahassee, with two field offices located near the producing fields at opposite ends of the state. One field office is in Jay, in the western panhandle, and the other is in Ft. Myers, in southwest peninsular Florida. Oil and Gas permits regulated by the section include: applications to drill oil, gas, or water injection wells; workover notifications; plugging and abandonment of wells; authorization to transport oil or gas from lease; and applications to conduct geophysical seismic operations.



## GEORGIA

Georgia Geologic Survey, Branch of Environmental Protection Division, Georgia Department of Natural Resources, Room 400, 19 Martin Luther King, Jr., Dr., S.W., Atlanta, GA 30334. Phone 404-656-3214.

### HISTORICAL SEQUENCE OF ORGANIZATIONAL NAME:

Geological Survey of Georgia, 1836-40  
 Geological, Mineralogical and Physical Survey, 1876-79  
 Geological Survey, 1890-1932  
 Georgia Geological Survey, Department of Forestry and Geological Development, 1932-37  
 Division of Mines, Mining and Geology, Department of Natural Resources, 1937-43  
 Department of Mines, Mining, and Geology, State Division of Conservation, 1943-72  
 Department of Natural Resources, Earth and Water Division, Geological Section, 1972-78  
 Georgia Geologic Survey, Branch of Environmental Protection Division, Department of Natural Resources, 1978-present

### NAMES AND TITLES OF ORGANIZATIONAL DIRECTORS AND DATES SERVED:

John R. Cotting, State Geologist, 1836-40	A. S. Furcron, Director, 1964-69
George Little, State Geologist, 1874-79	Jesse H. Auvil, Jr., Director, 1969-72
J. W. W. Spencer, State Geologist, 1890-93	Sam M. Pickering, Jr., Director and State Geologist, 1972-78
W. S. Yeates, State Geologist, 1893-1908	William H. McLemore, Director and Chief of Geologic Survey Branch, 1979-present
S. W. McCallie, State Geologist, 1908-33	
Richard W. Smith, Director, 1933-38	
Garland Peyton, Director, 1938-64	

### HISTORY OF THE GEORGIA GEOLOGIC SURVEY

#### INTRODUCTION

The history of the Georgia Geologic Survey begins in 1836 with the appointment of John R. Cotting as State Geologist. Cotting's mission was to make a geological survey of the entire state. Since then, there have been three geological surveys as follows: 1836-40, 1874-84, and 1889-present. These were headed by eleven State Geologists: J. R. Cotting (1836-40), George Little (1874-81), J. W. W. Spencer (1890-93), W. S. Yeates (1893-1908), S. W. McCallie (1908-33), R. W. Smith (1933-38), Garland Peyton (1938-64), A. S.

Furcron (1964-69), J. H. Auvil, Jr. (1969-72), S. M. Pickering, Jr. (1972-78), and W. H. McLemore (1979-present).

#### THE FIRST GEOLOGICAL SURVEY\*

The citizens of Burke and Richmond County engaged Dr. John R. Cotting to make a geological and agricultural investigation of their section of the state in the summer of 1836. This work, which was published as a 189-page volume, dated 1836, aroused the attention of Governor William Schley, who had seen the report and was favorably impressed. He recommended to the General Assembly that a

\*After Furcron, 1965.

geological survey of the entire state be made. A committee appointed by the Legislature recommended that the Governor be authorized to employ, as soon as possible, qualified persons to undertake this type of work for the state and that the sum of \$10,000 be appropriated for the purpose.

Upon favorable action by the General Assembly, the Governor appointed Dr. John R. Cotting as State Geologist. Dr. Cotting submitted his first annual report to the General Assembly in 1837. This report was favorably received by the Mining Committee, which noted the discovery of valuable deposits of marl, graphite, and other minerals, and that the magnetic variations were determined at 20 different points in the state. The committee recommended that the report be published. However, delays connected with some difficulties between Dr. Cotting and the State Printer prevented its publication by the date expected. In fact, there is no record that the report was ever published.

Dr. Cotting's writings seem to indicate that he believed the geology of the state could be determined by a crash program. But in that short time, of course, Dr. Cotting did not even make a reconnaissance of the entire state. For example, there is no mention made of gold although the Dahlonega gold rush was on, and the value of the reported gold production for that period was second only to that of agricultural production in the state. In 1838 a resolution was introduced to the House to abolish the Cotting survey, but the Senate did not concur. The resolution was again introduced in 1840, and geological work was abolished in November 1840. Had Survey geologists been available to advise and assist in exploration in the gold district during

this time, the Survey probably could have been practical and useful.

### THE SECOND GEOLOGICAL SURVEY\*

Through the efforts of Governor James M. Smith, an annual appropriation of \$10,000 was authorized by the General Assembly and was approved in February 1874 for the establishment of a 5-year "Geological, Mineralogical and Physical Survey" of the state. In August 1874, Governor Smith appointed Dr. George Little as State Geologist. As State Geologist, Dr. Little was provided seven assistants. After taking office, Little initiated a study of gold, marble, magnetite, and talc; iron and manganese ores near Cartersville; and copper deposits in Cherokee County. However, during the 1870's, the major interest of the Survey was gold. In fact, one staff geologist lost his life in an excavation that was being made for gold.

Dr. Little set up a collection of minerals in the State Capitol as his survey progressed. This collection attracted a great deal of notice and surprise, indicating the large variety of minerals present in the state. He took an active interest in advertising the state's minerals by setting up exhibits at the famous 1880 Cotton Exposition. A later exhibit, which he set up for the Georgia-Pacific Railroad, received so much interest that several years later he prepared one for the Paris Exposition.

In 1879 the new Geological Survey was again approved by the Legislature and Little was reelected State Geologist, but the necessary appropriation bill was not passed. However, he remained in office without staff 2 years longer, supporting himself by consulting work and by doing some work for the United

\*After Furcron, 1965.

States Government. Although Little's work and efforts were outstanding, apparently the Survey was considered as a crash program from the very beginning instead of a continuing program of development.

Dr. Little found very little time for writing in his busy life. His most important publication was written at the special request of Governor Smith, who wished to include it in a volume to be prepared by Dr. Thomas P. Janes, Commissioner of Agriculture. Little states, "I went home and shut myself in my room for a week and wrote a report covering 130 pages." This report may be found in the *Handbook of the State of Georgia*, accompanied by a geological map of the state, published by the Commissioner of Agriculture, Atlanta Georgia, 1876. As far as is known, this is the first comprehensive attempt to publish the geology of Georgia.

### THIRD GEOLOGICAL SURVEY\*

#### J. W. W. Spencer

On November 23, 1889, a bill was passed by the General Assembly "to revive the office of State Geologist, and to provide for a geological, mineralogical and physical survey of the State of Georgia, etc." The Governor was authorized to "appoint a competent person to this office who possessed a thorough, scientific and practical knowledge of geology and mineralogy and who was not connected with any school or college as an instructor."

Under the provisions of the Act, Governor J. B. Gordon appointed Dr. Joseph W. W. Spencer, who began his duties July 1, 1890, and served as State Geologist of Georgia from 1890 to 1893.

Although gold mining was a very prominent industry in Georgia at this time, Spencer spent most of his time on the limestones, shales, and sandstones

of northwest Georgia, for which there was little commercial use. He acknowledged the work of C. W. Hayes of the U.S. Geological Survey, but extended that work and prepared the first geological map of the northwest section of the state. His map, accompanied by an extensive text on Paleozoic rocks, represents, in fact, the first Survey bulletin on Georgia geology. It was published in 1893 under the title *The Paleozoic Group, the Geology of 10 Counties of Northwest Georgia*. Although Spencer was exceedingly well trained, he was not able to effectively convert his knowledge of science and research into service. It has been reported that probably there were not ten men in the entire state at that time who could have comprehended his book. (Note: By the 1980's, virtually any educated lay person in Georgia would have little difficulty in reading and understanding the book.) In 1893, Governor Northern found it necessary to appoint Professor W. S. Yeates as State Geologist.

#### W. S. Yeates

William S. Yeates was appointed State Geologist of Georgia in 1893. Mr. Yeates found little equipment at the Survey when he began his administration. He lists a poor microscope and one Smith Premier typewriter. There were only 215 books and pamphlets in the Survey library at the time. Field equipment consisted of five horses, three covered wagons, one long-bedded buggy, three sets of harness, two tents, chairs and cooking utensils. The technical field equipment consisted of a plane table and alidade, compasses, barometers, etc.

Yeates was interested in both ground and surface water and initiated cooperative projects with the U.S. Geological Survey near the beginning of

\*Spencer through Peyton administrations are after Furcron, 1965.

his administration. The interest which Mr. Yeates had in the earth sciences, with his practical ability to apply geologic work to the needs of the state, made him, from the beginning, a successful State Geologist. He dedicated his work to an inventory of the minerals of the state, was an enthusiastic collector and assembled in the State Capitol a mineral museum which earned an outstanding reputation throughout the country. In field studies, he began immediate investigations of gold, marble, and corundum, all of which obviously needed geologic assistance in their development. Much of his personal time was spent in the study of gold deposits, and the results of much of that work were published under the title *Gold Deposits of Georgia*. In addition to this bulletin, his Assistant Geologists published reports and bulletins on a number of economic commodities. Naturally, these reports represent only a small part of the services of the Geological Survey during that period. Unfortunately, records of the numerous requests answered by letter, consultations, and visits for assistance in mineral development, all of which consume so much of the time of the State Survey, are lost in obscurity. Mr. Yeates was faced with the problem of attempting to work in an economically disadvantaged state about which little was known from a geological point of view. In this regard, Yeates directed many of the Survey's efforts at (1) locating and documenting economic minerals, occurrences, and (2) displaying the minerals at national expositions so that "northern" investors would come into Georgia and invest capital in mines.

#### S. W. McCallie

Following the death of Professor Yeates on February 18, 1908, Professor Samuel W. McCallie was appointed State Geologist and Director of the Survey. After coming to the Georgia

Geological Survey in 1893, he published a number of important publications under the supervision of Yeates. He also published a number of bulletins after he was appointed Director. In many ways he followed the general plan of the Survey previously established by Yeates, that is, the system of completely covering the state as far as possible for each commercial mineral, one at a time. By this method, whoever wished to mine a mineral commodity could take the report of that specific mineral, and with the assistance of the State Geologist, attempt to locate and establish a new mining industry. This system obviously was modified by public demand. In some cases a commercial mineral would be industrially replaced by some other mineral or artificial product; thus, no succeeding or follow-up report was made. On the other hand, minerals such as clays, which were steadily becoming more important, were periodically reexamined, calling for later and more modern reports.

Also by this time, the urban population of Georgia began to require considerable surface and ground water for municipal water supplies. From the beginning, McCallie recognized that water and knowledge of water resources were among the most important factors for the development of industry and for the preservation of health and economic standing of the state.

Mr. McCallie stands out among other State Geologists of this country in having accomplished much with very little. There were times when he did not know whether or not he would have a budget sufficient to operate a Survey, and there were unpredictable events that often made it difficult for the Survey to continue. Mr. McCallie died on October 26, 1933.

#### R. W. Smith

Richard W. Smith was State Geologist from 1933 to 1938. His tenure of office was during the depths of the



depression and his budgets were small. There was renewed interest in gold during this period. The Survey staff was small and devoted most of its time to consulting with miners throughout various parts of the state. Mr. Smith's principal work for the Survey was the State Geologic Map (1:500,000), published in 1939 but prepared under his direction.

#### **Garland Peyton**

Garland Peyton (a.k.a. Captain Peyton) was appointed Director of the Georgia Geological Survey by Governor E. D. Rivers in February 1938. About that time, the State Geological Survey was reorganized under Governor Rivers and became the Division of Mines, Mining and Geology of the Department of Natural Resources. During Peyton's administration, which covered 26 years, 29 major bulletins on important mineral resources and contributions to water and geology were published. The first detailed geological map of the State of Georgia was published in 1939; many information circulars on a great variety of topics important to the economic development of the state also were published during his administration.

During Peyton's term of office, active field and laboratory research was continued or inaugurated on a wide variety of minerals. The Survey was especially active during the Second World War in investigating the strategic mica deposits in the state. Much attention was given at this time to the possibilities of petroleum and natural gas, particularly in the Coastal Plain. An Oil and Gas Law was passed, and rules and regulations were established for its administration. This enabled Survey geologists to do subsurface work on stratigraphy and structure, because once the Oil and Gas Law was passed, the Survey had access

to well cuttings and cores obtained by private oil and gas exploratory drilling. Special reports including the Georgia Mineral Newsletter were published, depending upon the demand for minerals. These reports also were written to develop a demand for minerals not yet commercially utilized.

#### **A. S. Furcron**

Dr. Aurelius S. Furcron served as Director of the Department of Mines, Mining and Geology, following the death of Garland Peyton in 1964 until his retirement in 1969. During this time the Survey shifted emphasis from studies of specific mineral commodities to detailed geologic studies of selected areas, particularly in the Blue Ridge and Piedmont provinces, as well as regional summaries. The continuing program of geologic and hydrologic studies, in cooperation with the U.S. Geological Survey, led to the publication of information circulars on the geology and/or hydrology of selected areas of north and south Georgia. Also, in cooperation with Georgia Institute of Technology, a series of reports was published as part of the "South Georgia Mineral Program" investigations on phosphate, clay, heavy minerals, and sand deposits of this region. This phase of the Survey history culminated in the publication of the first comprehensive mineral resource map of the state (1:500,000) as well as several generalized maps of the state's geology and mineral resources.

Perhaps Dr. Furcron's greatest contribution to the State of Georgia was his recognition of the critical need for detailed topographic mapping. Many days were spent trying to convince the General Assembly to adequately fund the Cooperative Mapping Program with the U.S. Geological Survey. During the final few months of Dr. Furcron's administration, this need for complete

topographic map coverage became apparent to the Governor and the General Assembly, and funding for cooperative topographic mapping accelerated.

#### **J. H. Auvil, Jr.**

Following the retirement of Furcron in 1969, Jess H. Auvil, Jr., was appointed Director of the Department of Mines, Mining and Geology, where he served until his resignation in 1972. During Mr. Auvil's administration, emphasis continued on regional studies and bibliographies. Information circulars were published on a wide range of topics including geochemical and geophysical studies of selected areas in the Piedmont, regional summaries and compilations, as well as geology and ground-water studies in cooperation with the U.S. Geological Survey. A new series of geologic reports, written for the general public, began with publication of pamphlets on ground water and oil seeps. A map of kaolin and fuller's earth mines and plants in the state also was published. Cooperative geohydrologic investigations with the U.S. Geological Survey, Water Resources Division, continued as well as cooperative funding with the USGS Topographic Division for the production of new and updated maps (primarily at 1:24,000).

#### **S. M. Pickering, Jr.**

In 1972 a major reorganization of state government was instituted under Governor Jimmy Carter. The Department of Mines, Mining and Geology was renamed the Earth and Water Division (subsequently renamed the Geologic and Water Resources Division in 1976) and placed under the newly created Department of Natural Resources. Samuel M. Pickering, Jr., was appointed Division Director and State Geologist where he remained until his

resignation in 1978. During the Pickering administration, published bulletins were predominantly compilations and summaries on various statewide subjects such as a gravity base, an annotated bibliography, abstracts of theses, and minerals of Georgia. Other, more focused subjects were also treated such as ultramafic rocks in north Georgia, petroleum geology of the Coastal Plain, and water supplies in northwest Georgia. Information circulars were also printed on various ground-water and/or geohydrologic studies in the state, as well as on Coastal Plain paleontology and on industrial minerals. Several new series of publications oriented to the general public were initiated. These include an Educational Series Atlas, Geologic Guide pamphlets, Hydrologic Atlases and Hydrologic Reports. A variety of maps and satellite imagery characterize a substantial portion of the products of the Pickering administration. Two milestones that are particularly noteworthy are the publication of a new state geologic map (1:500,000) and the completion of 7.5-minute (1:24,000) scale topographic mapping for the entire state under the State-U.S. Geological Survey cooperative program. The latter led to the development of related derivative maps including a topographic map of the Greater Atlanta region (1:100,000), selected slope and orthophoto maps of this area (1:24,000), and a slope map of the entire state (1:500,000). Other maps developed or sponsored by the Survey include small-scale gravity, geologic, and physiographic maps of the state (1:2,000,000), and a detailed geologic map of a two-county portion of the Piedmont province. The Survey also participated in the preparation of the U.S. Geological Survey's Landsat satellite imagery mosaic of Georgia (1:500,000) and the Georgia portion of the American

Association of Petroleum Geologists geological highway map.

**W. H. McLemore**

In 1978, the Survey acquired its present name, Georgia Geologic Survey, and was redesignated as a Branch of the Environmental Protection Division within the Georgia Department of Natural Resources. Mr. John George was appointed Acting Branch Chief (on "loan" from the U.S. Geological Survey,

Water Resources Division) in 1978, pending the appointment of a permanent State Geologist. During this transitional period a bulletin of collected articles on various aspects of Georgia geology was published. In April 1979, Dr. William H. McLemore was appointed State Geologist and Chief of the Geologic Survey Branch and has continued in that position to the present.

## HAWAII

Division of Water and Land Development, Department of Land and Natural Resources, P.O. Box 373, Honolulu, HI 96809. Phone 808-548-7533

### HISTORICAL SEQUENCE OF ORGANIZATIONAL NAME:

Hawaii Irrigation Authority, 1953-57  
 Hawaii Water Authority, 1957-60  
 Division of Water and Land Development, 1960-present

### NAMES AND TITLES OF ORGANIZATIONAL DIRECTORS AND DATES SERVED:

L. H. Herscheler, 1953-60  
 Robert C. Chuck, 1960-84  
 Manabu Tagomori, 1984-present

### HAWAII'S DIVISION OF WATER AND LAND DEVELOPMENT

Manabu Tagomori  
 Manager - Chief Engineer

The Division of Water and Land Development of the Department of Land and Natural Resources administers the State's programs in water resources management, mineral resources assessment, flood prevention and control, water development, and agricultural irrigation systems operation. The Division also serves as the technical arm of the Department, providing engineering services to other divisions.

**State Water Code.** With the passage of a new State Water Code by the 1987 Legislature, the Division programs will be affected as follows:

1. Basic data collection activities will be expanded, particularly in the gathering of both surface water use and ground water use data statewide.
2. Water resources planning activities will be broadened to include the development and implementation of a Hawaii Water Plan under a State Commission on Water Resource Management.

3. Regulatory activities will encompass not only ground water use, but also surface water use. Water uses will initially have to be certified and then continuously monitored and reported.
4. Existing windward Oahu instream use regulatory activities will extend to all streams in the State. All of the provisions of the Hawaii Instream Use Protection Act of 1982 have been included in the new State Water Code, enabling the Department to establish interim and final instream flow standards for streams to regulate stream channel alterations, and to expand the collections of instream use data throughout the State.

**Water Resources Management Program.** On-going activities include the collection of hydrological and climatological data, appraisal of surface and ground water resources, preparation of long-range plans, regulation of the use and development of ground water in designated areas, regulation of instream uses of water, and administration of the Soil and Water Conservation District program.



### **Mineral Resources Program.**

Activities include assessing geothermal resource areas, designating geothermal resource subzones, regulating geothermal well drilling, mapping geologic features, and canvassing mineral production data in cooperation with the U.S. Bureau of Mines.

**Flood Prevention and Control Program.** Activities of the flood prevention and control program include managing the use of flood plains, coordinating local government activities relating to flood prevention and control, and administering dam safety inspection and stream maintenance programs.

### **Water Development Program.**

Activities include exploratory well drilling and testing, installation of pumps, and construction of water tanks, pipelines and other water facilities.

### **Irrigation Services Program.**

Activities include the management of three irrigation systems on the islands of Oahu, Molokai, and Hawaii which serve 974, 4,410, and 487 acres, respectively, of diversified agricultural crops.

## **HISTORY OF THE DIVISION OF WATER AND LAND DEVELOPMENT**

The Division of Water and Land Development of the Department of Land and Natural Resources was established in 1953 as the Hawaii Irrigation Authority. Its duties and functions were to determine feasibility of and to design and operate irrigation systems in the Territory of Hawaii. The agency's program was broadened in 1957 to include a territory-wide water resources survey and a master plan for water development. In keeping with the enlarged scope of responsibilities, the name was changed to the Hawaii Water Authority.

When Hawaii became the Fiftieth State in 1959, the duties and functions of the Authority passed to the

Department of Land and Natural Resources under the provisions of the Reorganization Act of the First State Legislature of Hawaii. The name of the Hawaii Water Authority was changed to the Division of Water and Land Development on November 5, 1960. At that time, the Division's program was modified to include the responsibilities of land and mineral development, as well as the Authority's existing program of water resource studies and development. With the passage of the State Water Code in 1987, the Division was assigned the responsibility of administering the Code under the Commission on Water Resource Management newly-formed within the Department of Land and Natural Resources.

Mr. L. H. Herscheler was manager-chief engineer from 1953 to 1960. He was succeeded by Mr. Robert T. Chuck who served from 1960 to December 1984. Upon Mr. Chuck's retirement, Mr. Manabu Tagomori became manager-chief engineer of the Division.

## **PROGRAMS OF THE DIVISION OF WATER AND LAND DEVELOPMENT**

The Division of Water and Land Development administers the State's programs in water resources management, mineral resources assessment, flood prevention and control, water development, and irrigation services. The Division also provides engineering services to other divisions of the Department of Land and Natural Resources.

### **WATER RESOURCES MANAGEMENT PROGRAM**

Activities in water resources management include the collection of climatological and hydrological data, appraisal of surface and ground water resources, preparation of long-range plans, regulation of water development and use, protection of instream uses of

water, and administration of the Soil and Water Conservation District program.

### **Basic Data Collection and Resource Assessment**

The collection and dissemination of climate-related data--including rainfall, temperature, evaporation, wind, humidity, and solar radiation--is a primary activity.

There is a cooperative program with the U.S. Geological Survey (USGS) to collect surface and ground water data. The program provides basic data on streamflow, ground water withdrawals, and water quality. It also includes appraisals of the State's water resources to assess their characteristics and availability. Streamflow data are collected regularly from 85 measuring stations; low flows are measured periodically on eight stream; flood discharges are obtained from 106 crest-stage gages; water levels, specific conductance, and chloride concentrations of ground water are measured at about 191 wells; and field measurements of specific conductance, temperature and pH of stream water are made at scheduled intervals. Data collected are published in the annual USGS report series, *Water Resources Data for Hawaii and Other Pacific Areas - Volume 1, Hawaii*.

With the passage of a new State Water Code by the 1987 Legislature, the Division's basic data collection activities will have to be expanded, particularly in the gathering of both surface water use and ground water use data statewide.

### **Water Resources Planning**

The Division's water resources planning activities includes the review and revision of the State Water Resources Development Functional Plan, a critical link between the broad goals and objectives of the Hawaii State Plan and the specific water-related

programs and projects carried out by the Department.

The review and revision process is a major undertaking intended to update functional plans to take into account current conditions and trends, new policy directions, and new areas of emphasis. The process includes public reviews of the plans and will culminate in the submission of the revised plans to the Governor for his approval.

With the passage of the new State Water Code by the 1987 Legislature (Act 45), water resources planning activities in the Division will be broadened to include the coordination and development of a Hawaii Water Plan under the Commission on Water Resource Management within the Department. Parts of the water Plan will be developed by the State Department of Health, other affected State agencies, and each County.

### **Regulation of Water Development and Use**

Regulatory activities involve the processing of applications for development and use of ground water in the designated Pearl Harbor, Honolulu, and Waialua Ground Water Control Areas on Oahu. As applications for permits are received, they are recorded, reviewed in the field and office by technical personnel, and then forwarded to the Board of Land and Natural Resources for action.

The heavily drafted Pearl Harbor Ground Water Control Area (GWCA) is closely monitored by the Division. By the end of 1987, a study commissioned by the Division is expected to be completed on a review of ground water conditions and a reevaluation of the sustainable yield of the Pearl Harbor GWCA, particularly in the light of continued intensified urban land development and a change from furrow irrigation to drip irrigation by Oahu Sugar Co.

The new State Water Code will require the Division to expand its regulatory activities to include not only ground water use, but also surface water use. Ground water and surface water uses will initially have to be certified and then continuously monitored and reported.

#### **Protection of Instream Uses**

The new State Water Code will also extend the Division's existing windward Oahu instream use regulatory activities to all streams in the State. All of the provisions of the Hawaii Instream Use Protection Act of 1982 have been included in the new State Water Code, enabling the Department to establish interim and permanent instream flow standards for streams, to regulate stream channel alterations, and to expand the collection of instream use data throughout the State.

The Water Code requires the Department to establish interim instream flow standards by specific dates: Windward Oahu - July 31, 1987; Kauai and East Maui - December 31, 1987; Hawaii and Molokai - July 1, 1988; and West Maui and Leeward Oahu - December 31, 1988. Development of these interim standards are underway.

The Division prepared interim instream flow standards for windward Oahu and held public information meetings in Kaneohe and Hauula and met with windward Oahu farmers in July 1987. On July 30, 1987, interim instream flow standards for windward Oahu were adopted.

The Division also processed three applications for stream channel alterations in windward Oahu during 1987 for installation of a flood control structure, a channel lining, and a wildlife pond.

#### **Administration of Soil and Water Conservation Districts**

There are 15 Soil and Water Conservation Districts in Hawaii which play a major role in the conservation of the State's soil and water resources. The Division provides administrative services and support to the districts in their conservation planning efforts.

Each district is governed by five directors who plan and establish cooperative action programs for conservation, development, and management of soil and water resources within the district. In addition to encouraging and assisting land occupiers in implementing sound conservation practices, the districts serve to educate the general public about the conservation of resources through publications and demonstrations.

In an effort to reach the youth of Hawaii, the districts annually sponsor a Land Appreciation contest for students and youth organizations. The contest educates participants about the different types of soil in Hawaii and how to incorporate this knowledge into wise conservation practices.

#### **MINERAL RESOURCES PROGRAM**

The Mineral Resources Program focuses on the designation and regulation of geothermal resource subzones (GRS) in areas of the State having geothermal potential and on conserving the State's supply of mineral resources.

#### **Regulation of Geothermal Resource Subzones**

The Division regulates four geothermal resource subzones established in 1984 and 1985 by the Board of Land and Natural Resources--the Kapoho and Kamaili Subzones on the lower Kilauea East Rift and the Kilauea Middle East Rift Subzone, all in the Puna District of Hawaii, and the Haleakala Southwest Rift Subzone on

the southern slopes of East Maui. In September 1985 the Board held a public hearing to consider a proposal to establish the Kilauea Southwest Rift Subzone in the Kau District.

In the Kapoho Subzone, activities continue for the development of a 12.5 megawatt geothermal power plant by Thermal Power Co., operator of a State mining lease. In the Kilauea Middle East Rift Subzone, Campbell Estate obtained a geothermal mining lease from the State in 1987. As a result, Campbell Estate's geothermal developer, True/Mid Pacific Co., plans to begin geothermal exploratory well drilling in 1988.

#### **Regulation of Geothermal Well Drilling**

The Department regulates geothermal well drilling activities under existing laws and rules concerning exploration and development of geothermal resources. Field inspections are conducted at all well sites to ensure compliance with the Department's rules governing geothermal well drilling. In addition, activities at the experimental HGP-A well and power plant facility continue to be monitored.

#### **Inventory of Mineral Production**

The Division canvasses mineral producers in the State and maintains an up-to-date file on mineral production data and mining activities. Field inspections are made of various rock and cinder quarries. Requests for information, technical data, and rock samples are handled on a routine basis.

### **FLOOD PREVENTION AND CONTROL PROGRAM**

Activities of the flood prevention and control program include managing the use of flood plains and coordinating government actions in flood prevention and control, dam safety inspections, and stream maintenance.

### **Flood Plain Management**

The Division continues flood plain management activities under grants from the Federal Emergency Management Agency, including conducting community assessment visits to the four counties in the State and informational meetings to increase public awareness of the National Flood Insurance Program.

#### **Coordination of Flood Control Projects**

The implementation of Federal, State, and County flood control projects in Hawaii is coordinated under this program. Flood damage and stream maintenance problems are investigated, reports prepared, and problems referred to the property owners for final disposition, as specified by law.

#### **Coordination of Dam Safety Inspection**

The Hawaii Dam Safety Act of 1987 was passed by the 1987 session of the Legislature. The purpose of the Act is to protect the safety and welfare of the population living near certain dams by providing for the inspection and regulation of construction, operation, and removal of these dams when necessary, and the establishment of a State dam safety program.

The Act assigns the responsibility of administering the dam safety program to the Board of Land and Natural Resources. The Division, the responsible agency within the Department, held a Dam Safety Conference in August 1987 to discuss the new law and dam safety practices in other states. Participants included dam owners, consulting engineers, and technical personnel from other interested government agencies.

#### **Coordination of Stream Maintenance**

The Division continues the implementation of the State's role as



defined in Act 121, relating to maintenance of streams and drainageways, which was passed in the 1986 legislative session. The Act clarifies the responsibilities of the State, counties, and private owners for the maintenance of their respective streams. The State is also responsible to coordinate the resolution of maintenance problems for drainageways with multiple jurisdiction or of unknown ownership. Meetings with the respective Public Works Departments of the four counties have been held and will continue to be conducted to discuss the implementing provisions of Act 121.

### **EXPLORATORY WELL DRILLING PROGRAM**

The exploratory well drilling program, begun in 1961, has played a major role in the discovery of new ground water sources throughout the State. During the past 25 years, approximately 100 wells have been drilled, of which 65 produced fresh water and 21 produced brackish water. Most of the wells have been set aside to the county water departments for their use in providing municipal water. In 1987 five wells and five test holes were completed.

In central Molokai near Kualapuu a 1,100-foot deep well was successfully drilled and tested as a new potable water source for Maui County's Kaunakakai water system. Also, more water for the Molokai Irrigation System is being sought, with three exploratory wells being drilled in Waikolu Valley.

On Oahu, an 80-foot deep coastal well drilled in Makua Valley, Waianae, resulted in an irrigation water source for a new State park.

In the Waimea area on Hawaii, the Division completed five 100- to 150-foot deep test holes in the Kohala Mountains in search of possible perched ground water sources. Low water-bearing andesitic lavas were encountered. At Puukapu, about 2.5

miles seaward, a 1,750-foot deep, 16-inch diameter exploratory well was successful in locating dike-confined ground water standing 1,300 feet below ground surface. The well is scheduled to be tested soon and if results are successful, the well will serve as an emergency standby source for irrigation and domestic purposes during drought periods. In Hilo, the Piihonua exploratory well was successfully completed as a new potable water source and in the Puna District, the exploratory well at Olaa is under construction.

### **ENGINEERING SERVICES PROGRAM**

Under the Engineering Services Program, the Division implements various water and land projects, such as the 1.0-million gallons per day (mgd) demonstration desalting plant, exploration for high-level ground water, and development of agricultural parks and facilities. Projects administered under this program are guided by the goals, objectives, and policies of the Hawaii State Plan.

In addition, the Division provides engineering services to other divisions within the Department. Projects handled under this subprogram include the development of water sources, park facilities, silvicultural facilities, aquatic facilities, and related miscellaneous structures.

### **Water Development**

Nine projects to develop ground water throughout the state are under construction. These projects include the installation of pumps and controls to incorporate new well sources into various municipal and agricultural park water systems. In addition, major improvements are being made to our Waimanalo Irrigation System source and transmission facilities.

Engineering plans and specifications are expected to be completed during 1988 for the construction of a 1.0

mgd demonstration desalting plant in the Ewa coastal plain area on Oahu. In the planning stage since 1985, the desalting plant will be used to demonstrate the application of desalting technology in Hawaii and to show that desalted brackish ground water is a feasible alternative source of drinking water. Two wells to provide brackish feed water from both a caprock aquifer and a basalt aquifer are already under construction.

The utility of the Puu Pulehu Reservoir, which provides supplemental water storage for the Waimea Irrigation System, is presently under review. The Division proposes to reshape the reservoir and install an impermeable lining to increase the reservoir's capacity and its operational efficiency. Engineering drawings are being prepared and construction work is scheduled to begin in mid-1988.

#### **Agricultural Park Development**

Three agricultural parks are under construction on Oahu at Kahuku, Waiahole and Waianae. These agricultural parks are part of the Department

of Agriculture's program to utilize State lands for diversified agriculture and are being developed in cooperation with the Department of Land and Natural Resources.

#### **State Parks Development**

Numerous projects are under construction to upgrade or expand State park facilities, including utilities such as water and sewerage systems.

#### **Land Development**

One project to develop lands for public benefit is the transformation of State lands in Kona, Hawaii, into a marshaling yard for the consolidation and storage of fresh produce for transshipping to off-island markets.

#### **IRRIGATION SERVICES PROGRAM**

The Department operates the Waimanalo Irrigation System (974 acres) on Oahu, the Waimea Irrigation System (487 acres) on Hawaii, and the Molokai Irrigation System (4,410 acres) on Molokai.

## IDAHO

Idaho Geological Survey, University of Idaho, Moscow, ID 83843.  
Phone 208-885-7991.

### HISTORICAL SEQUENCE OF ORGANIZATIONAL NAME:

Idaho Bureau of Mines and Geology, 1919-84  
Idaho Geological Survey, 1984-present

### NAMES AND TITLES OF ORGANIZATIONAL DIRECTORS AND DATES SERVED:

Francis A. Thomson, 1918-28  
Arthur W. Fahrenwald, 1929-30  
John W. Finch, 1930-35  
Arthur W. Fahrenwald, 1934-54  
James D. Forrester, 1955-57

Earl F. Cook, 1957-65  
Rolland R. Reid, 1965-74  
Maynard M. Miller, 1975-87  
Robert W. Bartlett, 1987-  
-present

### HISTORY OF THE IDAHO GEOLOGICAL SURVEY AND ITS PREDECESSOR, THE BUREAU OF MINES AND GEOLOGY

By Earl H. Bennett

The Idaho Bureau of Mines and Geology (BMG) was created in 1919 by the Idaho Legislature. A major impetus for the formation of the agency came from Robert Bell, the State Inspector of Mines, who asserted in 1916:

There are few States in the Union that are without the services of a State Geological Survey, and Idaho is one of the few. There is no State in the Union that affords a richer, more varied, or more warranted field for the activities of such a public institution.

Others in the state must have shared Bell's practical concern for geological expertise. Francis A. Thomson, the dean of the School of Mines, was appointed the BMG's first administrator. With little fanfare, the BMG opened its state office with no more than a name over a door.

The BMG was housed at the University of Idaho and placed under the direction of a Board of Control. Members of the original Board were the Governor, the State Mines Inspector, the head of the Department of Geology



Francis A. Thomson  
1918-28

at the University of Idaho, the President of the Idaho Mining Association, and the Dean of the School of Mines, which had recently been established in 1918 at the university. The Dean also served as secretary of the BMG. The secretary was instructed by the Board to arrange for the publication of the agency's reports and studies. (The administrative title of "secretary" later evolved into "director." In this brief history, the term "director" will be used to distinguish the

role of the dean as head of the BMG.) Neither an initial appropriation nor the Board provided the means to staff the infant agency. Research for the state was to be contracted through federal agencies.

The enabling act did not provide for a State Geologist. Idaho was officially without one, although the Dean/Director acted in this capacity. Today, the Dean is officially the State Geologist and the Director of the Idaho Geological Survey (IGS), which replaced the BMG in 1984. The Director can serve as State Geologist or appoint someone to the position.

The BMG was established primarily so the state could allocate funds for arranging research to be undertaken by federal agencies in the state's interest. The state conducted the bulk of its research through cooperative programs with the U.S. Geological Survey (USGS) and the U.S. Bureau of Mines (USBM). The first BMG budget was written in three parts, labeled (1) U.S. Geological Survey cooperative programs, (2) U.S. Bureau of Mines cooperative programs, and (3) state mineral resources investigations. Other programs included topographic mapping, hydrographic surveys, publication printing, geologic field studies, and mining and metallurgical research.

An impressive series of studies had been finished or were nearly completed by the time of the second meeting of the Board of Control in 1920. Metallurgical research, the main cooperative program with the U.S. Bureau of Mines, was well established. By the next year, joint federal-state programs were providing a wealth of earth science data on Idaho. The BMG publications were only a small part of the research being published. Most publications on Idaho for which the BMG paid half the research costs were released through the U.S. Geological Survey and the U.S. Bureau of Mines as agreed in the state-federal cooperation. In addition, many

of the Bureau's projects were the result of research by the faculty of the School of Mines who were employed for the summer months. This practice of hiring part-time summer researchers was followed for years and produced many important papers. Prominent in the Bureau's affairs in this early period and into the 1950's was A. W. Fahrenwald who was recognized internationally for his contributions in metallurgy. Fahrenwald is perhaps best remembered for his pioneering work in separating complex sulfide ores by selective flotation.

From the beginning, the Bureau did not shy from public controversy. In 1922, speculators tried to stir up an oil boom near Lewiston. The BMG challenged the ostensible claims of those promoting it. Geologists representing the Bureau pointed out in the press and in appearances before the Lewiston Chamber of Commerce that there was virtually no chance of oil being discovered in the area. This was the first of many times the BMG would defend the public interest against the guile of unscrupulous speculators.

Preparing a state geologic map was first mentioned in 1923; however, the idea was not pursued. At that time, the USBM cooperative studies emphasized ore flotation and the state's nonmetallic commodities such as clay, feldspar, and mica.

One of the services provided by the BMG was the identification of mineral specimens. From 1,500 to 1,600 specimens had been identified by the Bureau in the period 1922-24. Analyzing samples for prospectors and classifying rocks and minerals has continued to be a popular BMG-Survey program to the present.

At the 1923 Board meeting, members decided several important matters, including one to omit topographic work during 1923-24. This decision, in effect, ended the BMG's active contribution to topographic



mapping. All mapping of this kind would be done by the USGS.

In 1924, the Bureau looked into an alleged occurrence of platinum-group metals in Kootenai County. A short report issued by the agency exposed the fraud. This was not the first nor the last of supposed commercial platinum discoveries in the state, none of which were ever substantiated.

Two geologists who would make landmark contributions to understanding Idaho's geology were initially mentioned in the minutes of the 1924 meeting of the Board of Control. The first was Clyde P. Ross. He started work in Idaho with the USGS under the BMG-USGS cooperative program to study the geology and ore deposits of the Hailey area. Ross also did a preliminary study on the copper deposits south of Salmon. The second geologist was Alfred L. Anderson, who began his career as Ross' field assistant. In 1924 Anderson had just completed graduate studies at the University of Idaho under a BMG fellowship. He was to become an expert on the geology and mineral deposits of Idaho. At times he disagreed professionally with the equally distinguished Ross over the geology of the state.

Public service has been an important BMG/IGS function in many ways over the years. For example, at the request of the city of Moscow in 1924, the Bureau reported on the ground-water potential under the town. Because of the report, the city posted a \$40,000 bond issue to carry out the Bureau's recommendations.

The first mention of problems with publication schedules appears in the minutes from 1924. So many reports were in preparation that it was difficult to get them published. The Board recommended that for the rest of 1924 the major effort would be to get out these publications. Since its beginning, the BMG/IGS has released over 410

reports and maps. Forty percent of these have been done since 1978.

The minutes of the Board meeting in May 1925 noted an incident of lasting significance to the future administration of the School of Mines and the BMG. The U.S. Bureau of Mines was planning to transfer A. W. Fahrenwald to another research station and replace him with a less experienced person. The then Dean/Director, Francis A. Thomson, rushed to stop the move. After consulting with the mine operators in the state, many of whom had benefited greatly from Fahrenwald's research, Thomson insisted that this valuable scientist be retained in Moscow. Fahrenwald remained in Moscow and would later become Dean and Director.

Projects underway in 1925 included a cooperative program with the State Department of Highways to evaluate road construction materials. This was the first job assigned to A. L. Anderson.

The same year the Board decided the policy of the publication account. The money that was accumulating from publication sales would no longer be returned to the state general fund but instead would be used to pay the printing costs of future publications. This practice of a revolving publication fund continues today.

By 1926, Fahrenwald was doing all of the cooperative work with the USBM and releasing his work in that agency's publications. By contrast, funds in the BMG's publication account had fallen so low that the Board discussed using the rest of the agency's biennial appropriation to publish those reports completed or in progress. In fact, funds were so short that no field studies were carried out that year. Inadequate state funding has never been a stranger to BMG/IGS.

Despite earlier decisions, the Bureau resubmitted a request to support or undertake more topographic mapping in the state. The mapping was needed to provide the base maps for

geologic studies. The Bureau had not actively participated in preparing topographic maps on any scale in previous years. In 1927, the agency tried to get a special \$10,000 appropriation from the State Legislature to do topographic mapping. The Legislature turned down the request. The industry representative on the Board of Control also rejected a plea from Thomson to transfer \$5,000 from the BMG budget for the mapping. Topographic mapping would never again be an issue of BMG responsibility.

By 1927, 31 research projects were underway in addition to Fahrenwald's work with the USBM. Most of these continued to be cooperative agreements with the USGS and the USBM. Thomson averted an impending cancellation of the USBM's cooperative program. In fact, in a turnaround of intentions, the U.S. Bureau of Mines began to consider putting a research station on the University of Idaho campus.

Ross had nearly completed work in the Casto quadrangle in 1927, and he planned to extend his study into the Bayhorse area. His research was to form the groundwork for geologic thinking in this part of Idaho for many years. Ross' stratigraphic nomenclature (with modifications and refinements) is still used today.

In 1928 the USGS published a major study by G. R. Mansfield describing the geology of a large section of southeastern Idaho. Although this work was not funded by the BMG, the Bureau was in fact responsible for its publication. The agency lobbied for a special appropriation from Congress to print the long report. This U.S. Geological Survey Professional Paper remained the definitive work on Idaho's phosphate district for many years and is still widely referenced today.

Thomson resigned in 1928. The President of the University of Idaho, F.

J. Kelly, took over as Acting Secretary of the Board of Control. Fahrenwald was to become Dean of the College of Mines and head of the BMG in late 1929.

Problems had developed over interpreting how the cooperative programs with the USGS would be run and especially in deciding which programs had priority. The USGS felt the state should turn over the money appropriated for the co-op program and let the federal agency direct the projects. The State Attorney General was called upon to settle the issue. He decided that the Board could not relinquish state funds to the USGS. As a result Fahrenwald noted:

In view of this ruling, it becomes our duty to develop with the U.S. Geological Survey a type of cooperation which includes active participation of the cooperating parties in the geologic work of our State in which the Bureau disburses the funds provided for its maintenance, and retains responsibility of the work to be accomplished.

The USGS might have the geologic experts that the state sorely needed, but the BMG would determine the work to be done.



Arthur W. Fahrenwald  
1929-30, 1934-54

The appointment of Fahrenwald to Dean/Director changed the cooperative

relationship between the BMG and the USBM. Before, the USBM cooperative money had been in the form of Fahrenwald's salary. With Fahrenwald no longer with the USBM, the cooperative program was now one of spirit rather than one of material support. The USBM discontinued funding the cooperative program in 1930. Both federal cooperative programs were on a different footing than in the past. Now a state Bureau of Mines and Geology could operate essentially independent of federal support. In another development pertinent to the autonomy of the BMG, a letter from Fahrenwald to the Board was instrumental in keeping the Bureau and faculty positions/salaries in the School of Mines separate. The BMG could thereby maintain its own identity independent of the larger School of Mines.

In 1930, Fahrenwald quite suddenly decided to give up the Dean/Director position and return to teaching and research. John W. Finch would be the Dean and Director until 1935.



John W. Finch  
1930-34

1931, W. W. Staley, a professor in the School of Mines, began work on a

series of simple, nontechnical pamphlets about gold prospecting and mining. The result was a popular series of publications that have been reprinted many times and are still best sellers today.

In 1935, Fahrenwald resumed the directorship, taking over from Finch. The official cooperative program with the USBM was dropped from the budget. Now the BMG had only two budget categories, the USGS's cooperative program and the state mineral resource investigations. By 1936, the mineral resources investigation program was almost entirely engaged in metallurgical studies under Fahrenwald, although geologic studies were also underway.

Anderson began working in the Boise Basin in 1932 under the USGS co-op program. His subsequent report would be a long, long time "in press" with the USGS. In 1938, a few years after the report had been submitted, Anderson considered asking the USGS to return the manuscript so that the BMG could publish it. Delays by the USGS in publishing manuscripts were constant problems for the Board of Control. In 1940, Anderson had to revisit mines in Boise Basin and rewrite parts of his paper that were now badly outdated. The report was finally published in 1947. Despite a labyrinthine genesis, it is perhaps Anderson's most important work in Idaho.

With the United States' entry into World War II, the BMG had difficulty in getting and keeping scientists. The war effort took nearly every able-bodied man. The predicament was especially troublesome for the BMG's activities because even though strategic metals were being given a high priority nationally, few scientists were being made available to work in this critical area. The BMG was able to hire Lewis Prater, a metallurgist who would be with the agency for over three decades.

In 1942, the USBM established a field office in Moscow with 15 people and an annual budget of \$200,000. It also revitalized the co-op program of 10 years before. The BMG, however, was still suffering from an acute shortage of professionals.

In 1943, the State Legislature unexpectedly allocated all the funds for the BMG budget under the mineral projects category. No funds were given to the USGS co-op program. The Board of Control decided that this funding "mistake" was a fortuitous one and that from then on all state funds would be used for the BMG programs and none would go into the federal co-op programs. This officially ended the funding arrangement with the USGS, although a high degree of cooperation has existed between the two agencies ever since. Another problem with the BMG budget surfaced that year when Fahrenwald could not spend the \$50,000 allocated because he had no personnel and could find none. Professors from the College of Mines were still conducting BMG projects during the summer, as had been the common practice since the agency's beginning.

Gold was the subject of considerable Bureau attention in the mid-1940's, even though gold mining had been shut down nationwide by the War Production Board. The BMG wanted to be ready to catch the postwar gold boom that everyone was sure would happen. W. W. Staley published *Gold in Idaho* in anticipation of the gold rush. During this period Fahrenwald had been successful in beneficiating phosphate ore and in finding a flotation method for processing barite (a mill was built using this technology at Hailey). His research provided important improvements to mining technology and in particular to Idaho's mining industry.

In 1947, T. H. Kiilsgaard was hired by the BMG. In his work with the BMG and during a professional lifetime with

the USGS, Kiilsgaard has produced many important studies on Idaho's geology. That year, the BMG published the long-awaited state geologic map (1:500,000) by C. P. Ross and J. D. Forrester. In 1948, the Board of Control felt the BMG was in the best professional and economic shape of its history.

Fahrenwald retired in 1953, after 22 years as Director. James D. Forrester was appointed the new Director. By 1955 the BMG had four full-time professionals and support staff. Professors from the College of Mines still worked on summer projects for the agency. The BMG began distributing rock kits to school children and other groups. Over 1,000 sets were handed out in 1955.



James D. Forrester  
1955-57

In 1956 Forrester asked the Board of Control if the BMG could form an Advisory Board selected from industry and government officials and leaders. This was approved. Late that year Earl F. Cook became Dean and Director. In 1957, Carl N. Savage joined the agency as Economic Geologist. Savage would publish many important works on Idaho over his distinguished career,



concentrating on countywide geologic reports and industrial rocks and minerals.



Earl F. Cook  
1957-65

The BMG began a cooperative program with the USGS in 1959 to prepare a series of road logs in Idaho. Only one, however, was finished 4 years later by C. P. Ross on the geology along U.S. Highway 93.

In the summer of 1961, the BMG moved into the new College of Mines building completed at a cost of about \$500,000. Savage published three county reports. His report on black sands has considerable interest today due to the rare earth content of these sands. Rare earths are important commodities in the recent research on superconductors.

New statewide problems were presenting challenges for the BMG in 1962. Ground water and geothermal resources were discussed as potential Bureau projects. The whole spectrum of federal land issues was also beginning to emerge. The Board of Control became concerned with the potential impact of proposed wilderness legislation and other mineral withdrawals, because two-thirds of Idaho is federal land. Oil,

always a topic of interest to the Bureau, loomed bigger than ever as a possible new mineral resource. The Idaho Oil and Gas Conservation Commission was established by the legislature in 1963 as part of the BMG. By 1962-63 the Bureau had seven full-time staff, three assistantships, and eleven other professionals who worked only in the summer.

In 1964 Rolland R. Reid became Dean and Director. Special Report 1, *Mineral and Water Resources of Idaho*, was published. This was a landmark collection of data, commissioned by the U.S. Senate Committee on Interior and Insular Affairs at the request of Senator Frank Church of Idaho. The BMG got state funding for a study of the geology and mineral resources of the Selway-Bitterroot Wilderness area. The agency also received funds to support four research fellowships. Field work for the Selway Bitterroot program was completed in 1968 and resulted in several BMG publications.

In 1965 Sylvia Ross and Carl Savage started the Earth Science Series, marking the initial effort by the BMG in earth science education. Work began in 1966 on the new state geologic map (eventually published in 1978) and in 1967 on a statewide bibliography of mineral resources.

Sylvia Ross started the first appraisal of the state's geothermal springs in 1968. To create space in the College of Mines Building, by now feeling the strain of overcrowding, the BMG library was sent to the University of Idaho library.

In 1969 the BMG was fortunate in obtaining a special appropriation of \$75,000 from the State Legislature for an electron microprobe. The microprobe was installed in 1970. Charles R. Knowles was hired to operate this special instrument. In 1977 the BMG purchased equipment for an atomic absorption laboratory. Together, these

instruments became the heart of the BMG's analytical services.

The BMG moved to Morrill Hall (present location of the IGS) in 1971 to ease the ever-overcrowded conditions in the Mines building. Numerous papers on ground water were published by the BMG up to the mid-1970's. In 1971-72, the BMG had 12 1/2 full-time employees and its largest budget to that time. A one-person branch office was set up on the campus of Boise State University to expand the agency's services to the southwestern part of the state. The BMG Advisory Board met with the Board of Control in 1971 for the first time. In 1973 the BMG sponsored a major symposium on the Belt Supergroup and related ore deposits.

In 1975 the new governor, Cecil Andrus, reorganized several hundred state agencies into 19 departments. Administratively, the BMG was placed in the Department of Lands under the Division of Minerals. The agency remained on the University of Idaho campus. The new arrangement kept the Dean as Director, or Chief as the position was to be called, but assigned the fiscal responsibility to the Director of the Department of Lands, Gordon Trombley, in Boise. The reorganization also disbanded the BMG's Board of Control. The BMG budget was now just a small part of the much larger Department of Lands' budget.

Even though the statewide reorganization was long overdue, the move to the Department of Lands would be troublesome for the BMG in coming years. The department for the most part managed forest practices on state land and had some regulatory functions. The BMG, on the other hand, was a research and service organization with no regulatory responsibility. Confusion over the BMG's use of federal funds from research grants and contracts became the crucial issue. The result was a funding crisis for the BMG in the early 1980's.

Other significant changes occurred in 1974. Rolland Reid stepped down as director in June. Until a new Dean/Director was selected, John G. Bond served as the Acting Dean/Director. A one-person field office was opened in Pocatello in December 1974. In the fall of 1975, Maynard M. Miller was appointed as Dean/Director. Carl Savage became Associate Chief after Lewis Prater retired with 31 years of service. Earl H. Bennett was hired that year as Geologist.

In 1976 the BMG underwent an internal reorganization. Both branch offices were closed. The Hydrology Section was dropped because the hydrologists had taken positions elsewhere. Despite these cutbacks, however, plans were in the works to expand the professional staff. In August, Bill Bonnicksen was hired as Economic Geologist.

The agency's first full-time editor, Roger Stewart, was hired in July 1977. Publication production and sales would soon exceed by far anything in the past. A chemist, Joseph F. Keely, was hired to assist in the analytical services section. The Bureau began to give overviews of the mining and mineral activity in the state at the Northwest Mining Convention held annually in December at Spokane, Washington. The agency initiated geochemical studies to develop mineral inventory data for large areas of the state. In a special ceremony at the State Capitol in December, Carl Savage was awarded the honorary title of Idaho State Geologist by Governor John Evans.

Three new positions were opened on the staff in 1978. The BMG hired Roy M. Breckenridge as Environmental Geologist, H. Theodore Smith as hydrologist, and Jerry L. Harbour as Mining Research Geologist. The BMG's first newsletter, the *Gem State Geological Review*, was released that spring and was well received. It would run for 5 years. The new state geologic

map (scale 1:500,000) was finally published after years in the making. The first in a series of 1:1,000,000-scale maps, *Gold Occurrences in Idaho*, made its debut. These new maps have been popular with BMG's customers.

In January 1979, Carl Savage died of cancer. He had served the BMG and the state of Idaho for 22 years. Savage was instrumental, along with Director Maynard Miller, in building the competent staff of geologists and other professionals the BMG has today. During the year, the BMG compiled the geology of the state on sixteen 1° x 2° maps. The agency also initiated a 3-year project to evaluate the phosphate reserves in southeastern Idaho. In an organizational move, the BMG established the Environmental Geology Section.

In 1980 Earl Bennett was appointed Associate Chief of the agency. Kurt L. Othberg was hired as Senior Geologist in the environmental geology section. That year exposed the anticipated problems with the agency's operating expense budget. The operating expense request was cut in half by the Department of Lands. The loss for the year was made up from the overhead money in federal grants and contracts. This proved only a temporary fiscal bandaid and would mean trouble in future years. The BMG began compiling the locations and information about the mines and prospects in the state. This project was completed in 1981 with over 8,000 mining properties tabulated and located. Two more maps at 1:1,000,000 scale were released. One was on oil and gas exploration and the other on energy resources in the state. Both have been very popular publications. On May 18, 1980, Mount St. Helens in Washington erupted and inundated northern Idaho above Lewiston with ash. The staff was kept busy dealing with the problems caused by the eruption.

The big run-up in silver prices in 1979-80 spurred interest in precious

metals. The result for the BMG's publication sales in 1981 was an increase of 25 percent over 1980. A major volcanic structure, the Bruneau-Jarbidge eruptive center, was discovered in southwestern Idaho by BMG geologists. The agency began work on publishing a collection of papers on the Cenozoic geology of Idaho. The book would be the largest publication ever by the BMG and would take nearly 3 years to produce. The BMG also initiated a Surficial Geologic Map series.

Although the research performance of the BMG was at an all time high in 1981, the fiscal woes of the state meant rough times ahead. Vacant positions were not allowed to be filled. In 1982, the agency's budget was cut 12 percent. Budgets in coming years would not even keep up with inflation. The loss of another geologist brought the total to three positions lost in 2 years. Yet, in spite of these hard times, the agency's publication sales reached an all-time record. One highlight was the release of the second edition of the very popular book, *Gold Camps and Silver Cities*. A further shortage in state funding in 1983 forced the closure of the atomic absorption laboratory and the loss of the chemist.

The Borah Peak earthquake of magnitude 7.3 occurred on October 28, 1983. Like the Mount St. Helens eruption, this natural disaster led to a flurry of activity for Bureau scientists.

In hopes of alleviating the Bureau's fiscal woes, legislation was introduced to dramatically improve the Bureau's role and image in the state. In 1984, Senate Bill 1269 established the Idaho Geological Survey as a special program at the University of Idaho. The IGS replaced the Bureau of Mines and Geology and had a new and updated mission as described in its enabling act. The Director of the IGS was still the Dean of the College of Mines and Earth Resources at the University of Idaho. In

addition, the Director also served as the State Geologist, or had the option of appointing someone to the position. Befitting its new image, the first publication released by the new agency was the *Cenozoic Geology of Idaho*, a 725-page book containing 42 papers.

In 1986 the IGS renewed its commitment to earth science education as a major service function. It organized, with the Department of Geology and Geological Engineering at the University of Idaho, a field geology workshop designed especially for earth-science teachers. The IGS conducted

workshops in the summers of 1986 and 1987.

Maynard Miller stepped down from the Dean/Director's position in 1987. Robert W. Bartlett, the new Dean and Director, took over duties in October. Bartlett, a metallurgist, appointed Earl Bennett as State Geologist effective July 1988.

The Survey has fared better under its new mission statement. Depleted operating funds have been restored. This year the Idaho Legislature authorized the hiring of two positions for the new branch offices in Boise and Pocatello.



Robert W. Bartlett, 1987-1988; Roland R. Reid, 1965-74; Maynard M. Miller, 1975-87 (from left to right).



## ILLINOIS

Illinois State Geological Survey, Department of Energy and Natural Resources,  
Natural Resources Building, 615 East Peabody Drive, Champaign, IL 61820.  
Phone 217-333-4747.

### HISTORICAL SEQUENCE OF ORGANIZATION NAME:

The Geological Survey of Illinois ("The Worthen Survey"), 1851-75  
No state-mandated geological survey existed, 1875-1905  
The Illinois State Geological Survey (ISGS), 1905-17  
The Illinois State Geological Survey (ISGS) Division, 1917-present

### NAMES AND TITLES OF ORGANIZATIONAL DIRECTORS AND DATES SERVED:

Joseph G. Norwood, State Geologist, 1851-58  
Amos H. Worthen, State Geologist, 1858-75  
Amos H. Worthen, Curator of the State Historical and Natural History  
Museum and State Geologist, 1877-88  
Joshua Lindahl, Curator of the State Historical and Natural History  
Museum and State Geologist, 1888-93  
H. Foster Bain, Director and State Geologist, 1905-09  
Frank W. DeWolf, Director and State Geologist, 1909-17  
Frank W. DeWolf, Chief and State Geologist, 1917-23  
Morris M. Leighton, Chief and State Geologist, 1923-54  
John C. Frye, Chief and State Geologist, 1954-74  
Jack A. Simon, Chief and State Geologist, 1974-81  
Robert E. Bergstrom, Chief and State Geologist, 1981-83  
Morris W. Leighton, Chief and State Geologist, 1983-present

### ILLINOIS STATE GEOLOGICAL SURVEY

By Jonathan H. Goodwin, Assistant to  
the Chief, and Robert E. Bergstrom,  
Chief Emeritus

#### THE FIRST SURVEY: 1851-90

In 1849, the American Association for the Advancement of Science appointed a committee to campaign for the establishment of geological surveys in those states which did not yet have them. Using the pleas of the AAAS and the findings of a study commission created by the General Assembly, Governor Augustus C. French, in his January 7, 1851, message to the Assembly called for the creation of a state geological survey in Illinois and

the state legislature responded favorably in February. Joseph G. Norwood, a medical doctor who had worked on geological and paleontological research with David Dale Owen in New Harmony, Indiana, began his duties as the first State Geologist of Illinois in October 1851 by examining the bluffs of the Ohio River from Shawneetown to Cairo. Norwood established his first headquarters at New Harmony, but moved the Geological Survey to Springfield in 1855.

In 1858, Amos H. Worthen (fig. 1), one of Norwood's assistants and a former staff member of the Iowa Geological Survey under James Hall, replaced Norwood as State Geologist. A man of exceptional ability, enthusiasm and vision, Worthen moved quickly to



Figure 1.--Amos H. Worthen (1813-88), State Geologist of Illinois from 1858 to 1872 and curator of the State Historical and Natural History Museum and State Geologist from 1877 to 1888.

reorganize the Survey and hire several outstanding paleontologists and geologists to assist him.

Between 1866 and 1890, the Geological Survey of Illinois was published in 8 volumes totaling 4,761 pages of text, figures, and plates. A geologic map that outlined the principal bedrock units was a part of the volume published in 1875. Included in the volumes were descriptions and figures of 1,626 species of fossils, nearly 1,500 of which were new species.

In the view of the legislature, the geological survey of the state had been completed, and from 1872 to 1875 only minimal appropriations supported publication of the remaining volumes, while Worthen continued to prepare them without compensation. In 1877, the State Historical and Natural History Museum was established and Worthen was named Curator and State Geologist. He spent the last 11 years of his life studying his fossil collections,

preparing most of the remaining volumes of the geological survey reports for publication, and compiling the three volumes of reprints and emendation published in 1882 as the *Economical Geology of Illinois*. The eighth and final volume of the Reports of the Geological Survey of Illinois was completed by his successor, Joshua Lindahl, and published in 1890, 2 years after Worthen's death (1, 2). From 1875 to 1905, no state agency was specifically charged with coordinating geological research in the state.

### THE BEGINNINGS OF THE MODERN SURVEY: 1905-23

Through the efforts of T. C. Chamberlin of the University of Chicago (a friend and neighbor of Governor Charles S. Deneen), the Western Society of Engineers, and the University of Illinois, the General Assembly passed legislation to establish a State Geological Survey (ISGS) at the University of Illinois at Urbana-Champaign in 1905. A three-member State Geological Commission, consisting of the Governor, the President of the University of Illinois, and an appointed member (Chamberlin), was to oversee the agency and H. Foster Bain (fig. 2), from the staff of the U.S. Geological Survey, was appointed the first Director.

Although he initiated many of the research programs still being conducted by the Illinois Survey, with an initial budget of only \$25,000 per year, of which \$10,000 was committed to the U.S. Geological Survey for topographic mapping, Director Bain had to rely heavily on the services of part-time consultants, many of whom were on the faculties of the public and private colleges and universities in the state. In 1906, Gilbert H. Cady, the Survey's pre-eminent authority on coal for more than 50 years, joined Bain's staff (2).

Bain called a meeting in Chicago in 1906 to organize the Mississippi Valley



Figure 2.--The first two directors or chiefs of the modern Illinois State Geological Survey: (l to r) H. Foster Bain (Director), 1905-09; Frank W. DeWolf (Director) 1909-17, (Chief) 1917-23; photographed in 1944.

Association of State Geologists. In part through the impetus of this organization, the Association of American State Geologists was formed 2 years later (2).

Bain was succeeded in 1909 by his assistant Frank W. DeWolf, who continued the expansion of the Survey's research programs to keep pace with the rapid expansion of Illinois' mineral industries. In cooperation with the University of Illinois Engineering Experiment Station and the U.S. Bureau of Mines, in 1915 the ISGS organized the Illinois Mining Investigation, a program to systematically study mining practices to improve safety and efficiency, inventory coal resources, and determine the physical and chemical characteristics of Illinois coal.

In 1917, the General Assembly passed a new Civil Administrative Code that became a model for state governmental reform. The Code organized the Illinois State Geological Survey (ISGS)

and its sister agencies, the Natural History and Water Surveys, as divisions in the new Department of Registration and Education and created the Board of Natural Resources and Conservation to supervise the three scientific surveys. The Board was to consist of the Director of the new Department as *ex officio* chairman, the President of the University of Illinois (or his representative), and one appointed member in each of the five fields of biology, geology, chemistry, engineering, and forestry. (The designations of specialties were later changed to replace "biology" and "forestry" with "animal biology" and "plant biology," and the President of Southern Illinois University was added to the Board.) (1) At the first meeting of this Board, it was agreed that the heads of the Scientific Surveys would be designated "Chief" to distinguish them from the politically appointed "Director" of the Department.

Chief DeWolf took a leave of absence to work in the U.S. Bureau of Mines during World War I and Thomas E. Savage, a noted authority on the stratigraphy and paleontology of Illinois who held a joint appointment with the ISGS and the University of Illinois, was designated Acting Chief for the period 1917 to early 1919, when DeWolf returned.

In 1923, DeWolf resigned to take a position in private industry. He turned over to his successor a Survey that consisted of 9 full-time geologists, a chief clerk, and 2 stenographers and had an annual budget of \$225,000, of which \$100,000 was committed to the USGS for coordinated topographic mapping studies. Chemical analyses and ceramic clay tests were performed by University departments with assistance from some ISGS staff. Fifteen geologists were temporarily employed during the summer field season of 1923.



Figure 3.--The third chief of the modern Illinois State Geological Survey, Morris M. Leighton, 1923-54; photographed in 1941.

#### THE M. M. LEIGHTON ERA: 1923-54

The new Chief, Morris M. Leighton (fig. 3), had been a part-time ISGS staff member in charge of Pleistocene studies while on the faculty of the University of Illinois. A native of Iowa with a B.S. degree from the University of Iowa, Leighton's Ph.D. degree was awarded by the University of Chicago. Within a few months of taking office, Leighton had introduced significant new research directions and placed a new emphasis on the publication of research results both in refereed journals and in the Survey's publication series (2).

Although the General Assembly passed an austere biennial budget for the first 2 years of his administration, by the late 1920's, budgets had grown enough for Leighton to significantly increase the Survey's staff. In addition to the Coal and Oil and Gas Sections established by his predecessor, from 1924 to 1930 Leighton started sections for research in Nonfuel Minerals,

Subsurface Geology, Stratigraphy and Paleontology, Engineering Geology, and Educational Extension. The creation of the Engineering Geology Section has been cited as the first formal recognition of this specialty field of geology and emphasizes the importance Leighton placed on multidisciplinary approaches to the solution of practical geological problems. The Educational Extension Unit has continued to provide services to teachers and the public to the present day.

The ISGS celebrated its 25th anniversary in 1930 with a 2-day program that included a symposium on regional studies of cyclic sedimentation in the Coal Measures strata from Pennsylvania to Texas. Harold R. Wanless of the University of Illinois and the ISGS and J. Marvin Weller of the ISGS later applied the name "cyclothem" to sets of rock layers deposited by the particular sequence of depositional environments common in coal measures and the controversial concept inspired significant studies of coal geology throughout the world (2).

Despite the economic uncertainties of 1930, Leighton was able to garner the support of leaders of mineral industries, business, and education for a greatly expanded program of multidisciplinary research and service by the ISGS, arguing that mineral discoveries and technological development might stimulate recovery from the depression. Heeding that call, the General Assembly increased the appropriations for the ISGS by more than 40 percent for the 1931 biennium, and Leighton established the Geochemistry, Mineral Economics, and Physics Sections. Among the scientists who joined the ISGS staff during this period were clay mineralogist Ralph E. Grim; chemists Frank H. Reed, Orin W. Rees, and Glenn C. Finger; mineral economist Walter H. Voskuil; petroleum engineer Frederick Squires; and physicist R. J. Piersoll (2).



Although budgets were austere through the later years of the Great Depression, much significant research was accomplished during the period. A 1930 ISGS map prepared by petroleum geologist A. H. Bell pointed to the oil possibilities of the then untested deep part of the Illinois basin. Seismic interpretations based on the map led to deep drilling between 1937 and 1940 that increased Illinois' oil production from 5 million barrels in 1936 to nearly 150 million barrels in 1940. In clay mineralogy, Ralph Grim and William F. Bradley identified and characterized the widespread clay mineral illite. M. King Hubbert pioneered in the use of electrical earth resistivity measurements as a tool for locating geological discontinuities. Studies in paleobotany (especially palynology), coal petrology, coal chemistry, and mineral matter in coal by Gilbert Cady, James M. Schopf and many others garnered international recognition and helped to maintain markets for Illinois coal. Fluorine compounds synthesized in ISGS chemistry laboratories were tested throughout the United States in industrial processes, drugs, pesticides and fungicides (2).

Since 1905, the Geological Survey had occupied offices and laboratories on the campus of the University of Illinois, first in Noyes Chemistry Laboratory and later in the Ceramics Engineering Building. By the late 1930's, the University insisted that it could not accommodate further expansion of the Geological Survey in existing facilities and Chief Leighton began to formulate plans to construct a new building. The Board of Natural Resources and Conservation approved a plan to construct a building to be shared by the Geological and Natural History Surveys, and Governor Henry Horner not only approved the necessary state appropriation but also personally campaigned for a federal grant from the Public Works Administration to help fund the con-

struction. The Natural Resources Building was completed in 1939, and the two Surveys moved into their new headquarters in the spring of 1940, but the laboratories were not fully equipped until March 1941. The Applied Research Laboratory, a separate building to house the Geological Survey's coal preparation studies and research on the coking, briquetting and stoking properties of Illinois coals, was completed in 1941 (2).

Emergency studies during World War II sought oil and gas resources in the Illinois basin, fluorspar in southeastern Illinois, and lead and zinc in the Upper Mississippi Valley District of northwestern Illinois. ISGS studies of the feasibility of making metallurgical coke for Illinois steel plants with blends of Illinois and eastern metallurgical coals reduced the need for transport of eastern coals to Illinois by more than 2 million freight car miles by the end of the war and added a market for 500,000 more tons of Illinois coal each year. ISGS chemists also provided a fluorine compound and the specifications for its preparation and purification for the Manhattan Project that developed the atomic bomb (2).

In the 1920's, the ISGS had published estimates of Illinois coal resources as part of the cooperative mining investigation program. Procedures for estimating coal resources continued to be refined and, with the advent of electronic computers at the University of Illinois in 1936, the use of punch cards to tabulate coal data and to computerize coal resource calculations was instituted (1). Following World War II, to revise the Survey's coal resource assessments, available data from drill holes and outcrops were used to compile maps of all coal seams more than 28 inches thick. Those 1:62,500 scale maps were used to measure coal resources in various thickness categories separated into four groupings based on data reliability. Areas of coal seams were

measured by standard planimetric methods, but the area, thickness, and other data were entered on punch cards and the large computers at the University of Illinois were used to calculate the resource estimates. In the mid-1950's updates of the original coal resource maps formed the basis for a series of regional reports on strippable coal resources, a category that had not been reported previously.

Beginning in 1945, Leighton and ISGS staff members participated in the work of the Illinois Post-War Planning Commission, supplying an atlas of mineral resources as a part of the commission report. Partly as a result of the Commission's recommendations for new state buildings, wings were added to both ends of the Natural Resources Building in 1950 that nearly doubled the available floor space for both the Geological and Natural History Surveys.

In 1954, Morris Leighton retired and was succeeded by John C. Frye (fig. 4), the former State Geologist of Kansas and, like Leighton, a specialist in the geology of continental glaciation. Over the 31 years of Leighton's administration, he had molded the Illinois Survey into one of the leading geological and geochemical research institutions in the country, conducting broadly based, multidisciplinary research programs in the geology and chemistry of coal, Pleistocene and Paleozoic stratigraphy, mineral economics, clay mineralogy and technology, the geology of fluorite and the chemistry of fluorine, ground-water geology, petroleum geology, and many other fields. The large program in chemistry established by Leighton in 1931 to provide analytical services and conduct original research has remained one of the distinguishing characteristics of the ISGS to this day. At the 50th anniversary celebration in 1955, Chief Frye reported that the small ISGS staff inherited by Leighton in 1923 had

grown to 48 geologists, 22 chemists and physicists, 4 engineers, 2 mineral economists, 2 editors, 2 photographers, a librarian, 30 research and technical assistants and a nontechnical staff of 20, a total of 130 (2).



Figure 4.--The fourth chief of the Illinois State Geological Survey, John C. Frye, 1954-74; photographed about 1970.

#### THE JOHN C. FRYE ERA: 1954-74

Throughout his tenure as Chief, Frye sought to maintain an appropriate balance between the fundamental geological research needed to increase the Survey's comprehension of the geological framework of the state and the applied studies needed to answer such questions as the location and nature of ground-water sources or the availability of coal resources. An avid researcher himself, Frye generally spent several weeks each year doing field work and preparing papers on the Pleistocene deposits of Illinois.

In the late 1950's and early 1960's, explosive development of suburban communities in the Chicago region placed heavy demands on available

ground-water resources. In cooperation with the Water Survey, the ISGS opened a field office in Naperville (later moved to Warrenville) to facilitate ground-water investigations in the area and to better serve the needs of the region for geological information. Partly in response to the variety of inquiries reaching this field office, a program of research and service evolved for which ISGS hydrogeologist James E. Hackett and Chief Frye coined the new term "environmental geology" in 1963. The term included applications of geology to the solution of problems created by human occupancy of land and development of natural resources, with the goal of promoting efficient and safe use of the physical environment (2). The *Environmental Geology Notes* series was begun in 1965 to rapidly publish geological information about such topics as solid waste disposal, construction and drainage conditions, land-use planning and water and mineral resources.

Requests for environmentally related geological information prompted the development of a series of "Geology-for-Planning" studies in cooperation with municipal, county, and regional governmental bodies. Among the earliest of these contributions to the regional planning process was a 1962 study of the occurrence of ground water and the potential for ground-water pollution in the six counties encompassed by the Northeastern Illinois Regional Planning Commission.

Geotechnical and environmental studies by Chief Frye, James Hackett, John Kempton, and other ISGS scientists in 1965-66 helped the State to bid successfully in a national competition for installation of the Fermi National Accelerator Laboratory near Batavia, a community near Chicago. Following the official announcement in December 1966, ISGS scientists began detailed geotechnical studies needed to select the specific site for the 1-mile

diameter accelerator ring and other underground facilities at Fermilab.

Continuing research by Hackett and Murray McComas from the Naperville office of ISGS, and John Kempton, Chief Frye and others in the Groundwater and Stratigraphy sections in the Champaign office led to the publication in 1970 of a stack-unit mapping concept to portray the sequence of geologic units to a designated depth. Recent geology-for-planning studies have made extensive use of the capacity for creating specialized, interpretive maps from the basic stack-unit map of a region. For example, a study of Boone and Winnebago Counties published in 1984 includes 11 interpretive maps indicating such characteristics as the suitability of areas in the two counties for various types of construction practices, for septic disposal systems and for land disposal of solid wastes. Areas containing abundant resources of sand and gravel and dolomite for construction aggregates also are highlighted.

Continuing a program to publish the latest information about the basic geological framework of Illinois, Harold B. Willman, Head of the Stratigraphy and Areal Geology Section, and others compiled a new bedrock geologic map of Illinois in 1967. The map replaced the version last updated in 1945.

Chief Frye, Willman, and their colleague Herbert D. Glass studied Pleistocene stratigraphy throughout Illinois, adapting the application of standard rock- and time-stratigraphic mapping and naming procedures to the complicated Quaternary deposits. Through studies of the detailed clay mineralogy of thousands of samples of surficial deposits, Glass developed techniques for analysis of clay mineral X-ray diffraction patterns that could be used to test the recognition and correlation of Pleistocene units.



Frye's strong interest in the geology of Pleistocene deposits, and the need for Pleistocene stratigraphic studies as a framework for environmental geology studies, prompted the ISGS to establish a radiocarbon dating laboratory in 1968. The laboratory remains the only one in Illinois and commonly turns out more than 100 radiocarbon dates each year both for internal ISGS research and for outside researchers as well.

From the earliest days of the ISGS coal research program, the effects of mineral matter on the combustion properties and other characteristics of coal had been recognized and studied extensively. In 1962, Harold J. Gluskoter joined the Coal Section to work on mineral matter in coal. With funding from the U.S. Environmental Protection Agency, Gluskoter and others in the Geology and Chemistry Groups began an extended research program on the trace element chemistry of coal. In their research, they pioneered the use of low-temperature oxygen plasma ashing as a means of quantitatively separating mineral matter from coal with minimal alteration of its chemistry and mineralogy.

Using the University of Illinois' mainframe computers in the 1960's, the ISGS began a concerted program to computerize some aspects of its vast information files. With digitizing boards, section corners of the Public Land Survey grid in Illinois were entered into computer files and a program called ILLIMAP was developed to plot base maps of the state at any chosen scale. In the late 1960's, key-punch operators also began the process of entering well locations, operator name and other "header" information from more than 180,000 well records onto punch cards and later to magnetic media storage.

Through contributions and some statutory requirements, the ISGS acquired large collections of drill cuttings and cores that were the

foundation for the Subsurface Geology Section started by M. M. Leighton. In 1973, the Geological and Natural History Surveys each moved some of their activities into newly constructed facilities at the Natural Resources Studies Annex located on the outskirts of the campus. The largest part of this facility used by the Geological Survey houses the Geological Samples Library, which now contains sets of sample cuttings from more than 66,170 drill holes representing more than 740 million feet of drilling and 13,300 cores representing more than 881,000 feet of drilling. The facility also provides well-lighted space to lay out several hundred feet of core for study and temporary storage of bulk samples for the Survey's scientists. Laboratory space and microscopes are provided for visitors who wish to examine cuttings or cores, and the Samples Library staff retrieves and lays out samples or cores for visitors.

In the late 1960's to mid-1970's, ISGS scientists, in cooperation with colleagues from the University of Wisconsin-Madison and the Canadian Centre for Inland Waters, led several cruises to study the stratigraphy and bottom sediments of Lake Michigan. These studies, published in a series of thirteen Environmental Geology Notes and in refereed journals, revealed significant stratigraphic correlations with glacial sediments exposed on land, and demonstrated that heavy metals such as lead, mercury, and arsenic were concentrated in fine-grained, organic-rich sediment sinks in the deepest basins of the lake.

#### **THE JACK A. SIMON YEARS: 1974-81**

After 20 years of service to the ISGS, Chief Frye retired in 1974 to accept the position of Executive Director of the Geological Society of America in Boulder, Colorado. As his successor, the Board of Natural Resources and





Figure 5.--The fifth, sixth, and seventh chiefs of the Illinois State Geological Survey: (l to r) Jack A. Simon, 1974-81; Morris W. Leighton, 1983-present; Robert E. Bergstrom, 1981-83.

Conservation named Jack A. Simon (fig. 5), a man who had spent his entire career at the ISGS. A native of Urbana, Illinois, and a graduate of the University of Illinois at Urbana-Champaign in geology, Simon had first worked at the Survey from 1937 to 1942 as a part-time undergraduate and graduate assistant. After war-time service as a navigator in the Army Air Force, Simon returned to the Coal Section of ISGS, completed his M.S. in geology at the University of Illinois in 1947 and began work in the Ph.D. program in geology at Northwestern University in Evanston. Upon the retirement of Gilbert H. Cady in 1951, Arthur C. Bevan, then Head of the Geology Group, was also named Acting Head of the Coal Section, but Simon replaced him as Coal Section Head in 1953. In 1967, Simon was named Principal Geologist and Head of the Geological Group upon M. L. Thompson's retirement from that position. He also served as Assistant Chief under John Frye during the period 1973-74.

From 1972 to 1976, the Governor imposed severe budgetary constraints on some branches of government in order to increase spending in other branches. Reserves on spending authority, and reductions or level

funding of operating lines in the face of heavy inflationary pressures forced Frye and Simon to direct increasing percentages of the Survey's resources into salaries to preserve the core staff of state-paid scientists and engineers needed to maintain research and service programs. Of necessity, the Geological Survey began to turn to nonstate funds in order to begin important new projects.

Reports on strippable coal resources published occasionally since the 1950's had continued to use hand planimetry of base maps to measure areas of various coal thickness categories. With assistance from the U.S. Geological Survey, ISGS began an extensive reassessment of coal reserves and resources in Illinois. Using a digitizing board and a small computer to carry out the complex calculations of reserves and resources, Colin Treworgy and other staff members of the Coal Section published new estimates of statewide reserves and resources of strippable coal in 1978, and of deep-mineable coal in 1982.

In 1973 and again in 1974, Lake Michigan reached historically high water levels and winter storms caused rapid erosion and damage to structures along the Illinois shore. During this period, Charles Collinson, who had become Head of the Stratigraphy and Areal Geology Section in 1968 when H. B. Willman retired, instituted an extensive program for riparian property owners and municipalities seeking technical advice on the best ways to protect shore properties. The program included regular monitoring of shore recession rates through low-level aerial reconnaissance flights along the shore, detailed bathymetric mapping, and studies of the stratigraphy and engineering properties of glacial deposits in the bluffs along the northern reaches of the Illinois shore. These studies were continued at modest levels, even when the lake fell to less threatening levels

during the late 1970's. When Lake Michigan again rose to dangerous levels in the 1980's, the Geological Survey was able to use its storehouse of data to offer immediate responses to municipal, county, state and federal agencies that needed information about the extent of damage caused by severe winter storms in February 1987, and advice on the efficacy of various shore protection measures.

In 1978, as a culmination of years of effort, Jerry A. Lineback of the Stratigraphy and Areal Geology Section completed the compilation and scribing of a new Quaternary Deposits Map of Illinois. The map, published in 1979, was the first state-wide Pleistocene map for Illinois to emphasize map units based on lithology rather than geomorphology.

In May and June of 1979, the ISGS hosted the technical sessions of the Ninth International Congress of Carboniferous Stratigraphy and Geology. This quadrennial meeting, held in the United States for the first time in part to honor the U.S. Geological Survey's centennial celebration, brought more than 600 scientists from 25 foreign countries to Champaign-Urbana to listen to symposia and lectures, review manuscripts, and examine and discuss scientific problems.

The educational functions of the Department of Registration and Education had been transferred to other agencies shortly after World War II, and, thereafter, the Scientific Surveys and the State Museum were the only nonregulatory divisions remaining in the Department. In 1978, the Scientific Surveys, the State Museum, some energy research and planning functions of the Department of Business and Economic Development, and the environmental research arm of the Illinois Environmental Protection Agency, the Institute for Environmental Quality, were merged into a new Institute of Natural Resources, and, in 1981, under

revised enabling legislation, the Institute became the cabinet-level Department of Energy and Natural Resources (DENR). All previously existing relationships with the Board of Natural Resources and Conservation, the University of Illinois and other agencies were left intact.

In February 1981, Jack Simon suffered a severe stroke while attending a meeting in Chicago. To replace Simon, the Board of Natural Resources and Conservation named Robert E. Bergstrom (fig. 5), then Assistant Chief and Head of the Geological Group, Acting Chief of the Survey.

#### **THE ROBERT E. BERGSTROM YEARS: 1981-83**

A graduate of Augustana College with a B.A. in English, Bergstrom joined the ISGS in 1953 immediately after receiving his M.S. and Ph.D. degrees in geology from the University of Wisconsin-Madison. Although trained primarily in Paleozoic stratigraphy, at the ISGS Bergstrom's research concentrated on ground-water resource exploration and, later, geology-for-planning studies. As Head of the Geological Group in the 1970's, and later as Chief, he especially encouraged the environmental geology studies in Boone and Winnebago Counties.

In the late 1970's and early 1980's, under the Federal Lands Unsuitable for Mining Program (LUMP), the Scientific Surveys seized an opportunity to make a major advance in machine-processing of geographically based information. With matching funds from the federal and state governments, a large mini-computer and other hardware were acquired, specialized programs for handling geographically based data were purchased, and a contractor was hired to digitize many of the Scientific Surveys' data bases. By late 1983, the Scientific Surveys had set up a computerized Geographic Information System with one of the largest initial

data bases in the world, a large part of which consisted of the basic well data file, the land survey grid system and other ISGS files.

The problem of sulfur in coal has been a major theme of ISGS coal research programs throughout the years. Recognizing that the high sulfur content of Illinois coals poses both a threat to the environment and to the markets of Illinois' coal mining industry, the ISGS established a research program to find ways to remove sulfur from coal before it is burned. In 1982, remodeling of the Applied Research Laboratory was completed and many of the chemical and minerals engineering aspects of the coal desulfurization research program were moved into these facilities. Neil Shimp, an expert in spectrochemical analysis who joined the Chemistry and Minerals Engineering Group staff in 1957 and was named Head of the Group in 1973, was instrumental in advancing this research program and in furthering plans to provide substantial support for the research from the state's Coal Development Bond Fund. To coordinate the state's research in coal desulfurization, Chief Bergstrom, Neil Shimp, and Dr. Carl Kruse helped to establish the Center for Research on Sulfur in Coal (CRSC). Shimp was named Acting Director until a search for a full-time director could be completed.

#### **THE M. W. LEIGHTON YEARS: 1983-PRESENT**

On September 16, 1983, Morris W. Leighton (fig. 5), middle son of the former Survey Chief, took up the reins that his father had relinquished 29 years earlier. The younger Leighton received his B.S. degree in chemistry from the University of Illinois in 1947, and his M.S. and Ph.D. degrees in geology from the University of Chicago in 1948 and 1951, respectively. Upon graduation, he joined the staff of Carter

Oil Company, a subsidiary of the Standard Oil Company, and remained with various subsidiaries of Standard Oil (Exxon) throughout his career. Before retiring from Exxon in 1983, he had been Chief Geologist for Esso InterAmerica, the company's South American exploration arm.

Shortly after taking over the ISGS, M. W. Leighton reorganized the administration of the Survey to more closely mirror the activities being carried out by the various Sections. In the 1930's, M. M. Leighton had gathered the various scientific and nonscientific sections into related Groups, each under a Group Head. Over time, sections had proliferated as the staff grew in numbers and the Geological Group now consisted of nine sections. To bring closely related research functions together and reduce the large Group to units of a more manageable size, Leighton split the Geological Group, creating the Mineral Resources Group containing the Coal, Oil and Gas, Industrial and Metallic Mineral Resources, Geological Samples Library and Mineral Economics sections, and the General and Environmental Geology Group containing the Groundwater, Computer Research and Services, Environmental Studies and Assessment, and Earth Hazards and Engineering Geology Sections. The Chemistry and Minerals Engineering Group, containing the Analytical Chemistry, Geochemistry, and Minerals Engineering Sections, remained largely unchanged under the new organization, as did the Administrative Services Group.

Although the ISGS had begun to study geologic issues related to siting of waste disposal facilities and the interactions of earth materials with organic chemicals and landfill leachates during the mid-1960's, waste management research programs had begun to grow rapidly in the 1970's. Robert A. Griffin joined the Geochemistry Section



in 1973 and embarked on a program to evaluate the ability of earth materials to adsorb organic chemicals and thereby attenuate the concentrations of potentially hazardous leachates from landfills. That laboratory research ultimately led to the development of standard techniques for the measurement of adsorption characteristics of earth materials.

Recognizing the need to further expand research efforts on the impacts of hazardous wastes, Chief Leighton, Keros Cartwright (the new head of the General and Environmental Geology Group), and Robert Griffin worked with the other two Scientific Surveys and DENR to establish a new organization, the Hazardous Waste Research and Information Center (HWRIC), within the State Water Survey.

A major emphasis of the ISGS research program in Waste Management has been directed at field studies of the movement of fluids through saturated and unsaturated geologic materials. For example, with funds from the U.S. Environmental Protection Agency and from the landfill operator, ISGS scientists conducted intensive geological and geochemical studies during the exhumation of a leaking hazardous waste landfill at Wilsonville to determine why this apparently well-sited disposal facility had failed. Hydraulic conductivities of the glacial materials measured by ISGS in the field explained the leakage rates observed in monitoring wells at the facility, whereas measurements made in the laboratory on repacked soil samples, the accepted test method when the facility was constructed, gave hydraulic conductivities two to three orders of magnitude too low. As a result of the ISGS investigations, in situ hydraulic conductivity measurements are now routinely required when applying for a site permit for a hazardous waste disposal facility in Illinois.

The expertise of the ISGS in studies of the movement of fluids through porous media is now being applied to a field study of fluid transit times in earthen liners for solid waste disposal facilities. An instrumented, full-scale model earthen liner 3 feet thick has been constructed to conduct controlled experiments on fluid movements through low permeability materials. Tests on a prototype liner constructed on a somewhat smaller scale showed that liners built from Illinois till with normal construction methods can meet U.S. Environmental Protection Agency requirements for a hydraulic conductivity no greater than  $10^{-7}$  cm/sec.

With the formation of the CRSC and recognition by the Illinois Coal Development Board of the research expertise in the geology, petrology and chemistry of coal available at the ISGS, funding for sulfur-in-coal research has rapidly expanded. From its inception in the spring of 1982 through fiscal year 1988, the CRSC has awarded more than \$3.3 million in state Coal Development Board and other funds to the ISGS to conduct various projects in coal desulfurization research. These research funds have provided for the addition of staff with expertise in process engineering and the installation of a well-equipped thermal analysis laboratory.

Two coal desulfurization techniques developed at the ISGS in cooperation with researchers at Southern Illinois University and other institutions show particular promise and are being extensively tested and evaluated. The aggregate flotation process uses special surfactants to physically remove 80 percent or more of the pyrite and other ash minerals from finely ground coal while recovering 80 percent or more of the combustible material. The second technique, the carbon monoxide/ethanol process, currently uses three reaction steps to remove organically bound sulfur from coal.



When the possibility of constructing the Superconducting Super Collider (SSC) particle accelerator facility was first discussed by the high energy physics community and preliminary schedules for the project were released by the U.S. Department of Energy in 1984, Governor James Thompson of Illinois moved quickly to develop a detailed proposal for the state. The ISGS used its previous experience in the nationwide competition for the siting of the Fermi National Accelerator Laboratory, won by Illinois 20 years earlier, to recommend to the Governor's SSC Task Force the geotechnical and environmental studies that would be required to prove the suitability of a site in Illinois. Recognizing that many of the criteria that favored siting Fermilab in Illinois were also valid for the SSC, and that the Fermilab facilities constituted a significant advantage to the state's proposal, it was decided initially to determine whether a site adjacent to those facilities was feasible. After preliminary screening of existing data in the files of the three Scientific Surveys showed that the area west of Fermilab contained no geological or environmental "fatal flaws," the ISGS and its sister agencies embarked on a complete geotechnical and environmental investigation of the region that included 16,374 feet of exploratory drilling, examination and testing of 10,574 feet of bedrock core and detailed geophysical and hydrogeologic studies. The Geographic Information System has played a major part in the development of the state's proposal and will significantly reduce the cost of determining the optimum location for the SSC tunnel if Illinois is selected.

The period 1984 through 1987 brought major capital investments for new scientific equipment. Chief Leighton and Neil Shimp, working with the Chiefs of the other two Scientific Surveys, DENR and the Board of Natural Resources and Conservation

pushed for legislation to earmark more than \$3.9 million in appropriations from Governor Thompson's "Build Illinois" program for new scientific instruments for the three Scientific Surveys. Some major additions at ISGS include a new x-ray diffractometer, x-ray fluorescence spectrometer, gas chromatograph-mass spectrometer, scanning electron microscope, isotope ratio mass spectrometer, porosity-permeability analyzer, carbon-hydrogen-nitrogen analyzer, liquid scintillation counter, and necessary site modifications for installation of the new instruments. These acquisitions allow the ISGS to operate more efficiently, open new avenues of research and help to attract and retain qualified staff. In addition, the state's Capital Development Board has approved expenditure of nearly \$900,000 to remodel and upgrade some of the older laboratories in the Natural Resources Building and the Natural Resources Studies Annex. Additional funds will be used to install a modern fire alarm and smoke detector system throughout the Natural Resources Building.

### THE FUTURE

Large-scale, interdisciplinary, multiagency research projects have become a major aspect of ISGS research programs. Currently the ISGS is coordinating or leading several cooperative programs involving federal and other state agencies. Each of these programs includes data-base automation elements that will increase the public and private sectors' access to ISGS information.

Basic geologic mapping will continue to be a major part of future ISGS programs. Through the leadership of Heinz Damberger, Head of the Coal Section, ISGS recently released the first three geologic quadrangle maps of a planned series of 16 under the U.S. Geological Survey's Cooperative Geologic Mapping Program. Those maps

also form a core of research and modern control for the Paducah 1° by 2° sheet in the Conterminous U.S. Mineral Assessment Program. The ISGS and its sister agencies in Indiana, Kentucky, and Missouri are cooperating with the USGS to complete the necessary mapping, data compilation, and topical studies for this region by 1990. This will be the first CUSMAP project to make extensive use of automated mapping and GIS capabilities. Other CUSMAPs on the Upper Mississippi Valley Zinc-Lead District are being considered.

In cooperation with the U.S. Bureau of Mines, ISGS is coordinating the Illinois Mine Subsidence Research Program. With state and federal funds, ISGS researchers led by Paul DuMontelle, Head of the Earth Hazards and Engineering Geology Section, and their colleagues from several Illinois universities are seeking the information needed to develop mining guidelines that will allow Illinois' underground coal mines to utilize high-efficiency mining methods while protecting the productivity of overlying prime farm lands. ISGS also will continue its efforts to protect Illinois' coal markets by developing new coal cleaning and desulfurization techniques.

With funds from the State and from the U.S. Department of Energy, Donald Oltz, Head of the Oil and Gas Section, and other ISGS scientists are planning a major research program directed toward detailed geological, geophysical, geochemical and mineralogical reservoir characterization in order to advise the many small, independent oil producers in Illinois about oil well completion and production practices

that will provide the maximum possible recovery of unswept mobile oil remaining in the ground.

Representing a consortium of more than 125 scientists from numerous universities and other organization, J. James Eidel, Head of the ISGS Mineral Resources Group coordinated the submission of a proposal to drill the Illinois basin Ultradeep Drillhole (IBUD) at a site in the deepest part of the Illinois Basin. The ISGS is continuing to develop the IBUD proposal as a linchpin in a package of continent-wide seismic profiling and research drilling patterned after the successful Ocean Drilling Project.

ISGS Senior Geologist Dennis Kolata is leading a Basin Analysis Task Force within the ISGS' Mineral Resources Group charged with coordinating a research program that will create modern quantitative models of the burial, thermal and geochemical history of the Illinois Basin.

As the ISGS approaches its first centennial in 2005, it remains one of the leading geological research institutions in the country. With the State of Illinois' long history of scientific research support, we expect to continue our tradition of leadership throughout our second century.

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## INDIANA

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### HISTORICAL SEQUENCE OF ORGANIZATIONAL NAME:

Geologist for the State of Indiana, 1837-39  
State Geologist, 1859-61  
Department of Geology and Natural Science, 1869-70  
Department of Statistics and Geology, 1879-81  
Department of Geology and Natural History, 1881-89  
Department of Geology and Natural Resources, 1889-1918  
Division of Geology, Indiana Department of Conservation, 1919-51  
Geological Survey, Indiana Department of Conservation, 1951-64  
Geological Survey, Indiana Department of Natural Resources, 1965-present

### NAMES AND TITLES OF ORGANIZATIONAL DIRECTORS AND DATES SERVED:

David Dale Owen, Geologist for the State of Indiana, 1837-39;  
State Geologist, 1859-60  
Richard Owen, State Geologist, 1860-61  
Edward Travers Cox, State Geologist, 1869-79  
John Collett, State Geologist, 1880-84  
Maurice Thompson, State Geologist, 1885-88  
Sylvester Scott Gorby, State Geologist, 1889-94  
Willis Stanley Blatchley, State Geologist, 1895-1910  
Edward Barrett, State Geologist, 1910-18  
William Newton Logan, State Geologist, 1919-36  
Ralph Emerson Esarey, State Geologist, 1936-45  
Charles Frederick Deiss, State Geologist, 1945-59  
John Barratt Patton, Director and State Geologist, 1959-86  
Norman Curtis Hester, Director and State Geologist, 1986-present

### HISTORY OF THE INDIANA GEOLOGICAL SURVEY

By John B. Patton

#### THE EARLY YEARS

On February 6, 1837, in the 20th year after Indiana achieved statehood, the State legislature approved an act that began with the words:

Be it enacted by the General Assembly of the State of Indiana, That the Governor be and is hereby authorized and required annually hereafter to appoint and commission a person of talents, integrity,

and suitable scientific acquirements as Geologist for the State of Indiana, who shall receive in consideration of his faithful performance of his duties an annual salary not exceeding \$1500.00 and necessary expenses not to exceed \$250.00, to be paid as the salaries of other civil officers of the State.

Where to find a person of talents, integrity, and suitable scientific acquirements in any sparsely populated frontier state of that era might have proved to be a problem, but Indiana was the home of a person so well fitted for the role that we must wonder whether the position was not created to utilize

his talents. The man was David Dale Owen (fig. 1), one of the sons of Robert Owen, who had purchased the town of New Harmony, on the Wabash River in Posey County in 1824.



Figure 1.--David Dale Owen, Geologist for the State of Indiana, 1837-39; State Geologist, 1859-60.

And how did it happen that David Dale Owen, as well as his brother Richard, became geologists? Surely we must attribute the circumstance in considerable part to the fact that William Maclure had, in 1825, become a partner with Robert Owen in the ownership of New Harmony.

Self-trained in geology, Maclure accumulated a fortune in business at an early age and was then able to devote years to his avocations, geology and applied public education, with such success that he has been referred to as the father of American geology and the William Smith of America, and the first chapter of Merrill's volume (1924) *The First 100 Years of American Geology* is entitled "The Maclurian Era, 1785-1819."

Maclure's reputation was established before he came permanently to North America. His geologic investigations and publications in this country, including some of the first regional maps showing the eastern portion of the continent, added to his luster, but this work preceded his investment in New Harmony. He continued to publish, mostly on topics of global scale, through 1832, but his work did not emphasize the geology of midwestern North America, although the last two of his American papers were published in New Harmony.

It was Maclure, without doubt, who attracted other eminent geologists to New Harmony and gave to the New Harmony cultural and scientific movement a geologic flavor that was unique in the New World. The most lasting impact that Maclure had on American geology may well have been the inspiration that he afforded to the then-young David Dale Owen, a person of great talent but without specific direction of interest until about 1835, after Maclure's departure from New Harmony. Maclure himself, his immense collections, and the eminent scientists that he attracted to New Harmony must have been major factors in Owen's decision to become a geologist. For this purpose he entered medical school at Cincinnati and received the M.D. degree, apparently with no intent of becoming a practicing physician but because he regarded medical training as the best method of filling the gaps in his scientific knowledge. He had already some expertise in chemistry, and he thought it necessary to master physiology and anatomy in order to work with fossils that were the key to deciphering the geologic record in the Midwest. In 1836, apparently between sessions of his medical training, Owen assisted Dr. Gerard Troost, then State Geologist of Tennessee, in a survey of that state. Troost, a Hollander, had spent a period



in New Harmony during 1825 to 1827, when Maclure was there.

In the course of horseback traverses in 1837, Owen determined the stratigraphic succession of the bedrock (Owen, 1838, p. 11-19) and accurately placed the units in relation to the time scale that was evolving for systemic nomenclature in Great Britain. He correctly separated the systems that later became in America the Mississippian and Pennsylvanian, and he distinguished between the rocks that form the present-day Ordovician and Silurian Systems, even though the Ordovician System was not proposed by Lapworth until 1879. To accompany his reports, Owen prepared in 1838 an outline map of the geology of Indiana that was never published but was deposited in the State Library, from which it must have been lost or taken before many years had passed, as there appears to be no certain reference to it except Owen's own. In the report for 1838 (Owen, 1839, p. 40-45) he described what he termed "The accompanying map" in sufficient detail to establish the fact that the boundaries shown must have been essentially the same as those shown on a map printed as part of an Owen paper published in England (1846). A reprinting of the report for 1838 (Owen, 1859, p. 53) carries an asterisk after the words "The accompanying map . . ." and the footnote "The original map, here referred to, was deposited in the State Library, but has not been published."

Further reference to the 1838 Owen map may have been intended by Brown (1854) in the words:

The labors of Dr. Owen, some years ago, have furnished us with an outline map of the Geology of the State, so that the lines of outcrop of the several formations are pretty accurately defined.

But by then Owen's 1846 map, which covered much territory outside Indiana, was available, and so we cannot be certain that Brown's comment affords

evidence that Owen's earliest map of the state was still in the State Library.

That Owen was able to tie the European and American continents together stratigraphically, carrying on precedents set by Maclure and Samuel George Morton, may not seem today to have been a notable accomplishment, but we are speaking of an era in which much of the stratigraphic work was done in a manner that did not offer any correlation between the rocks described and strata elsewhere. Stratigraphic units were most commonly named at the time by their lithologic characteristics, and Owen's were no exception, but their boundaries accorded with those of the classic British systems. His coal formation was the equivalent of the Upper Carboniferous of Great Britain, now the Pennsylvanian System in North America. The map correctly separated British Lower Carboniferous that became our present Mississippian System from the underlying Devonian and Silurian Systems of the time. A boundary that encircled the crest of the Cincinnati Arch delineated the top of the then Lower Silurian that became the Ordovician System. In establishing the time relationship of these units with the classic British type sections, Owen extended traditional stratigraphic treatment into a region more than 6,000 miles from the home base and thus furthered the concept of global chronostratigraphy.

The Fenton and Fenton volume *Giants of Geology* (1942, p. 163) commented unfavorably on the tendency for geologists of that time to restrict their interests to the collection and identification of fossils, but they quoted from the first Owen report (1838, p. 4) as follows:

I have considered it my duty, while surveying a country so new as ours, to remember, that a State just settling, is like a young man starting in life, whom it behooves to secure to himself a competency, before he indulges in unproductive fancies. I have considered it the most important

object, to search out the hidden resources of the State, and open new fields of enterprise to her citizens. That object effected, time enough will remain to institute inquiries (which a liberal policy, forbids us to overlook) of a less productive and more abstract character; inquiries which are interesting in a scientific, rather than a commercial, point of view.

The Fentons continued, "a sane as well as practical rule, and one which made the man who framed it America's first great economic geologist."

Owen correctly predicted (1838, p. 26) that commercial coal would not be found beneath the uppermost of the limestones that are now classified as Mississippian in age. He called attention to both limestone and sandstone suitable for building stone, to clays and shales usable for ceramic ware, to natural cement rock, to iron ores that would suffice for the small-scale recovery operations of that day, to rock units that could be fashioned into whetstones and rotary grindstones, and to sand and gravel deposits. Owen did not actually discover all of these mineral resources, as most had already been noted and used, but he placed the materials into a geologic order that permitted a scientific approach to their location.

The Owen survey failed to mention only two of the resources that have contributed in any substantial measure to the mineral economy of the state during the ensuing 150 years, petroleum--and we should remember that his work preceded the drilling of the Drake well at Titusville, Pennsylvania, by more than 20 years--and gypsum, which does not appear at the surface in Indiana and was not recognized as having economic potential until the 1950's.

Political support was strong for continuation of the Indiana survey, but the opposition was strong also. Not until 2 days before the end of the 1839 legislative session was a bill for continuation approved, and it was

amended to cover only 1 year instead of the proposed 3 years. Although the bill passed in February 1839, the governor did not immediately appoint Owen for continued service, and reappointment was not offered until June; by then David Dale Owen had become interested in, and was fairly assured of receiving, appointment as a geologist for the federal government. He declined the Indiana appointment. State-supported geologic investigations in Indiana virtually ceased for a period of 20 years, except for employment from 1851 to 1853 of Ryland T. Brown as Geological Agent for the State Board of Agriculture and a single published geologic report (Brown, 1854) that resulted from the assignment.

Certainly the geologic activities of David Dale Owen and a number of his professional colleagues, including his brother Richard, did not cease, and New Harmony remained a center for geologic work, but most of it did not concern Indiana geology (Hendrickson, 1943; Patton, 1979, 1987; Patton, Millbrooke, and Nelson, 1983).

Maclure had died in Mexico in 1840, and at the request of Maclure's heirs Owen spent some time classifying the huge Maclure collection, to which he added many items from his own fieldwork. He made a lengthy collecting trip along the Ohio River in 1841, and the resulting 2 tons of material exceeded the capacity of the building that he was then using as a laboratory, the second in a series. Maclure's sister then gave him a large building (fig. 2) that had been constructed of sandstone and brick by the Harmonists for use as a granary and that has been called the "Old Fort." He remodeled it extensively, and it came to be known as "The Laboratory." It contained storerooms, workrooms, and a large lecture hall, as well as exhibit space. In 1846 the noted British geologist Sir Charles Lyell, with Lady Lyell, was the guest of the Owens, and Sir Charles "spent much time in

Owen's laboratory and carefully inspected the fossil and mineral cabinets. In company with Owen he visited various points of geological importance in the neighborhood" (Hendrickson, 1943, p. 69). Soon afterward Owen and Joseph Norwood, who later became State Geologist of Illinois, explored central Kentucky, apparently on their own and without other financial backing.



Figure 2.--Harmonist granary (the "Old Fort") at New Harmony, David Dale Owen's laboratory and now (in modified form) the property of Kenneth Dale Owen.

In 1854 the Kentucky Assembly approved a geological survey of that state, and the governor selected Owen to head it. In 1857 the governor of Arkansas offered Owen appointment as State Geologist for a first survey of that state, and Owen accepted the appointment after arranging with the governor of Kentucky to continue direction of the Kentucky survey without salary.

During the years of Owen's involvement in surveys of the territories and of Kentucky and Arkansas, efforts had continued to resume state-supported geologic work in Indiana. These efforts were successful in 1859, when the General Assembly authorized a Geological Survey under the super-

vision of the State Board of Agriculture and created (anew) the office of State Geologist. The board wished no one but Owen to supervise the work, and Owen accepted the assignment with the provision that his brother Richard would begin the study and pursue it until the Arkansas survey was completed. Richard Owen conducted a 65-day field season beginning in September and returned to New Harmony with 1,000 pounds of specimens. David Dale Owen reported to the State Board of Agriculture in Indianapolis in January 1860 on the progress of the work and plans for the following season, during which Richard Owen concentrated principally on the Coal Measures.

David Dale Owen had in the meantime further complicated his life by undertaking the construction of a new laboratory (fig. 3) in New Harmony to serve the former functions of the old granary. He designed every aspect of the new building and supervised the construction.

Since the 1854 field season in Kentucky, he had been in poor health from bouts with some fever, and to these miseries were added those of acute rheumatism in October 1860. His biographer, W. B. Hendrickson, recounted (1943, p. 130-131) that Owen was bedfast and dictating the second Arkansas report to two secretaries. His personal physician warned him, "Doctor, if you go on thus you will die in a week." Owen's reply was, "I only want 13 days to finish." He continued dictation until 3 days before his death on November 13, 1860, at the age of 53. J. P. Leslie wrote to James Hall, "Poor Owen is dead, suicide!" which in a sense was true; Hendrickson observed, "David Dale Owen literally worked himself to death."

#### THE SECOND INDIANA SURVEY

The second Indiana survey was completed by Richard Owen (1862 and



Figure 3.--David Dale Owen's fourth laboratory, built in 1859; now the New Harmony residence of Kenneth Dale Owen; south end of the third laboratory, with a gable roof installed after a fire, may be seen to the right.

fig. 4), who was appointed State Geologist to succeed his brother. That the report, except for sections credited to Dr. Robert Peter, Prof. Leo Lesquereux, and Mr. J. P. Leslie, was largely Richard Owen's work is clear.

It should be noted that the two Owen surveys of Indiana conducted in 1837 to 1839 and 1859 to 1861 were in charge of a person rather than an organization. The funds for salary and expenses were paid through the budget of the Indiana Department of Agriculture, but David Dale and Richard Owen were free to hire whom they chose and be reimbursed for such expenses as they incurred, all within the dollar limit set by the enabling legislation.

On March 5, 1869, the Indiana General Assembly approved An Act providing for a Geological Survey and for the collecting and preserving of a Geological and Mineralogical Cabinet of the Natural History of this State, and creating the Office of the State Geologist, defining his duties,



Figure 4.--Richard Owen, State Geologist, 1860-61.



fixing his salary, and appropriating a sufficient sum of money to defray the necessary expenses of said Survey and for the collection and preservation of said Cabinet.

A new organization named the Department of Geology and Natural Science was established under the State Board of Agriculture, and Edward Travers Cox (fig. 5) of New Harmony, a former associate of the Owens in various investigations, was named to head it, which he did for 10 years, turning out 10 annual reports published in seven volumes.



Figure 5.--Edward Travers Cox,  
State Geologist, 1869-79.

In 1879 legislation replaced the Department of Geology and Natural Science with a Department of Statistics and Geology. The salary of the State Geologist was lowered appreciably, as were the operating funds, and the duties were vastly expanded in nongeologic directions. Cox declined to continue, and John Collett, who had served as an assistant to Cox, was appointed and accepted. The new department lasted only 2 years, and in 1881 a Department of Geology and Natural History was established. The term of appointment for the State

Geologist was increased from 2 to 4 years. Collett continued in the position and turned out four annual reports.

Between 1869 and 1884 Cox and Collett had been dutifully listed as faculty members *ex officio* in the Indiana University catalogs without, so far as can be determined, having any involvement with the academic program.

Collett had been appointed to a 2-year term by a governor who was a Democrat and a 4-year term by the next governor, who was a Republican. A Democrat was elected governor in 1884 and appointed Maurice Thompson, who was a civil engineer and a successful author of fiction. He served only 3 years, from 1885 to 1888. Two annual reports were issued during his tenure, and their geologic high points were new information concerning the thickness and character of the glacial drift, confused interpretation on the part of both Thompson and his assistant S. S. Gorby on the Niagaran reefs at the surface in northern Indiana, and the first accounts of the discovery of natural gas.

Thompson resigned before his term was completed but after the election of 1888, and the outgoing governor appointed Sylvester S. Gorby to fill the position. The new governor was a Republican, but the legislature remained firmly in the hands of the Democrats, and they set out to remove the governor's veto, abolished the Department of Geology and Natural History and the appointive office of State Geologist connected therewith, and established a new Department of Geology and Natural Resources, to be headed by a Director elected by the **General Assembly**. The legislature then appointed (not elected) Gorby "State Geologist." The new governor refused to recognize the act, and in March 1889 he appointed Collett to the post. Gorby declined to give up the office, and Collett apparently did not

press the issue. In November the Supreme Court held that the legislature had no power to create an office and then fill it; the choice must be made by the governor or by popular election. Gorby managed to hold on until 1890, when he was nominated by the Democrats and won the election.

The sixth State Geologist of Indiana, Willis Stanley Blatchley (fig. 6), was, in the writer's judgment, the greatest builder of program strength during the first century of the period covered by this study. He served from 1895 to 1910--a longer period than any of his predecessors; time in office is surely a factor in establishing a program, but from the beginning of his tenure he demonstrated an unusual ability to identify and attract capable scientists, either to work for his organization or to publish the results of their investigations in the annual reports without being paid. The authors of the papers in annual reports issued during the Blatchley years constitute a merit list in geology. Blatchley was primarily an entomologist rather than a geologist; he established an enviable record of productivity with meager funds--the sign of an able administrator.

In the election of 1910 Blatchley was defeated by Edward Barrett, who served two 4-year terms during which an increasing proportion of the published work was in the form of county soil surveys, and this concluded a period of 28 years during which the office was elective.

Indiana state government underwent massive changes when a reorganization act was passed early in 1919 and took effect in April of that year. The Indiana Department of Geology and Natural Resources was abolished, and its responsibilities were assigned to a Division of Geology within a newly created Department of Conservation. Because the office of State Geologist was elective, it had to be



Figure 6.--Willis Stanley Blatchley, State Geologist, 1895-1910.

placed on the ballot in 1918, even though it was virtually certain to terminate. The victor was Louis Roark, who was a new faculty member in the Department of Geology at Indiana University. He never served in the office to which he was elected. In the new arrangement the Division heads were appointive, and the governor designated William M. Logan, who had joined the Indiana University faculty with the 1916-17 academic year, to head the Division of Geology concurrently with his academic duties. With Logan's appointment there began the closest alliance between the University's Department of Geology and the state program that has ever existed. An office that managed such regulatory matters as drilling permits and plugging of wells continued in Indianapolis, but the office of the State Geologist was on the Bloomington campus, and faculty members and students carried out most of the investigations, many of them through summer field parties. The annual reports that had been issued for so many years and that had included, in single-volume bound form, all the year's publications became brief admin-

istrative accounts of the year's activities; scientific papers were issued, generally separately, within a numbered Department of Conservation series that included publications from other divisions. An exception was the *Handbook of Indiana Geology* (Logan, 1922), which contained six parts and ran to 1,120 pages. Included was C. A. Malott's "The Physiography of Indiana," in which Malott named and described seven bedrock physiographic regions that cover all of southern Indiana south of the Wisconsin glacial boundary and extend, recognizable from subsurface records, beneath the thickening glacial drift to the north. Dr. Malott preferred to term himself a physiographer rather than a geomorphologist, and the writer believes that he was correct in doing so. He had the unusual ability to describe terrane in a manner that made it recognizable to persons seeing it for the first time. In the years since Malott named the physiographic units, no changes have been made in their designation, possibly because Malott described them so well. Another part of the *Handbook* is John Robert Reeves' paper "Preliminary Report on the Oil Shales of Indiana" (1922), a work that has received much attention during the past 1 1/2 decades of energy concerns.

Another example of the University-state agency cooperative effort referred to is the Indiana Department of Conservation Publication 75, *Geology of the Silurian Rocks of Northern Indiana* (1928), one of a triumvirate of papers by E. R. Cumings, Chairman of the Department of Geology at the time, and his graduate student Robert R. Shrock. The three papers were fundamental works on reefs and their environment, and they have joined the ranks of classics. Reef geology, largely neglected during much of the time since Darwin's day, was principally of academic interest at the time of the Cumings and Shrock studies, but its significance to

petroleum geology brought it to the forefront in the 1940's.

Dr. Logan retired after the 1935-36 academic year, and Ralph Emerson Esarey became State Geologist and served until 1945. During his tenure in office two external events greatly affected the Survey and its activities. A major new oil play developed in the Illinois Basin and spread to the Indiana portion by the latter 1930's; subsurface information became available at a rate that made it difficult to record and impossible to digest. The Indianapolis office from which the Survey's regulatory functions were administered was hard pressed, and the entry of the United States into World War II in 1941 caused constant change, and ultimately diminution, of staff.

#### THE CHARLES F. DEISS YEARS

Near the end of World War II, President Herman B Wells of Indiana University proposed to the Indiana Department of Conservation that the Geological Survey and the Department of Geology be directed by a single head and that the Department of Geology faculty constitute most of the professional staff of the Survey. Research Associateships and funds for field expenses were to be supplied through the Conservation budget. The search for a new head resulted in the selection of Charles F. Deiss (fig. 7), then head of the Department of Geology at Montana State University at Missoula, to be Chairman and State Geologist. He arrived in 1945 and began immediately to build staff. The Geological Survey grew under his direction to a staff of about 50 in a dozen years. At his request the Survey was freed by legislative act in 1947 of regulatory authority and duties related to the petroleum industry, and a separate Division of Oil and Gas in the Department of Conservation was established.



Figure 7.--Charles Frederick Deiss,  
State Geologist, 1945-59.

The plan to use departmental faculty as professional staff for the Survey proved, after about a year, only partially successful, and Dr. Deiss moved the organization systematically toward a staff of its own. When this writer came to the Geological Survey in 1947, the Survey consisted of a Petroleum Section with two professional employees and had an excellent drafting and photographic unit. The mission was to establish a program in industrial minerals and head a new section with that name. Geochemistry laboratories were set up in 1948 and section status was given to the field of geochemistry in 1952. A publications office, a Coal Section, and a Geophysics Section were established at the beginning of the 1950's.

The name of the organization was changed, by act of the General Assembly, from Division of Geology to Geological Survey in 1951. Paleontology and Glacial Geology Sections were established during the 1950's and fused into a Geology Section in 1959.

## THE JOHN B. PATTON ERA

The rapid expansion of both the Geological Survey and the Department of Geology during the latter 1940's and the 1950's had posed imperative space needs to which Indiana University responded valiantly. The two organizations were headquartered in Owen Hall (fig. 8) but occupied parts or all of 11 buildings when consolidation into the present quarters (fig. 9) took place in 1962 for the Department and 1964 for the Survey.



Figure 8.--Owen Hall, oldest building on the Bloomington campus of Indiana University, housed the State Geologist's office and some of the Geological Survey's working quarters from 1937 until 1962.

At the beginning of the 1965-66 fiscal year, the Survey's parent organization, the Department of Conservation, was fused with the Indiana Flood Control and Water Resources Commission into a new Indiana Department of Natural Resources that was divided into two Bureaus, and the Geological Survey became a division of the Bureau of Water and Mineral Resources. With each expansion of the chain of command, a unit such as the Geological Survey was farther removed from top management of state government.





Figure 9.--Geology Building on the Indiana University campus in Bloomington; only Geological Survey wing shown.

When Dr. Deiss died in 1959, the writer became State Geologist and Director. The Coal and Industrial Minerals Sections were joined in 1975. During that period the Indiana Survey received widespread recognition for its quality research and service to the mineral industry of Indiana. The writer retired at the end of June 1986 and was succeeded by Dr. Norman C. Hester. Under his direction, reorganization has been extensive, many staff changes have taken place, and the organization is moving in new directions, some of which are too recent to evaluate for results but which should lead to added capabilities required for the ever-changing geologic needs of the State of Indiana.

The Indiana Geological Survey has no archive of its own for the period preceding Charles Deiss's administration, which began in 1945. During much of the 28 years that the office of State Geologist was elective, transfer of records between succeeding office-

holders was probably minimal, although it is apparent that projects initiated during the Blatchley administration were completed during his successor's tenure.

Whether any continuity existed to span the transfer from elective office (the Barrett administration) to an appointive position, the writer does not know but personally saw correspondence and other records from the Logan administration (1919-36) in Ralph Esarey's files during first employment by the Survey (1939-40). They included such items as correspondence between Logan and Charles Schuchert concerning Paleozoic and Huronian stratigraphic correlations of subsurface units in Indiana with those in other states. Curiously, no such records were incorporated in the Deiss files, probably because Esarey continued as head of the Petroleum Section in the new organization and retained them.

The absence of any such archive adds difficulty to the compilation of an accurate organizational history, but fortunately Blatchley (1917) reviewed the period before 1916 extremely well and did it at a time when the documentation was more feasible than it became later. At some date the Indianapolis office of the Geological Survey and an accompanying museum display were moved from the lower floor of the State Capitol. By the early 1930's the offices were housed on an upper floor and at the rear of the Indiana State Library Building. The whereabouts of the earlier exhibits, and perhaps retired files, was unknown to those of us in the organization from the 1930's until the 1950's, when a structure west across Senate Avenue from the Capitol, at that time called the Department of Highways Annex, was razed to make way for a new State Office Building. After demolition was well underway, we were notified that a sealed-off basement had turned out to contain geologic materials. We organized a hasty rescue expedition and retrieved, between swings of the wrecking ball, some cubic yards of tumbled debris--fossils, mineral rock specimens, labels (none still with the object that they were to identify), books, and miscellaneous papers. All had been under water, and few written words could be deciphered. Much of the material had gone to a landfill before we were called, and we had to let most of the remainder follow because time ran out, but the part that was recovered and examined suggested that little could have been gained if the entire mass of debris had been salvaged.

Blatchley's account (1917) of what he termed "A Century of Geology in Indiana" was reviewed by Melhorn (1967) in a paper that also contained coverage of an additional 50 years.

Surely the most significant event in the Survey's history was the decision, toward the close of World War II, to

unite the geologic program for the State of Indiana with the academic geologic effort at Indiana University. The time was right, and the choice of a person selected to head the dual effort was fortunate. In an amazingly short while, two faltering programs were on the move. Although that part of the concept that would have used faculty as professional Survey staff was less than fully successful, the Department of Geology included persons with expertise in fields that the Survey needed to pursue. The Survey, in turn, soon had specialists in fields not immediately among the offerings of the Department's curriculum. Field and laboratory apparatus was available for sharing, without loss to the nominal owner, and some items that could not be afforded by **either** partner could be acquired jointly, always with fiscal accountability.

As an example, by 1948 the Geological Survey, which previously had essentially no geochemical capabilities, shared a first-rate wet-chemistry laboratory and an analyst with the Department of Geology, had its own spectrographic facilities and spectrographer, and had access to an X-ray-diffraction laboratory in the academic department. The Geochemistry Section established in 1952 soon had its own X-ray equipment and has subsequently acquired most of the sophisticated facilities for instrumental analysis that have been needed for research in Indiana geology.

The Indiana Geological Survey was one of the first state geological organizations to make extensive use of the geophysical techniques that were becoming so rapidly available to the civilian world in the immediate post-war period. In 1948 Dr. Deiss arranged a cooperative program with the U.S. Geological Survey to make an aeromagnetic survey of the Kentland region of disturbed rocks in northwestern Indiana. Although the results of this preliminary survey were

inconclusive, the method showed promise for providing information about the igneous and metamorphic rocks that form the basement complex of the state. As a result, a survey of the entire state was made by the U.S. Geological Survey on a matching-funds basis, and Indiana became the first state to have total aeromagnetic coverage. County maps showing these data were published at a scale of 1 inch to the mile.

In 1950, beginning a program of close cooperation of the geophysics efforts of the Indiana Geological Survey and the Indiana University Department of Geology, a field party began a seismic-refraction survey of the thickness of glacial deposits in northern Indiana. A Geophysics Section was formed in 1951 and grew rapidly to include four full-time geophysicists. Seismic-refraction surveys continued and were expanded to include investigations of preglacial drainage systems in connection with water-resource studies and mapping of bedrock configurations at dam sites. In all, the section obtained refraction data from nearly 12,000 seismic shots.

The section also worked to supplement the interpretations of the aeromagnetic data. Magnetometer and gravity surveys were made over some of the most striking of the aeromagnetic anomalies, and a gravity survey of the entire state was completed in 1953.

The section obtained a 24-trace reflection seismograph in 1953 and began surveys to map the depth to basement rocks in southwestern Indiana. This program provided some new insight into the framework of the state, but it also afforded the final impetus for acquisition of our own drilling equipment. In order to detonate the amount of explosive needed for seismic-reflection surveys, a drilling rig was required.

Since the writer's return from the oil industry to the Survey in 1947, I had

been frustrated by our inability to answer the many questions that depended on specific information that a fairly shallow drill hole would provide. The seismic program was expensive to operate, and reflection shots were made only during a few weeks each summer. During the remainder of the year the drilling rig worked away at the accumulated problems for which cores or perhaps cuttings could provide conclusive answers. When our first rig burned in 1957 as a result of a natural-gas blowout, it was replaced by larger and more effective equipment. During the 35 years of the Indiana Geological Survey coring program, more than 400 logged stratigraphic drill holes have provided a fairly clear picture of the shallow bedrock geology of Indiana--even under the four-fifths of the state that is covered by glacial deposits. Geologists of the Coal and Industrial Minerals Sections also made effective use of the drill to define in detail the mineral resources of the state that have been of great value to the mineral industries.

Without doubt the mineral industries have been supportive of the Geological Survey during most of the past 40-odd years, and the Survey has in turn been able to assist countless firms and individuals in developing mineral resources. Credit has been formally given to the Geological Survey for the present major gypsum operations in the state and for initiating the production of quartz pebble and high-silica sand.

The history of statewide geologic mapping in Indiana through 1972 has been summarized (Patton and Gray, 1973), and significant advances have followed. The need for a new state map showing bedrock distribution was recognized from the beginning of the Survey's postwar rejuvenation. At the annual meeting of the Association of American State Geologists in Austin in 1958, the Army Map Series quadrangles covering 1° of latitude and 2° of

longitude at 1:250,000 scale were on display as the basis for California mapping, and they appeared to me to offer a mechanism for remapping our part of the Midwest in manageable units that would ultimately cover the entire state and its surrounding areas and at the same time eliminate state-line faults and discrepancies in stratigraphic terminology. Late in 1958 Charles Deiss convened a meeting in Bloomington attended by the State Geologists of Illinois, Kentucky, Michigan, and Ohio and by other staff members of some of those organizations. The result was agreement for a cooperative effort in which the geological surveys of our surrounding states would provide coverage of their portions of the eight 1° by 2° quadrangles that covered all of Indiana except for a few townships in the Evansville Quadrangle and small areas in the Paducah and Belleville Quadrangles that could be attached as extensions to the Vincennes sheet. It was agreed that both bedrock and unconsolidated deposits would be shown, and later it was decided that bedrock would be in pattern and unconsolidated deposits in color. The Illinois and Michigan Surveys were able to contribute their coverage. The four eastern sheets were completed after the western sheets were done, and by then changes in the fortunes and available staff time of the Ohio Survey occasioned its withdrawal from the cooperative arrangement after only part of the glacial geology and none of the bedrock compilation for the eastern sheets had been submitted, but Jane Forsyth continued her assistance with the Ohio glacial deposits after she left the Ohio Survey and joined the faculty of Bowling Green State University. She compiled the coverage of the glacial geology for the Fort Wayne, Muncie, and Cincinnati Quadrangles. Bedrock coverage for the Ohio portion of the

eastern sheets was compiled by the Indiana Geological Survey.

At the outset of the project, it appeared that the Kentucky coverage would be assured through the massive contract into which Kentucky had entered with the U.S. Geological Survey to map the entire state on 7.5-minute quadrangles, but many of those quadrangles in the Ohio River region fell late in the schedule, and ultimately we had to go to press without Kentucky coverage on the Cincinnati, Louisville, and Vincennes Quadrangles. In August 1972 we displayed the eight joined quadrangles (one of them a days-old color proof) as a single huge map at the International Geological Congress in Montreal. After the first sheet, the Indianapolis Quadrangle, was issued, we printed three versions of each--a composite that showed both bedrock and unconsolidated materials and color versions of bedrock and unconsolidated deposits separately. A revised edition of the Indianapolis Quadrangle (1979) offered all three versions. These Regional Geologic Maps, as we named the series, have served the needs of many kinds. The worksheets from which they were compiled, 7.5-minute quadrangles and aerial photos, may well be the Survey's most valuable file holdings.

Subsequent maps at 1:500,000 scale show bedrock topography (Gray, 1982a, 1982b), thickness of unconsolidated deposits (Gray, 1983a, 1983b), and bedrock (Gray, Ault, and Keller, 1987).

In the period following World War II, President Wells of Indiana University viewed the Geological Survey as a service and research arm of the University--a grassroots association with Indiana's populace and economy--as well as a division of state government, and both he and the University administration of the time were interested in the Survey's program, growth, and financial support. With the University's backing and in



harmony with the Indiana Conservation Commission and the Department of Conservation, the Geological Survey grew to approximately its present staff size by the early 1960's. After President Wells' retirement, no subsequent president of the University saw the relationship in the Wells sense, although the University administrative offices have continued to be helpful in handling their appropriate parts of the Survey's business matters.

When it became apparent, in the middle 1950's, that entirely new quarters were the only satisfactory answer to the pressing space needs of both geologic units, a single building was initially planned, but the University was able to budget funds for new academic construction before the Department of Conservation was successful in obtaining support for Geological Survey quarters. As a result, the academic part of the Geology Building was completed and occupied in 1962 a month before ground was broken for a wing to house the Geological Survey. For both organizations the new space, built for the purpose in a way that existing space could never have been remodeled to duplicate, changed the pace and quality of professional life. To have the entire staff of the Geological Survey in a single and scientifically luxurious structure instead of attics, cellars, old residences, and Quonset huts and other temporary structures, as well as some excellent space assigned generously by the University, permitted a new degree of coordinated productivity.

In 1947 a severance tax of 1 percent well-head value was imposed on Indiana oil and gas production, and the revenues were paid into a dedicated fund to support the Geological Survey, a newly established Division of Oil and Gas, and the costs incurred by the Indiana Department of Revenue in administering the tax program. In its early years the severance tax supported

quick growth in the Survey, but it seemed discriminatory to tax a single one of the state's mineral industries, and this writer never favored it as the source of our funding. The time came when Indiana oil production diminished to the point that the yield of the severance tax would not finance our existing program, and neither the state budget agency nor the General Assembly was inclined to supplement from the General Fund without a battle. We had good years and bad ones, the poorest of which resulted in a fiscal-year appropriation of 1 dollar to support the Survey--rather worse than no appropriation at all, as it revealed intent. Somehow we survived, and in time high oil prices revived the yield of the severance tax for a period, but not for long. During those years the writer tried to persuade the Department of Natural Resources to shift the Survey's funding request to the General Fund, but the answer was always that it was not desirable to rock the boat.

Under the terms of the agreement effectuated in 1945 between the Indiana Conservation Commission and Indiana University, the Chairman of the University's Department of Geology was to serve also as State Geologist, and Charles Deiss occupied this dual role from 1945 until his passing in 1959, as I did from then until 1971. By the 1960's both programs had reached a level that merited a full-time head, and in 1966 the writer recommended review of the arrangements for the purpose of separating the administrative positions. To facilitate consideration without any embarrassment concerning what to do with the incumbent, the writer proffered his resignation, but it was not accepted, and the situation remained the same through four changes in the deanship of the College of Arts and Sciences, during which the writer offered annually to resign and clear the way, but in 1971 the change was effected, and an Acting Chairman was

named for the academic department. The writer continued as a faculty member, teaching a course each semester and directing graduate-student research.

At the time of my retirement, the association between the two organizations was thoroughly reviewed again, and the decision was to continue joint faculty-Survey appointment, as has been done in the case of my successor, and mutual benefits are still derived through shared interests and capabilities.

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## IOWA

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### HISTORICAL SEQUENCE OF ORGANIZATIONAL NAME:

The Geological Survey of Iowa, 1855-58  
State Geological Survey, 1866-69  
Iowa Geological Survey, 1892-1986  
Geological Survey Bureau, Iowa Department of Natural  
Resources, 1986-present

### NAMES AND TITLES OF ORGANIZATIONAL DIRECTORS AND DATES SERVED:

James Hall, State Geologist, 1855-58  
Charles A. White, M.D., State Geologist, 1866-69  
Samuel Calvin, State Geologist and Director, 1892-1904  
Frank A. Wilder, State Geologist and Director, 1904-06  
Samuel Calvin, State Geologist and Director, 1906-11  
George F. Kay, State Geologist and Director, 1911-34  
Arthur C. Trowbridge, State Geologist and Director, 1934-47  
H. Garland Hershey, State Geologist and Director, 1947-69  
Samuel J. Tuthill, State Geologist and Director, 1969-75  
Stanley C. Grant, State Geologist and Director, 1975-80  
Donald L. Koch, State Geologist and Director, 1980-86;  
State Geologist and Bureau Chief, 1986-present

### THE STATE GEOLOGICAL SURVEY OF IOWA

By Jean C. Prior

#### INTRODUCTION

State geological surveys are permanently woven into the fabric of geological science in the United States. Their contributions have helped to advance the study and application of geology, and their existence reflects a long tradition on the part of individual states of recognizing the importance of geologic conditions to their economic and environmental welfare. The following quote by David Dale Owen sets the tone for a chapter titled "Necessary for Welfare and Progress, 1855-1861" in Mary Rabbitt's (1979) detailed history of events leading to the founding of the U.S. Geological Survey.

Is it not incumbent on every country and every state of this Union, to adopt measures calculated, first to develop their resources in the various raw materials necessary for their welfare and progress, and having done so, to direct public attention to their stores of mineral wealth? . . . What better method can a State adopt for this purpose than to institute and support with liberality a well-conducted and judiciously managed geological survey. (David Dale Owen, 1858)

Her title based on his quote clearly identifies characteristics that have been the mainstay of state geological surveys--an emphasis on the practical application of geology to the resource issues of the time. Writing for the Geological Society of America centennial about the contributions of state geological surveys, Gordon Oakeshott (1985) concludes, "The state geological surveys are economically and politically responsive to state authority and therefore have developed a unique



capability to serve directly the geological needs of the public."

The origins of state geological surveys can be traced to the early 19th century and the influence of Benjamin Silliman of Yale and his student Amos Eaton (Oakeshott, 1985). Eaton's lectures to the New York State Legislature led to the establishment of that state's survey in 1836. The first state geological surveys west of the Mississippi were established in the 1850's. In 1906, H. Foster Bain, an Assistant State Geologist with the Iowa Geological Survey in the late 1890's and then with the Illinois Geological Survey, organized a regional coalition of state geologists which eventually became the Association of American State Geologists--the group sponsoring this compendium of state histories.

Despite their widespread geographic distribution, state geological surveys have experienced similar patterns of development. These patterns were shaped both by developing concepts in the field of geology and by changing trends in the national experience. Yet each state, because of its restricted borders, also has a unique history, colored by its individual geologic setting and resources, and by the individual geologists who spend all or part of their careers within its borders. The state geological survey in Iowa, first established in 1855, mirrored those beginning in other states and employed geologists whose influence and contributions were important to other state surveys as well. Today, the continuing examination of Iowa's geology by Survey geologists provides valuable interpretations to science, as well as important information and direction to the state's resource assessment, environmental protection, and economic development.

### THE EARLY YEARS

The Mississippi and Missouri Rivers, which form Iowa's eastern and

western borders, were primary avenues of exploration into the continent's interior. Marquette and Joliet (1673) Julien Dubuque (1788), Zebulon Pike (1805), Henry Schoolcraft (1820), and George Catlin (1835) are strongly associated with the Mississippi River, while Lewis and Clark (1804) and Prince Maximilian and Karl Bodmer (1833) are associated with the Missouri. Basic observations about the land were entered in journals and drawn in sketch books, and these became the earliest references to Iowa's geology.

These two rivers were important, not only as early routes of exploration but, as avenues for developing concepts in New World geology. In 1809, English naturalist Thomas Nuttall examined limestone outcrops along the Mississippi River valley between Prairie du Chien, Wisconsin, and St. Louis. He determined, for the first time in this country, the presence of Carboniferous rocks on the basis of their fossil content, and he correlated these limestones with those of the Pennine Range of northern England (Keyes, 1919, p. 409). The following year Nuttall ascended the Missouri River, and at an Omaha Indian settlement below the mouth of the Big Sioux (where Sioux City is now located), he examined strata in the bluffs. Keyes wrote that on the basis of fossils and lithology, Nuttall compared these strata to the "Chalk Division" of northern France and southern England--the earliest recognition of Cretaceous rocks in America (Keyes, 1919, p. 410). This intercontinental correlation of geologic deposits was a significant departure from the geological thinking of the day and represented one of the earliest applications of principles which form the basis of modern geology.

This exploratory era was followed by settlement and by more purposeful geological reconnaissance and mapping. The settlers of the Black Hawk Purchase petitioned Congress to

organize them into a separate territory. Following establishment of the Iowa Territory on July 4, 1838, French geographer Jean N. Nicollet was selected to lead a party of the U.S. Army Engineering Corps in the preparation of a detailed map of the region, which included Iowa, most of Minnesota, and all of the Dakotas. This map (1843) was regarded as a major contribution to American geography.

Then in the fall of 1839, Dr. David Dale Owen was commissioned by the General Land Office to make a geological reconnaissance of about 11,000 square miles in Wisconsin, Iowa, and Illinois for the purpose of collecting information needed to assist the President and Congress in preparing a plan for the disposal of public mineral lands. Between mid-August and mid-November of 1839, Owen marshaled provisions, engaged 139 assistants, instructed them in the needed principles of geology, organized 24 working corps, and proceeded to examine and map every quarter-section in the three-state area comprising the mineral lands of the Dubuque, Mineral Point, and Galena districts, as well as to collect and label several thousand specimens. This remarkable accomplishment is a tribute to Owen's organizational and logistical skills (Merrill, 1924, p. 196-199).

Owen's work is regarded as the first official geologic investigation in Iowa. The results of this and later, more extensive investigations of lands drained by the Upper Mississippi River system (1847-51), directed by the U.S. Treasury Department, were published in 1852 under the title *Report of a Geological Survey of Wisconsin, Iowa and Minnesota; and incidentally of A Portion of Nebraska Territory*. This 639-page monograph was published in Philadelphia (Lippincott, Grambo and Co.) and is richly illustrated with stylized sketches of landscapes, finely detailed drawings of fossils, and colored

maps of cross-sectional valley profiles, including the Mississippi and Des Moines Rivers. Most of the illustrations, prepared as wood-cuts or engravings on copper, steel, or stone, are from original sketches drawn in the field by either D. D. Owen or his brother, Richard. In addition to his much-sought talents in geological reconnaissance, he was a skilled artist, and like many of the early geologists of this period, he received his education in science through the study of medicine. During his career, Owen also served as State Geologist of Indiana, Kentucky, and Arkansas.

Iowa was admitted to the Union on December 28, 1846. The first geologic inquiry publicly undertaken by the State was under the authority of legislation proposed by Governor James W. Grimes and passed in 1855 which provided for a geological survey of the state. Looking eastward for talent and to New York as the model for geologic investigations of the day, James Hall of Albany was appointed State Geologist. Hall's friend Josiah D. Whitney of Massachusetts (subsequently State Geologist of California) was named as Chemist and Mineralogist, and Amos H. Worthen (subsequently State Geologist of Illinois) was engaged as an Assistant in paleontology. This work was funded for 3 years, and the results were published in a two-part volume in 1858. Part I focused on the general geology and stratigraphy of the eastern half of the state, including regional comparisons between the Paleozoic strata of the midwest and that of New York and Pennsylvania, as well as information on the chemistry of coals and the distribution of lead/zinc and iron ores. Part II was devoted exclusively to the paleontology of this region and was regarded as a benchmark contribution to the knowledge of Carboniferous crinoids and echinoderms. The beautifully detailed line-drawings which illustrate the plates in this section were drawn by Fielding B.

Meek. Hall's energy and domineering, egotistical personality are legendary (Dott, 1985). Always short of funds, seldom in Iowa because of other involvements, and single-minded as well as devious in his quest for fossil collections, he still was unquestionably one of the most prominent scientists of his day and left a lasting influence on American paleontology, geological organizations, and state geological surveys.

In 1853, Hall sent Meek and Dr. Ferdinand V. Hayden on their first trip up the Missouri River to study the geology of the Dakota Badlands and collect fossils for him (Rabbitt, 1979). Thus began their well-known expeditions into the western territories. The Cretaceous exposures they examined in the Sioux City area were among the first rocks of this age to be studied in America, and Meek and Hayden's "Upper Missouri Section" described there (1862) remains a keystone in the formulation of Cretaceous stratigraphic nomenclature.

The Geological Survey of Iowa was reactivated from 1866 to 1869 under the direction of Charles A. White, also an M.D., and largely self-educated in the study of natural history. White engaged Orestes H. St. John, on the strength of a recommendation by Louis Agassiz, as Assistant Geologist and Rush Emory as Chemist. Agassiz, the renowned Swiss naturalist, visited Iowa City in the summer of 1866 and with White and the others examined the Devonian outcrops upstream along the Iowa River (Stromsten, 1950). Since Hall's work was devoted largely to eastern Iowa, White and his colleagues concentrated on the western part of the state. White and St. John also accompanied F. B. Meek on a traverse across southern Iowa in 1867 to help correlate the coal-bearing formations of Iowa with those which Meek and Hayden were mapping in Nebraska (St. John later joined the Hayden surveys of Wyoming, Colorado,

and New Mexico). A final report in two volumes was published in 1870, and included information on coal, gypsum, peat, and building materials as well as geological summaries of the western counties. White's generous acknowledgment of his coworkers in this report supports impressions that he was a kindly man, always ready to help and encourage others (Merrill, 1924), and he was highly respected by his students and colleagues at the State University of Iowa.

Among the illustrations in the 1870 report are 13 long-admired landscape lithographs known to have been drawn by St. John. In 1975, Ian Campbell, then with the California Academy of Sciences in San Francisco, forwarded six original pencil sketches which were found there and had been dated, signed, and annotated by St. John. Five of these sketches are of Iowa; four are the original field sketches for four of the lithograph illustrations in the 1870 report; the fifth sketch was drawn at one of the illustrated locations but of an opposite view (Prior and Milligan, 1985). St. John, like Owen and other geologists of the period, relied on his own artistic skills to document significant geologic characteristics of the regions he studied.

These two forerunners to the establishment of a permanent geological survey in Iowa were similarly broad in their mandated scope of work. Their charge, to carry out a complete geological and mineralogical survey, included examination of rocks, fossils, ores, coals, and the quality of soils for agricultural purposes. Information on prairie and woodland vegetation, climate, and the potential of streams for navigation or power-generation was also included. Reports, maps, and specimens were to be assembled and the information communicated, in order "to give the people of the State the greatest amount of practical information in



relation to its resources" (White, 1870, p. 8).

Geological work under the auspices of the State lapsed again, this time until 1892. In the meantime, a report on "The Pleistocene History of Northeastern Iowa" was prepared by W. J. McGee, an Iowa native, and published in 1891 in the *Eleventh Annual Report of the U.S. Geological Survey*. This detailed and interestingly written account was regarded as the most important contribution to Iowa geology to follow White's reports. In addition, its appeal to the general public is credited with broadening the base of interest in geology and with developing an appreciation of the need for and support for a more comprehensive geological survey of the state (Arey, 1912). Other important contributions of this interim period included St. John's work on Paleozoic fishes of the midwest (1875), with many of the study collections from Iowa; T. C. Chamberlin and R. D. Salisbury's report on the Driftless Area of the Upper Mississippi Valley (1886) which included part of Iowa; and Charles Wachsmuth and Frank Springer's three-volume work on North American crinoids (1895), which was based on the prolific occurrence of these fossils in the Mississippi Valley region. In fact, the great sequence of limestones along the river bluffs in the vicinity of Burlington, Iowa, are also historically significant as the starting point for the classification of the "Lower Carboniferous" limestones, and thus compose the type locality for the Mississippian System, one of the basic divisions of geologic time recognized throughout the world (Wilmarth, 1925).

This early reconnaissance activity and these pioneering geological reports were of great value. They called attention to features and places of special interest in the state, and they established a preliminary framework of Iowa's geology and its relationship to adjacent states that provided a valuable

foundation for the more detailed studies that followed. Samuel Calvin, who was to lead the state geological survey of Iowa for almost the next 20 years remarked, "Considering the limitations under which the earlier geologists labored, the extent and accuracy of their observations are matters of constant surprise to their successors" (Calvin, 1909, p. 11). Looking today at the work of Calvin and his colleagues, we too admire the scope and value of their achievements under what we often regard as trying circumstances.

#### A PERMANENT GEOLOGICAL SURVEY ESTABLISHED

A permanent geological survey, as a separate agency of state government, was established in 1892. In accordance with the legislative provisions, a Geological Board also was established to govern the broad administrative policies of the Survey and to appoint the State Geologist. (This Board was dissolved in December 1980, and the State Geologist was to be appointed directly by the Governor.) The Board was composed of the Governor, the State Auditor, and the presidents of Iowa State University, the University of Iowa, and the Iowa Academy of Science. They elected Professor Samuel Calvin, Chairman of the Department of Geology at the University of Iowa, as State Geologist, and from that time until 1947 (through the Kay and Trowbridge administrations), both positions were held by the same individual. Offices were maintained in Des Moines and overseen by the Assistant State Geologist until 1934 when state budget cuts resulted in placing the headquarters permanently in Iowa City, where most of the actual work was done. Since that time, the Survey has been housed on the University of Iowa campus, but with no administrative ties to the University. Initially the staff occupied limited space in the geology building (Calvin Hall), and then in 1938



moved next door to the "Geology Annex," a former Botany Department greenhouse and laboratory. According to former State Geologist H. Garland Hershey, on the day of this move all the well-sample cuttings were put in the greenhouse. A hailstorm a few hours later demolished most of the panes, and considerable time was spent separating glass from samples, and later, building storage space under the greenhouse slab. In 1951, an addition to the main building was constructed over this space. In 1963, arrangements for off-campus warehouse facilities were completed. In 1975, the Survey and the Geology Department both moved into Trowbridge Hall, and in 1979 the sample library, publications and archives, laboratory facilities, and additional offices were installed on the University's satellite "Oakdale Campus" in northwest Iowa City.

It is interesting to note that the 1892 legislative mandate for the Geological Survey called for (in addition to classical geological pursuits):

...investigating the characters of the various soils and their capacities for agricultural purposes; the growth of timber, the animal and plant life of the state, the streams and water power, and other scientific and natural history matters that may be of practical importance and interest.

It is not unusual to see the individual county geological reports published in the Annual Report Series supplemented with extensive botanical reports on prairie and forest flora, as well as meteorological records or information on archaeological remains. In fact, the Bulletin Series (1901-30) devotes entire volumes to the grasses, weed flora, rodents, raptorial birds, and honey plants of Iowa. This broad approach to natural science characterized individual geologists as well as the role of geological institutions of the time. Men such as Calvin, Thomas Macbride, and Bohumil Shimek were equally at home in several fields of natural history now regarded as separate scientific dis-

ciplines. Louis H. Pammel, Ada Hayden, and Charlotte M. King were recognized botanists who served as special assistants on the Survey staff. Charles R. Keyes, William H. Norton, and H. Foster Bain were other geological authors whose highly readable county reports were written in a personal, almost poetic style seldom seen in today's technical literature.

As noted, Iowa's counties became the geographical unit in which the state's more detailed geological information was compiled. By 1941, 38 volumes in the Annual Report Series were published (only 5 out of the state's 99 counties were not completed), and to a large degree the history of the Iowa Geological Survey during this period is contained within them. In addition to the county reports, these volumes were also devoted to special topics such as, bibliography of Iowa geology, coal, gypsum, lead and zinc, artesian wells, clays, cement materials, quarry products, Devonian fishes of Iowa, peat, underground water resources, Pleistocene mammals, road and concrete materials, iron ore, origin of dolomite, the Des Moines Valley, Iowan drift, Pleistocene of northwestern Iowa, extinct Lake Calvin, Devonian echinoderms, Mississippian stratigraphy, trilobites, altitudes in Iowa, deep wells, pre-Illinoian Pleistocene geology, the Maquoketa Shale, the Dakota Stage, Pleistocene gravels, and Illinoian and post-Illinoian Pleistocene geology. This listing of some of the more lengthy reports demonstrates the growing diversity in geologic investigations as well as the attention devoted to economic aspects of the state's geology.

These county reports also contain concepts important to the evolution of geologic thought in the United States, as well as worldwide. Iowa played an important role in presenting the stratigraphic facts which established the concept of multiple continental glaciations during the Pleistocene. The

complexity of these glacial periods, including the existence of warm, interglacial episodes as interpreted from the "Aftonian" gravels of western Iowa and their classic fauna of Pleistocene mammals, was unraveled by such men as McGee, Chamberlin, Salisbury, Calvin, and Leverett (see photo). Confirmation of the windblown origin of loess, based in part on his study of land snails, was presented by Shimek in the *Geology of Harrison and Monona Counties* (1909). This emphasis on midwestern Pleistocene studies continued under George F. Kay and Arthur C. Trowbridge. Problems related to glacial drifts, gravels, buried soils, peats, and loess were inseparable from economic geology in Iowa. The adaptability of Iowa's terrain and soils to agriculture, and the importance of agriculture to Iowa's economy and as a factor in today's environmental issues ensure the continued justification for Quaternary research.

Together, these county reports admirably reflect Calvin's philosophy as set forth in 1892 when he wrote,

The work of the Survey is now fairly begun. The questions of greatest economic interest to the people of the State cannot all be fully settled at once. . . . It must also be borne in mind that the determination of the economic problems, which must ever be kept in view as the end sought after in this Survey, is an impossibility without the preliminary determination of questions relating to the genesis and order of succession of the geological strata.

The significance of Calvin's influence is best summed up by Melvin F. Arey's comments in reference to the first twenty Annual Report volumes,

. . . which will ever stand as a worthy monument to the energy, scholarship, and eminent ability of the great souled man who planned the work and himself did no small part of it and who chose and directed as his assistants men who, in the midst of other heavy tasks, gladly gave themselves to the furtherance of the plans of their great leader, who for forty years was so identified with Iowa Geology that the one can scarcely be thought of apart from the other. (Arey, 1912, p. 70)

Since the Calvin administration, the Survey has maintained a long-standing association of cooperative programs with the U.S. Geological



This photograph, taken about 1898 at a field conference near Peoria, Illinois, shows several of the geologists who made lasting contributions to Pleistocene studies in the midwest. Right to left: Frank Leverett, Samuel Calvin, Thomas C. Chamberlin, H. Foster Bain, and Johan A. Udden. (From the Calvin Collection, Department of Geology, The University of Iowa.)

Survey, beginning with topographic mapping in 1907. In the 1930's stream and lake gaging projects with the surface-water branch, and water-level and chemical-quality monitoring of wells with the ground-water branch of the federal survey were initiated with regional staff based in Iowa City. In fact, the ground-water corps was directed for a time by State Geologist Hershey and shared the Geology Annex offices of the Iowa Survey until 1975 when all the USGS employees were combined in the new federal building downtown. Other cooperative projects include regional bedrock-topography maps, regional water atlases, water-supply bulletins, and computerization of the well-log data base.

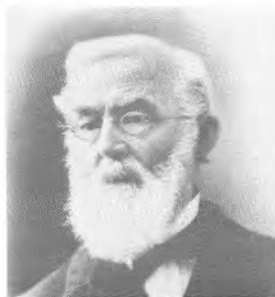
In 1947, H. Garland Hershey succeeded Trowbridge with whom he served as Assistant State Geologist beginning in 1939. This was also the watershed year in which the Director of the Geological Survey and the Chairman of the Geology Department were separated into two full-time positions. Today the Geological Survey and the Geology Department continue to enjoy a beneficial association, sharing a good library and lab facilities, with the Survey providing opportunities for student employment, staff guidance on Iowa-based thesis projects, and occasionally filling the role of adjunct professor.

In his 22 years of service, Hershey greatly expanded the Survey's ground-water research and service functions. The post-war expansion of Iowa's economy included industry as well as agriculture, and Hershey observed that "One of the first needs of new industry locating in Iowa is a good water supply, usually obtained from wells they drill with the aid of information from our records" (Jensen, 1955). Those records now include over 30,000 wells, including sample sets of drill cuttings, drillers' logs, and rock cores. The collection and interpretation of these

records is the heart of the Survey data base. They reflect a continuing, cooperative association with the state's water-well drillers and are invaluable in the preparation of ground-water availability forecasts and in addressing water resource issues. This improved data base also made possible the siting of underground natural gas and liquid-petroleum-gas storage facilities in Iowa.

Samuel J. Tuthill's career as State Geologist and Director began in 1969 and is notable for the creative application of the Survey's traditional research and service functions to the resource, environmental, and energy issues that faced Iowa in the early 1970's. A scientific investigation of Cold Water Cave was conducted to determine its potential as a scientific and public resource. New regulations governing site selection of sanitary landfills were adopted based on geologic criteria designed to protect water resources. The Remote Sensing Laboratory was established within the Survey to apply information from aerial and satellite imagery to a broad range of interagency users. The first land-use map of the state was produced and new methods of flood-hazard assessment were inaugurated using this information base. The expansion and diversification of public services and interagency cooperation included his teaming with other agency administrators and the Governor's Office to coordinate Iowa's response to the 1973 Arab oil embargo. A coal-resources evaluation program and a drilling program to examine the hydrology of carbonate aquifers in the eastern Iowa ground-water district were also established. He focused public attention on the role of carbonate rocks and the impact of agriculture on ground-water problems. In a 1972 speech delivered to a seminar for community leaders he stated, "It is not the use of chemicals that serve agriculture, it is the chemicals that escape productive agricultural systems

# *State Geologists of Iowa*



James Hall  
1855-58



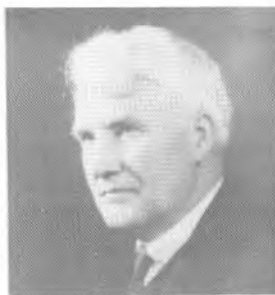
Charles A. White, M.D.  
1866-69



Samuel Calvin  
1892-1904 1906-11



Frank A. Wilder  
1904-06



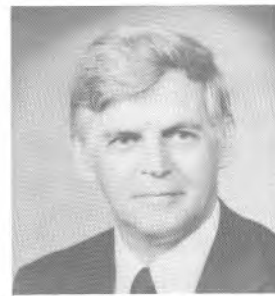
George F. Kay  
1911-34



Arthur C. Trowbridge  
1934-47



H. Garland Hershey  
1947-69



Samuel J. Tuthill  
1969-75



Stanley C. Grant  
1975-80



Donald L. Koch  
1980-



that damage water resources." This emphasis on the importance of understanding geologic systems in addressing the state's environmental concerns continues today as a concept fundamental to our existence.

Stanley C. Grant took over the reins of the Iowa Geological Survey in 1975. As the staff had grown from about 14 in 1965 to 41 in 1978, he initiated an internal reorganization into several management divisions reflecting the Survey's various programs and functions. An annual *Newsletter* joined the list of Survey publications in 1976 and in 1979 became known as *Iowa Geology*, a magazine of illustrated articles designed to communicate important and interesting information about the state's geology to the public. The Survey's advisory role to other state and federal agencies continued to expand in the areas of remote sensing applications, energy resources, data systems management, and "environmental geology," a term that came in vogue to describe this more intense and visible, practical application of geology to contemporary resource issues. Highlights of programs that continued or were initiated during this period included development of a state water plan, study of strippable coal reserves, availability of ground water for irrigation, applied soils engineering and surficial geology studies, monitoring of earthquake activity, appraisal of ground-water occurrence and quality by aquifer and region, uses of Mississippi River dredge materials, geologic analysis of the Cherokee Archaeological Site, Missouri River landownership litigations, toxic waste problems, Plum River Fault Zone mapping, Pleistocene stratigraphy, and improvements in data storage and retrieval systems.

Donald L. Koch became Director and State Geologist in 1980, noting the Survey's improved capabilities in problem-solving and service functions

as a result of refinements in data collection and interpretation over the years. Growing interest in the Mid-continent Rift Zone, a good example of refinements in geophysical techniques, resulted in the 1987 completion of the deepest well yet drilled in Iowa, the M. G. Eischeid No. 1 in Carroll County, an AMOCO Production Company oil and gas test to 17,851 feet. Also, 1987 was a milestone in terms of the completion of state-wide map coverage by the USGS 7.5-minute quadrangle series. An abundant concentration of Mississippian amphibian fossils, perhaps the oldest known tetrapods in North America, was discovered in Keokuk County in 1985. Major studies also continue in water resources evaluation, especially the documentation of water-quality degradation in shallow carbonate and alluvial aquifers. Future research efforts will be oriented toward development of land treatment and management strategies that can be implemented to reduce ground-water contamination. Other studies include agricultural drainage wells, leakage from underground storage tanks, abandoned coal-mine lands and subsidence problems, geomorphological influences on the preservation of archaeological resources, Des Moines Lobe surficial geology, a municipal water-supply inventory, Plum River Fault Zone mineralization, and enhanced computer processing capabilities.

#### LOOKING TO THE FUTURE

The centennial observance of the continuous existence of a state geological survey in Iowa will be in 1992. The U.S. Geological Survey celebrated its centennial in 1979. The Geological Society of America celebrates its centennial this year, 1988, with its ambitious *Decade of North American Geology* publications project nearing completion. Our staff's comprehensive stratigraphic review of

the geologic section in Iowa is part of the DNAG contribution, and additional products are scheduled for completion to coincide with our own centennial. The AASG's sponsorship of this volume of state geological survey histories is another example of the considerable interest sparked by these anniversaries in tracing the roots of geological science in this country and among the individual states. They have caused us to take a long look back, evaluate our current status, and consider the future. It is clear, as stated at the outset, that our existence and work is very much tied to the state's economic and political tides and to the state's definition of the geological needs of the public. Under plans to reorganize state government, the original Iowa Geological Survey was merged with three other state agencies to form a new Department of Natural Resources, effective July 1, 1986. The State Geologist is now also Chief of the Geological Survey Bureau, within the Energy and Geological Resources Division, and is appointed by the Director of the DNR. This change too reflects similar patterns experienced by other states and their geological surveys.

As this historical review becomes meshed with current events, the focus becomes closer and more detailed with a consequent clouding of broader perspectives. We have seen a shift from naturalist to specialist among geologists; a shift from drawings to cameras, aerial photography, and satellite imagery as a way of looking at the earth's resources; a shift in orientation of data acquisition from surface exploration, spurred by the 19th century influence of railroads in quest of routes and resources, to subsurface exploration spurred by the 20th century role of the water-well and petroleum industries.

The future of the state geological survey of Iowa will be closely tied to economic and environmental concerns. The inventory, development, manage-

ment, and conservation of the state's geological resources are recognized as vital elements in Iowa's economic stability and future growth. There is a finite limit to these resources, and they are not uniformly distributed in quantity or quality. There are competing interests for their use. Sensitive geological environments exist which are vulnerable to contamination from man's activities. Iowa's diverse public interests need a technically qualified source of reliable information on water, mineral, rock, soil, and energy resources to aid the resolution of environmental issues and to develop assessments for resource development, protection, and management. This framework of needs will guide our future. Calvin (1909) wrote,

It has been the aim of the Survey to collect and furnish trustworthy information, the fullest possible, relative to the geologic structure and resources of Iowa; but while the purely economic side of the subject has necessarily been emphasized in all the work so far done, any facts that could make knowledge clearer, broader, more definite, have not been neglected. . . . The pure science of today becomes the basis of the applied science of tomorrow, and enlightened states, the world over, realize that money expended for the prosecution and encouragement of scientific research, is money well invested. By the substitution of definite knowledge for vague uncertainty relative to water supplies . . . and all other natural products, the Survey has saved to the citizens of Iowa, many times over, all that the Survey has cost.

This philosophy also must be part of our future. Finally, communication of these research results to the public and to nongeologists needing geological information will be increasingly important. About this Calvin said,

. . . the Survey has earned its place as an important factor in contributing . . . to public education, helping the people to see and appreciate and correctly interpret the geological phenomena which lie all about them.

Calvin's well-articulated message, of responding to the state's economic

resource needs, with information based on scientific research, and communicated effectively, is as valid today as it was nearly 100 years ago.

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## KANSAS

Kansas Geological Survey, The University of Kansas, 1930 Constant Avenue,  
West Campus, Lawrence, KS 66046-2598. Phone 913-864-3965.

### HISTORICAL SEQUENCE OF ORGANIZATIONAL NAME:

Geological Survey, 1864-65  
University Geological Survey, 1889-1907  
State Geological Survey, 1907-present

### NAMES AND TITLES OF ORGANIZATIONAL DIRECTORS AND DATES SERVED:

Benjamin F. Mudge, State Geologist, 1864  
George C. Swallow, State Geologist, 1865  
Erasmus Haworth, State Geologist, 1895-1907; State Geologist and  
Director, 1907-15  
W. H. Twenhofel, State Geologist and Director, 1915-16  
Raymond C. Moore, State Geologist, 1916-37; Co-State Geologist and  
Director, 1937-45; State Geologist, 1945-54  
Kenneth K. Landes, Co-State Geologist, 1937-41  
John C. Frye, Executive Director, 1945-52; State Geologist and  
Executive Director, 1952-54  
Frank C. Foley, State Geologist and Director, 1954-70  
William W. Hambleton, State Geologist and Director, 1970-86  
Lee C. Gerhard, State Geologist and Director, 1987-present

### KANSAS GEOLOGICAL SURVEY

In 1541, Francisco Vasquez de Coronado made the first European observation about the geology of Kansas. After his celebrated, circuitous ride to the center of the state, he pronounced it void of gold. Coronado was uninterested in the geologic resources, such as flint and clay, that were already being utilized by the Indian tribes native to Kansas. Genuine geologic reconnaissance waited until the 1700's and 1800's, and the expeditions of M. Veniard de Bourgmont, Lewis and Clark, Zebulon Pike, Stephen Long, and John C. Fremont. The naturalists in those expeditions often commented on geologic features, such as glacial erratics, that are still obvious today, and they characterized part of the state as belonging to the Great American Desert.

Geologists began to look closely at Kansas in the 1850's and especially in 1864 with the establishment of the first formal geological survey of the state. In some ways, the geologic exploration of Kansas coincided with the maturation of geology as a discipline. Charles Lyell's *Principles of Geology* was published in 1830 as explorers were crossing the plains. And Darwin's *Origin of Species*, in 1859, appeared as Kansas was making the painful transition from territory to state in the midst of the pre-Civil War political process.

A geological survey was proposed for Kansas several times before a survey bill was finally passed in 1864. That first survey was established after vituperative legislative debate, including the following report by a Legislative committee.

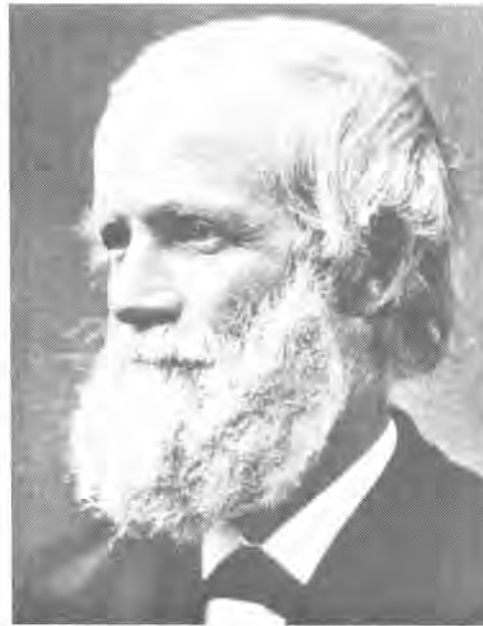


In conclusion, we may be permitted to remark that, though we are disciples of progress, and are willing and eager to learn, we deem it advisable, for the permanent growth and future prosperity of our State, that we should "hasten slowly," lest, peradventure, we should make "more haste than speed," and that, in view of the limited population and tax-payers' ability of the State, instead of running the car of progress, "high pressure" system, we should decidedly incline to favor the narrow gauge, single track, low pressure style, with Prudence ever on the lookout--Economy, master and conductor of the train--Caution standing ready to "put down the brake," and all hands on watch to prevent dead heads from stealing rides at the expense of the honest stockholders.

The bill to create the survey survived that diatribe, although, as others have observed, some legislators may have thought they were creating a railroad.

With the passage of the bill, the Legislature appointed Benjamin Franklin Mudge as the first State Geologist. Mudge was a native of Maine who had practiced law for 16 years in Massachusetts. He later gained background in petroleum chemistry at a Kentucky refinery and taught school in what is today Kansas City, Kansas. Mudge was, fortuitously enough, in Topeka giving the Legislature a series of lectures about the state's geology. Shortly thereafter, the Legislature passed the bill creating the geological survey, and Mudge was appointed to the post, probably at least in part because of his proximity to the political process, and probably in part because of his record as a Massachusetts abolitionist. At least one unsuccessful candidate for the job, George C. Swallow from Missouri, was accused of pro-slavery leanings.

Mudge faced an awesome task. With a staff of five scientists--only one of them a solidly trained geologist--Mudge was to lead a geological survey of 82,000 square miles of prairie, much of it occupied by Indian tribes with various degrees of antipathy toward



Benjamin Franklin Mudge, first director of the Kansas Geological Survey. Mudge, who later held posts at Kansas State College and the Kansas State Board of Agriculture, was one of the foremost fossil collectors in the Kansas Cretaceous.

white encroachment. To do that job, Mudge was given \$3,500 and less than a year's time to deliver a report. Mudge assembled as Assistant Director a surveyor named Frederick Hawn; the same George Swallow from Missouri to report on paleontology; a physician named Tiffin Sinks to study chemistry and meteorology; and a second doctor, C. A. Logan, to report on botany and "sanitary relations" of the state.

These men combined to produce a 56-page pamphlet entitled *Geology of Kansas*, the first formal publication by a state geological survey in Kansas. This report broke little new scientific ground, concentrating on economic geology, especially salt and coal. Another 15 pages were devoted to stratigraphy, although most of that focused on eastern Kansas, probably due to travel constraints and Indian trouble. Mudge mentioned several significant geologic phenomena, particularly salt springs

and chalk outcrops in far western Kansas.



George C. Swallow, paleontologist for the first Kansas Survey and director of the second Kansas Survey.

That first survey lapsed at the end of 1864, though a second survey was created in 1865, this time with less political intrigue and more money--namely \$7,500. Mudge left the survey to teach at Kansas State College and was replaced by the same George Swallow who had been a candidate for the job the first time around. Swallow and his staff, mostly the same staff that worked for Mudge, produced a *Preliminary Report of the Geological Survey of Kansas*, much in the same vein as Mudge's report. The report concentrated on eastern Kansas, Swallow wrote, "on account of the Indian troubles on our western border . . ." But Swallow's report included 39 pages on the state's stratigraphy, providing the first detailed description of the state's geologic setting. The 23-page description of the geology of Miami County (probably selected because it was the site of numerous oil seeps and therefore

offered economic opportunities) was the first county-wide geologic investigation in Kansas history and set a style and standard that strongly influenced the Survey reports that followed.

PRELIMINARY REPORT

OF THE

GEOLOGICAL SURVEY

OF

KANSAS.

BY

G. C. SWALLOW,

STATE GEOLOGIST.

LAWRENCE, KANSAS:

JOHN SPEER, PRINTER TO THE STATE.  
1866.

Cover of Swallow's report by the second Kansas Geological Survey, published 1866.

Swallow's report also included somewhat more unusual reports on the meteorology and sanitary situation in the state. In some respects, the Survey's interest in medicine was not surprising. State geological surveys of the 1860's often investigated more than geology. A number of state legislatures ordered their surveys to study natural history; several surveys made botanical reports and the Minnesota Geological Survey

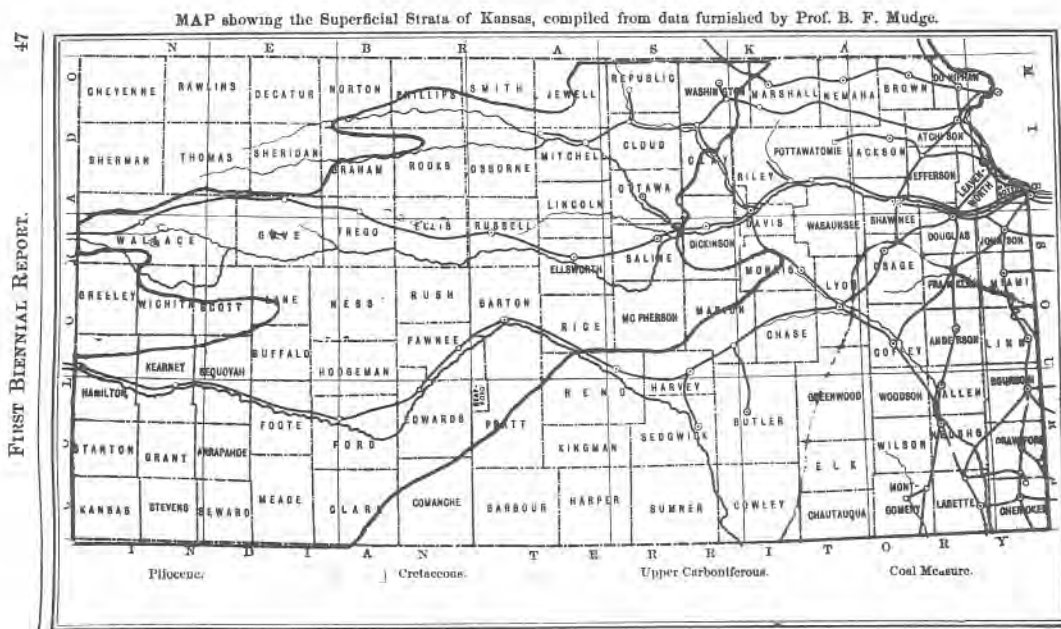
even studied a grasshopper plague. Physicians early recognized the association between geology and disease on the frontier, though Logan's report, which included a number of recommendations for improving and protecting public health, apparently did little to sway public opinion. However, the report does represent a stirring of concern about public health on the plains.

The Survey's 1865 report, published in 1866, has a sense of finality about it. While the 1864 Survey clearly left a great deal to be done, almost as if there were expectation that funding would be provided for a second year, the 1865 incarnation of the Survey seemed to suggest that it had done all that it could, at least for the time being. Obviously, much work remained, particularly in western Kansas, but members of the 1865 Survey clearly did not expect an extension of their funding.

They were right. After those first 2 years, funding for the Survey lapsed. It was 24 years before the Legislature created another geological survey, and

30 years before it provided any specific funding. Such a lapse, however, was not unusual among state surveys. Of the state surveys that were created before the year 1900, few existed continuously from the time of their creation until the end of the century. Obviously, there was a sense that surveys were created to do a job, and then go out of existence.

In Kansas, that passing out of existence came at an especially inopportune time in terms of geological exploration. In the 1860's, the army began building forts in western Kansas, providing cover for pioneers on the Smoky Hill and Santa Fe trails. The surgeons assigned to those posts produced some of the earliest vertebrate fossil finds from the Kansas Cretaceous. In 1868, for example, the post surgeon at Fort Wallace, near the Colorado border, uncovered a fossil mosasaur from the Niobrara chalk, the first major vertebrate find from the Kansas Cretaceous. That discovery, along with others that soon followed, set off an explosion of interest in the Kansas chalk and made it a mecca for



B. F. Mudge's geologic map of Kansas appeared in a report by the State Board of Agriculture in 1878.

paleontological exploration. Many of the collectors, such as B. F. Mudge, lived in Kansas, but the Kansas Cretaceous attracted E. D. Cope, O. C. Marsh, and Leo Lesquereux. For a time Kansas was among the best-known collecting locations in the world. Along with mosasaurs, the collectors found fish, pterodactyls, sharks, swimming birds, and hordes of invertebrate specimens.

There was, of course, no Kansas Geological Survey during this time, and many of the specimens that might otherwise have stayed in Kansas were shipped to east coast and European museums. Nonetheless, western Kansas fossils probably did have an influence on the Survey when it was recreated in 1889. One of its first and most noted staff members was paleontologist Samuel Wendell Williston, who cut his scientific teeth in the chalk beds of western Kansas. Williston, who had a Ph.D. in entomology and an M.D., returned to Kansas from Connecticut, where he had worked for the State Board of Health. His position at the Survey and the University of Kansas, combined with the Cretaceous finds in western Kansas, probably helped lead to an interest in paleontology at The University of Kansas that has survived to the present.

From 1889 to the present, the Kansas Geological Survey's history has been inextricably tied to the University of Kansas. After encouragement from the Kansas Academy of Science, a series of bills creating a geological survey was introduced in Kansas legislatures of the 1880's. None succeeded, however, until 1889, when the Geological Survey was made a part of The University of Kansas and the University's chancellor made the Survey's *ex officio* Director. This arrangement, though taken for granted in the state today, was more than a little unusual at the time. The Survey's placement at KU, and not Kansas State College (as it was called



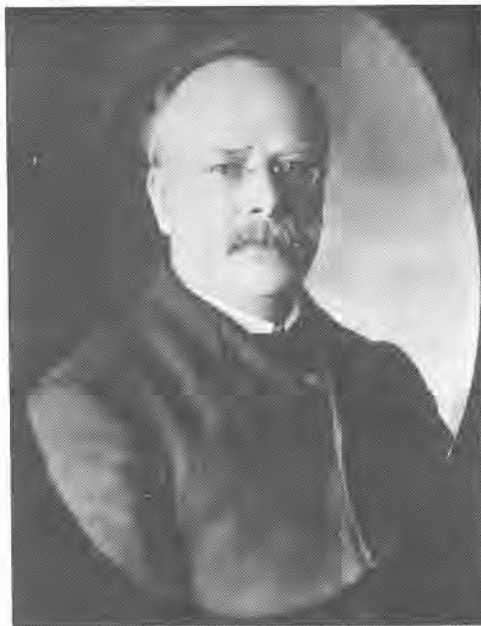
Samuel Wendell Williston in a photo taken in 1898. Williston was the Survey's paleontologist in the 1890's, before leaving to become the first Dean of the University of Kansas Medical School.

until 1960) in Manhattan, may have been the result of remaining bitterness over B. F. Mudge's dismissal from Kansas State in 1874. Mudge was accused of interfering with the choice of the College's head administrator and summarily dismissed. (He wound up at the State Board of Agriculture, where he was responsible for the first published geologic map of Kansas. In fact, the annual reports of the State Board of Agriculture and the *Transactions of the Kansas Academy of Science* provided the most popular publication avenues for Kansas geologists from 1865 to 1889.) At least a few members of the geologic community--S. W. Williston, in particular--never forgave Kansas State, and that lasting concern may have played a role in the Survey's venue at KU and Lawrence.

Though the 1889 Legislature authorized KU to begin a geological survey, legislators conveniently failed



to appropriate funds specifically earmarked for the task. If KU wanted to support a survey, it had to do so out of its own rather limited resources. At first, the University did not, and the survey existed in name only, but in the early 1890's, as the University hired scientists with a geologic bent, the Survey began to develop its own identity. Erasmus Haworth, "Daddy" to his students, began to use the Survey as the umbrella for field work. Though he published the first results of that work in the *Kansas University Quarterly*, Haworth was producing detailed stratigraphic sections, drawing detailed geologic maps, and, in short, taking on the classical role of a scientist at a geological survey. Other KU staff members soon joined the effort. Williston provided unmatched paleontological expertise, and E. H. S. Bailey did chemical analyses.



Erasmus Haworth, in a photo taken in 1887, shortly before he joined the University Geological Survey in 1889.

The result was the University Geological Survey, which finally was awarded separate funding through the

University in 1895 and shortly thereafter began its own series of publications. Though the staff members of that early Survey headed three separate but equal departments, Haworth was widely regarded as the leader of the band. He was the author listed on the first publication from that University Geological Survey, a 320-page volume that included cross-sections, photographic plates, and a geologic map drawn in semiperspective. The format stuck, and the Survey published 12 subsequent volumes using many of the same publishing techniques, on such subjects as paleontology, mineral waters, coal, gypsum, oil and gas, and lead and zinc. All of those geologic subjects were on the minds of contemporary Kansans, as the state experienced a lead-and-zinc mining boom in southeastern Kansas and was among the nation's leaders in gypsum and salt production. Perhaps as a result of that economic activity, Haworth's Survey also began to publish annual reports on Kansas' mineral production and its economic value.

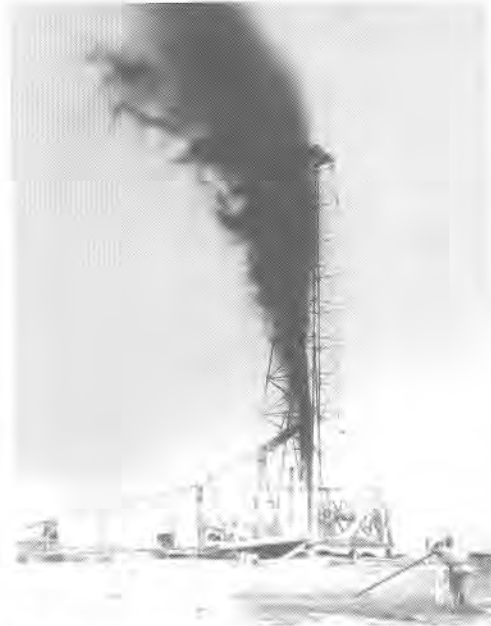
From the beginning of his tenure as Director, Haworth had a definite, proscribed view of the Survey's role as a public institution. From the time it was created, up to the present, the Survey has struggled with an essential tension between public service--work done for the public and written largely in nontechnical terms that the public could comprehend--and work done mostly for the sake of basic knowledge, in which immediate application was secondary and priority was given to enhancing a body of knowledge, particularly in academic circles. Certainly, the two surveys of the 1860's tended toward the former. The Kansas Legislature clearly expressed a desire for economic and applicable benefits; and, for the most part, Haworth's Survey continued that emphasis. Many of the early publications were aimed at economic topics and written in relatively



comprehensible language. "It should be remembered by the scientific reader," Haworth wrote, "that these reports are intended primarily for the masses of the citizens of Kansas, and that therefore an elementary character must be preserved, not however, it is hoped, at the expense of scientific accuracy." Haworth identified his audience clearly, and he wrote for them. Haworth led a Survey that did basic geology, even basic paleontology, but nearly always with an eye toward an economic purpose.

As a result, at least in some respects, the Survey's greatest influence in Kansas was in economic geology, particularly in oil and gas. Shallow oil deposits were drilled in eastern Kansas in the 1860's, and natural gas became a major economic resource for lighting and later in industry in the 1870's. As drilling became more common in the late 1800's and early 1900's, particularly in south-eastern Kansas, the Survey and Haworth became more involved. Haworth was credited with using surface mapping to discern several of the anticlinal structures that led to the 1915 discovery of the El Dorado field. The El Dorado has since produced nearly 300 million barrels of oil, making it a United States giant and the largest producing field in Kansas history.

In 1907, during Haworth's tenure, the Kansas Legislature changed the Survey's enabling legislation, providing the basic statutory foundation that guides the Survey today. That legislation, first, changed the name from the University Geological Survey to the State Geological Survey, though it continued the University Chancellor as *ex officio* Director and charged him with the responsibility of appointing the State Geologist and Director of the Survey. Perhaps most important, that legislation outlined the Survey's mandate, its *raison d'être*, in a short



Shooting a well in the giant El Dorado field in south-central Kansas 1919.

paragraph that still guides Survey operations.

The University of Kansas is hereby authorized to continue the operations of the state geological survey of Kansas, and to make as far as possible a complete geological survey of the state of Kansas, giving special attention to any and all natural products of economic importance, in order to determine the character, location and amount of such products, and to prepare reports on the same as hereinafter prescribed.

That enabling Legislation was later modified slightly, but it still set the standard for today's Survey. The name and the charge were not the only things that changed as the Survey entered the 20th century. The personnel were different. Williston had left. In 1899, he became the first Dean of the University of Kansas Medical School. In 1902, he left Kansas altogether to teach paleontology at the University of Chicago, but Haworth and Bailey remained, along with other geologists who came and went depending on the subject at hand.

The guiding force, however, remained in Haworth. He continued to

oversee Survey operations, including the publication of annual reports on mineral production in Kansas. Those publications chronicled a sprawling mineral industry in the state, particularly in the form of booming oil and gas production shortly after the turn of the century. That boom, in fact, may have been responsible for Haworth's departure from the Survey in 1915, when he left to go out on his own as a consulting geologist (although he remained Chair of the KU Geology Department until 1920). Haworth was probably encouraged, at least in part, by the sudden success in the oil fields in south-central Kansas. Haworth followed that path, consulting at times with his son, Henry, until his death in 1932.

Haworth's departure from the Survey, however, signaled no sudden change in its operations. William H. Twenhofel, at the time a professor of geology at KU, was named as Haworth's replacement, although he lasted for only a year before resigning to take a teaching post at the University of Wisconsin. Twenhofel was followed by a 24-year-old native of Washington who was fresh out of a Ph.D. program in paleontology at the University of Chicago--Raymond C. Moore.

Though Erasmus Haworth made the Survey a viable, recognized part of State government and the University of Kansas, it was Raymond Moore who helped establish its scientific credentials. In many ways, R. C. Moore was the Kansas Geological Survey of the first half of the 20th century. Moore wrote volumes on the oil and gas resources of Kansas--important volumes that quickly became as indispensable as they were rare. In the 1920's, he headed field parties for the U.S. Geological Survey and was the expedition geologist for a group that surveyed the Grand Canyon and reported their experiences in the *National Geographic* magazine. He continued to study sedimentary

deposits and their relationship to petroleum, eventually helping to devise theories about the cyclic deposition of limestones and shales in the Pennsylvanian and Permian of eastern Kansas. Those theories, published with Max Elias and Norman Newell, are still vigorously debated today and continue to be refined and reshaped. In 1933 he produced *Historical Geology*, a volume issued by McGraw-Hill Book Company; it was the first of several books on the subject that Moore would write.

In academic circles, however, Moore was best known as perhaps the premier invertebrate paleontologist of his time. In the late 1920's, he began to publish on Paleozoic invertebrates. As the decades went by, he focused in particular on crinoids, though he regularly published on corals and bryozoans and brachiopods and jellyfish--even protozoans. Moore's sweeping knowledge of invertebrate fossils eventually led to his founding, in 1948, of the *Treatise on Invertebrate Paleontology*, which he edited for many years. The *Treatise* was quickly recognized as the ultimate source on the subject and continues today as a publication from The University of Kansas and the Geological Society of America. It is funded in part through proceeds from Moore's estate.

Without question, Moore became the recognized leader in his field, and the prestige of his activities added to the credibility of the Kansas Survey, which was developing its own scientific identity during those years. Not surprisingly, much of that work was driven by the economics of the times and that meant studies on oil and gas. With the discovery of the El Dorado field, south-central Kansas began producing petroleum at an unprecedented rate. The El Dorado field by itself was responsible for at least 6 percent of the nation's oil production in 1918--production that was especially welcome in the waning days of World War I. Those finds were followed a decade later



by discoveries in western Kansas along the Central Kansas Uplift, which became the most densely drilled major target in the country.

Work at the Kansas Survey reflected that milieu. Of the 12 publications produced by the Survey from 1920 to 1930, nearly all focused on economic geology in one aspect or another. If not oil and gas--as one might expect, that was the most popular topic--then clay or volcanic ash. In some cases, the Survey published basic geologic information about parts of the state, but the subject of the study was nearly always influenced by the latest drilling boom. Ellis and Russell Counties, on top of the Central Kansas Uplift, were two areas that were studied in detail, and the Survey revived the idea of county-wide geologic studies, an approach that dated back to the Swallow survey of 1865.

While oil, and to a lesser extent coal, were the dominant topics of publication for the first two decades of Moore's Survey, that changed in the late 1930's. Drought made Kansas, especially southwestern Kansas, a part of the Dust Bowl and was probably largely responsible for the Survey's attention to ground water. In 1937, the Kansas Survey signed a cooperative agreement with the U.S. Geological Survey. The work was coordinated with a number of other state agencies, but the Kansas Survey and the U.S. Geological Survey were clearly the two primary players in ground-water study in the state.

Kansans, especially those who moved into western Kansas, were painfully aware of water problems. From the time that Kansas was tagged as part of the Great American desert, settlers had worried about water. Though many moved into western Kansas with the hope that "the plow would bring the rain," it soon became apparent that farmers would have to adapt to arid conditions through

dryland farming, or they would have to irrigate. Irrigation was nothing new. Taos Indians, who built a lone pueblo in today's Scott County in west-central Kansas in the late 1600's, probably practiced the first irrigation in the state when they dug ditches to water their crops from springs. Much more widespread irrigation began in the late 1800's and early 1900's, when eastern dollars poured into western Kansas and financed the building of an extensive canal system to carry water from the Arkansas River into fields around Garden City and Dodge City. Hundreds of miles of ditches were dug, though the canals were never really profitable.

Irrigation was one illustration of the difference in water conditions from west to east in Kansas. Once it became clear that surface water was insufficient, western Kansas came to rely on ground water--especially from the Ogallala aquifer--to supplement the scanty rainfall. Eastern Kansas received more rain and thus more surface water, though it had far fewer reliable supplies of ground water. East or west, the drought of the 1930's made clear the severity of the problem and led to some of the first cooperative scientific studies between the USGS and the Kansas Survey. Among the earliest of those studies were investigations of the Equus Beds, a central Kansas aquifer that was, and still is, an important source of water for Wichita, the largest city in the state. Cooperative work with the USGS left a legacy that continues. The surveys together supported a number of ground-water studies in the state and jointly supported branch offices in western Kansas.

Through the 1940's and 1950's, the Survey continued in much the same pattern that Moore had set in his early years. It continued to be heavily involved in oil and gas studies, publishing tracts by well-known geologists such as Wallace Lee and W. A. Ver Wiebe. It continued to produce county-

by-county reports on geology; in the early 1940's those county reports began to include ground water in their titles, reflecting that change in focus. John C. Frye, John Mark Jewett, Bruce Latta, Norman Plummer, Walter Schoewe, along with other distinguished geologists, were the driving force behind many of those publications. Frye, who was named the Survey's Executive Director from 1945 to 1952, was partially responsible for pushing the Survey into Pleistocene geology, particularly as it related to ground water. Frye left the Kansas Survey in 1954 to become head of the Illinois Geological Survey, a position he held until 1974, when he became Executive Director of the Geological Society of America.

While economic topics clamored for study, particularly during the years of World War II, Moore did not abandon basic science. In 1937 Moore and Kenneth Landes produced the Survey's first published 1:500,000 scale geologic map of the state, a map that was largely completed when former oil-man Alf Landon was the state's governor. In 1951, Moore and others produced the first modern, detailed stratigraphic rock column for the state. But the emphasis in Survey publications, and research efforts, was on coal, water, and particularly oil and gas.

Moore retired as head of the Survey in 1954. He continued to teach and publish; his last publications appeared in 1973, a year before his death in 1974. In many ways, Moore set the scientific tone for the Survey, not only for the 37 years that he was State Geologist but for the decades that followed. Like his predecessors and successors, Moore had to guide the Survey between the courses of research and service. In summary, he apparently steered somewhat closer to research than did Haworth before him. Moore wrote that a geological survey is

... first of all, a scientific research bureau... The purpose of the state

geological survey is to investigate areas and mineral deposits, to undertake a study of geological problems within the state, and to bring together, correlate and preserve all possible information which will add to knowledge of state geology, and promote the best development of state mineral resources. The value of such work consists in the scientific contributions to knowledge which result in promoting the best development of mineral resources.

To Moore's mind, then, the Survey's first role was one of basic geology designed to aid in the knowledge of and development of economic resources. He also believed in the Survey's role as a conservator and disseminator of information, again primarily as it pertained to economics.

A state survey is a continuing institution--a scientific bureau which through periods of years gathers and preserves geological information which in many cases might otherwise be lost. The value of such a repository for geological data in a state is seen, for example, in the records of deep wells, samples of drill cuttings, rock specimens and fossils which are brought together for permanent record and reference.

Under Moore's guidance, the Survey worked with the Kansas Geological Society to develop a library of cuttings from Kansas oil and gas wells. That library, established in Wichita in 1938, today contains cuttings from more than 125,000 Kansas wells and is the Survey's only branch office. The Wichita Well Sample Library was clearly part of Moore's view of the Survey's role as providing a service that would eventually have economic benefit.

Yet, Moore did make the distinction of the Survey as, first and always, a "scientific bureau." It was not merely an arm of state government or an appendage of the University. The concept of the Kansas Geological Survey as a source of scientific information--information with economic consequence, but scientific nonetheless--was clear. Clear not only in what Moore said but in what he did and in what the Survey published. In many ways, Moore

cast the die for the Kansas Geological Survey of the 20th century. His death, at age 82, was anything but the end of an era. Certainly, Moore came from an old school of geological thought, one that denied plate tectonics, but his vision of the Survey remained long after the scientific revolution that made the continents move.

Moore was followed at the Survey by Frank Foley, a native Canadian who had a Ph.D. from Princeton and had previously been the State Geologist of North Dakota and head of the Ground-water Section at the Illinois Geological Survey. Though Foley's forte was ground water, he did not immediately move the Survey from its traditional studies of basic geology and oil and gas. Rather, the changes from Moore to Foley--and the changes in staff that

worked at the Survey during those times--were slowly transitional. Much of the work that appeared early in Foley's tenure as State Geologist was directed toward basic geology and oil and gas, probably in part because Kansas reached a peak in oil production during the 1950's. J. M. Jewett's *Oil and Gas in Eastern Kansas*, published by the Survey in 1954, became the standard beginning reference work for oil and gas drilling in eastern Kansas. At the same time, the Survey developed an emphasis on public information and education, producing nontechnical publications for schools and community organizations. Grace Muilenburg led that effort at the Survey and quickly became known as the foremost popularizer of the state's geology.



Seventy years worth of experience as State Geologist of Kansas. From left, R. C. Moore (State Geologist from 1916-54), William W. Hambleton (1970-86), and Frank C. Foley (1954-70).

In the late 1950's and early 1960's, the tenor of Survey research began to change. In part, the changes may have been due to differences in leadership. More likely they were due to the changes that were sweeping through the earth sciences at the time, not only from the scientific revolution created by plate tectonics, but through the application of new instrumentation and quantitative approaches to studying the earth. Geology had long been as much an art as a science. In fact, many early geologists had an artistic flair that came in handy for sketching those features in the field. Obviously, artistic talent was requisite before there were photographic cameras, but long after cameras were common in the field--and that includes nearly all of the time that the Kansas Survey existed--geologists sketched their work, perhaps figuring that the best way to know an outcrop was to draw it. R. C. Moore, for example, was a prolific artist, and his sketches are still regularly used in Survey publications.

Geophysics, mathematical geology, and computers did not change that artistic approach, but they certainly added a new sphere of available information. In 1957, William Hambleton, then the Survey's Associate Director, and Daniel Merriam collected papers for a volume on geophysics in Kansas that discussed the application of gravity, magnetics, resistivity, seismic surveys, and other geophysical techniques. At approximately that point, the topic of geophysics and computer-oriented approaches to studying geology joined more traditional Survey studies, such as ground water, oil and gas, paleontology, and stratigraphy. Survey studies of stratigraphy tended to be dominated, at least in eastern Kansas, by the question of cyclicity of deposition in the Pennsylvanian and Permian limestones. The Survey also published at least two classic reference works in Kansas geology during the 1960's. In

1963, Dan Merriam produced a compendium of information about the state in his *The Geologic History of Kansas*, which remains the starting point as a technical introduction to the state's geology; in 1968, Doris Zeller edited *The Stratigraphic Succession in Kansas*. That bulletin had a list of contributors that read like a who's who of mid-20th century Kansas geology: J. M. Jewett, Charles Bayne, Edwin Goebel, Howard O'Connor, Ada Swineford. Both Merriam and Zeller's books remain as standard references today.



Howard O'Connor, Survey geologist, in Chase County, Kansas, in the late 1940's.

In the waning years of the 1960's, the Survey began to move into other less traditional fields. Perhaps the most notable and long-lasting was environmental geology, and not so much at the Survey's choice but because of contemporary events in Kansas and the rest of the nation. In 1968, the Atomic Energy Commission began to study an abandoned salt mine in the central Kansas town of Lyons as a possible site for storage and disposal of radioactive



waste. The site was initially accepted, both politically and scientifically, as a reasonable option and work began on testing and studying the site. The Survey was drawn in to study the local geology and soon found problems with the integrity of the site, not the least of which was the lack of information on unplugged oil and gas wells that penetrated through the proposed repository. Though Survey studies accepted bedded salt as a reasonable place to put radioactive waste, the work was critical of the Lyons location as the site. At about the same time the Survey studied the location, political opposition coalesced, and the plan was eventually dropped. In short, the Lyons situation drew the Survey into the arena of environmental politics and provided increased visibility.

William Hambleton, who had been the Survey's Associate Director since 1956, was the Survey administrator most actively involved at the Lyons site,

and in 1970, he succeeded Frank Foley as the Survey's eighth Director. Hambleton, like his predecessors, was not a native Kansan. Born in Pennsylvania, he completed a Ph.D. in geology at KU in 1951 and taught in the KU Geology Department before moving to the Survey, where his impact was felt long before he took over as Director. In particular, he helped encourage the Survey's movement into the use of computers to analyze geologic data. With his ascension to Director, those research directions underwent little change.

As had his predecessors, Hambleton wrestled with the Survey's dual role as a research and service organization. Like his mentor R. C. Moore, Hambleton sided more toward defining the Survey as a research bureau, arguing that service flowed naturally from good research. While the organization continued to be visible in its service functions, with such experiences as the



The Lyons, Kansas, salt mine and the AEC's study of radioactive-waste disposal. Lyons gave the Kansas Survey scientific and political visibility in the 1960's.

one at Lyons, Hambleton deliberately created research-oriented sections of the Survey that focused on computers, mathematical geology, and automated cartography. While fostering those areas of study, Hambleton steadfastly resisted including any sort of regulation in the Survey's activities. He actively protected the Survey's status as a line-item in The University of Kansas budget and fought attempts to make the Survey part of a larger State Department of Natural Resources.

At the same time, water began to take on a more significant role at the Survey and in the state. The 1970's saw the spread of large-scale irrigation in western Kansas, irrigation that changed the economic character of eastern and western Kansas. New technology allowed the development of center-pivot irrigation systems--systems with wheels that could "walk" over uneven land. Land no longer had to be leveled to allow irrigation, and that opened up huge new tracts of western Kansas that had previously been limited to dryland farming. Irrigation allowed western Kansas farmers to produce new crops, such as corn, that generally did not thrive on the High Plains. With corn came more and bigger feedlots, and with the feedlots came packing houses, so that Kansas became the largest cattle-feeding state in the nation. The largest slaughter house in the world was built outside Garden City. These developments led, not only to an economic boom in southwestern Kansas but, to a decline in the importance of the cattle industry in traditional sales locations like St. Joseph, Kansas City, and Wichita.

The slaughter houses, feedlots, and farmers all depended, one way or another, on water, and most of the water came from the Ogallala aquifer. In much of the western third of Kansas, the Ogallala consisted of hundreds of feet of saturated thickness. The porous sands and gravels of the Ogallala

produced prodigious amounts of water, hundreds of gallons per minute--at first. In the mid- to late-1970's, the water table in the Ogallala began to show alarming drawdowns in some locations. While much water remained, it was deeper below the surface, and higher energy prices made it more expensive to pump. The result was greater concern about ground-water quantity; in some areas there was related concern about ground-water quality. As a result, the Survey increased its commitment to water research. By the end of the 1970's, the Geohydrology Section was the Survey's largest single component. Geohydrology staff not only dealt in the traditional role of data collection, but began to develop mathematical models that helped pinpoint areas of greatest concern and helped predict the impact of attempts to manage the resource.

Ground water was just one area of increased emphasis. Geophysics efforts grew, particularly in the form of aeromagnetism and gravity, earthquake studies, and high-resolution seismic reflection. Mathematical geology, particularly as applied to mapping and well-log analysis, continued. The Survey's physical plant changed in 1973 when the Survey moved off of the main KU campus, where it had long shared a building with the KU Geology Department, into a separate headquarters, named for R. C. Moore, on the west campus. By 1985 the Survey had added a separate building as a center for Geohydrology Research--that building was named for Frank Foley--and another building--this one named for Hambleton.

Hambleton retired in 1986 and was replaced by Lee C. Gerhard, who came to the Survey from an appointment at the Colorado School of Mines. Gerhard was a native of New York. Like Hambleton, he had a Ph.D. from KU and had studied with R. C. Moore. Like Foley, he had been State Geologist of North Dakota. Gerhard's background,

however, was more petroleum-related, with an emphasis on stratigraphy.



Lee C. Gerhard, the Kansas Survey's ninth Director.

The Survey that Gerhard took over was vastly different than the Survey that had been created at The University of Kansas a hundred years earlier. The 19th-century Survey had three sections: Geology, Chemistry, and Paleontology. The 1987 Survey had four research sections--Geologic Investigations (focusing mostly on environmental geology, mapping, coal, and engineering geology), Petroleum Research (which included geophysics), Geohydrology, and Advanced Projects (focusing primarily on mathematical geology). In 1987, geochemistry was done primarily in support of other Survey research and was part of a Service Section. Paleontology received significantly less emphasis and, in 1987, was part of the Petroleum Research Section. The 1987 Survey had two broad areas of emphasis--mathematical geology and geophysics--that did not even exist in 1889. Geohydrology, one of the main

components of the Survey's research and service, played a far more prominent role in the 1987 Survey, and obviously, the names had changed from Haworth, Williston, and Bailey to Gerhard, Don Steeples, John Davis, and a number of others.

Areas of emphasis were not the only changes. The 1889 Survey consisted of three professionals and several students. The 1987 Survey had more than 50 full-time professionals, everything from computer scientists to cartographers, and more than 50 student research assistants. The budgets of those early days of the Survey were measured in a few thousand dollars; annual appropriations were measured in four figures until 1919. By 1987, the State-appropriated budget was nearly \$4 million, and outside grants and contracts added several hundred thousand dollars annually. By nearly every measure, the Kansas Survey was well regarded and highly ranked among its peer institutions.

The first years of the Survey's existence, from 1864 to the early 1890's, were clearly times of geologic reconnaissance. The late 1890's and early 1900's marked the establishment of the Survey as a viable, credible scientific institution. The 1920's began something of a redefinition of the Survey's role as a research organization, taking it beyond work as a service agency. Over most of the rest of the 20th century, the general philosophy behind the Survey remained the same, though the nature of the research changed from banging on rocks to a much more quantitative, data-based science. That essential tension, that tug and pull, between research and service remained and is almost daily played out, as the Survey continually makes decisions about appropriate areas of emphasis. While the future will offer different areas of research and emphasis, those efforts will clearly be based on much of the work that has gone before.

## KENTUCKY

Kentucky Geological Survey, University of Kentucky, 228 Mining and Mineral Resources Building, Lexington, KY 40506-0107. Phone 606-257-5500.

### HISTORICAL SEQUENCE OF ORGANIZATIONAL NAME AND DIRECTORS:

- William W. Mather, State Geologist, 1838
- Kentucky Geological Survey**
- David Dale Owen, State Geologist, 1854-57\*
- Nathaniel S. Shaler, State Geologist and Director, 1873-80
- Kentucky Geological Survey and Bureau of Immigration**
- John R. Procter, State Geologist and Director, 1880-92
- Kentucky Geological Survey**
- Charles J. Norwood, Director, 1904-12
- Joseph B. Hoeing, State Geologist, 1912-18
- Department of Geology and Forestry**
- J. E. Barton, Commissioner, 1918-19
- Willard R. Jillson, Deputy Commissioner and State Geologist, 1919-20
- Kentucky Geological Survey**
- Willard R. Jillson, Director and State Geologist, 1920-32
- Bureau of Mineral and Topographic Survey, University of Kentucky**
- Arthur C. McFarlan, Director and State Geologist, 1932-34
- Division of Geology, Department of Mines and Minerals**
- Daniel J. Jones, State Geologist, 1934-48
- Kentucky Geological Survey, University of Kentucky**
- Arthur C. McFarlan, Director, 1948-58
- Daniel J. Jones, State Geologist, 1948-58
- Wallace W. Hagan, Director and State Geologist, 1958-78
- Donald C. Haney, Director and State Geologist, 1978-present

\*David Dale Owen left Kentucky to become State Geologist of Arkansas. Robert Peter, State Chemist, brought manuscripts to completion and saw them through press; therefore, this survey was probably active until about 1860.

### HISTORY OF THE KENTUCKY GEOLOGICAL SURVEY

The Kentucky Geological Survey is an earth-science and mineral-resource research and public-service department in the University of Kentucky for the Commonwealth of Kentucky. With the University, it shares a record of more than 100 years of service to the Commonwealth.

State-sponsored geological investigations in Kentucky began in 1838 when William W. Mather was appointed to be the first State Geologist

by Governor James Clark. Mather conducted his field work during the summer and early fall of 1838, and the results of his investigation were published in 1839.

David Dale Owen is credited with organizing the first continuing Kentucky Geological Survey in 1854, 11 years before the establishment of the University of Kentucky and 25 years before the founding of the U.S. Geological Survey. Since that time the organization has had a diverse history, with periodic interruptions and varied fortunes. The Survey has been attached



to, or been a part of, the Kentucky Bureau of Immigration; Kentucky Department of Forestry; Kentucky Department of Mines and Minerals; University of Kentucky Department of Geology; Kentucky Department of Commerce; and the Kentucky Energy Cabinet, as well as being a separate department. Headquarters have been located in either Frankfort (the State Capital) or Lexington (the location of the University of Kentucky).

Traditionally, the activities of the Kentucky Geological Survey have been recorded as being part of a numerical sequence, with the organization in 1854 being designated the "First Survey." Reorganizations, reinstatement after interruptions of activities, and administrative changes generally created new surveys with different numerical designations. Publications have also been designated part of a numerical series. In addition, some surveys have been referred to in literature as the survey of the Director or State Geologist, rather than by number. For example, the Kentucky Geological Survey of 1904-1912, the publications of which carry the designation "Series III" or "Series 3," may be cited by some writers as the "Third Survey" or the "Norwood Survey." A brief chronology is presented below. It is here noted that the business of the Commonwealth of Kentucky has been conducted on a fiscal-year basis (currently July 1-June 30) rather than a calendar-year basis, thus accounting for an apparent overlap of dates.

- 1838 W. W. Mather, State Geologist. No organizational arrangement; apparently Mather was the only staff member.
- 1839-53 No organization; no State Geologist.
- 1854-60 First organized Kentucky Geological Survey; D. D. Owen, State Geologist from 1854-1857; Robert Peter, State Chemist, supervised the activities of the office from 1857-1860.
- 1860-73 No organization; no State Geologist.

- 1873-93 Kentucky Geological Survey (Second or New Survey); N. S. Shaler, State Geologist and Director, 1873-80, and J. R. Procter, State Geologist and Director, Kentucky Geological Survey and Bureau of Immigration, 1880-93.
- 1893-1904 No organization; no State Geologist.
- 1904-12 Kentucky Geological Survey (Third Survey); C. J. Norwood, State Geologist and Director.
- 1912-18 Kentucky Geological Survey (Fourth Survey); J. B. Hoing, State Geologist.
- 1918-20 Kentucky Department of Geology and Forestry (Fifth Survey); J. E. Barton, Commissioner; no State Geologist, 1918-19; W. R. Jillson, Deputy Commissioner and State Geologist, 1919-20.
- 1920-32 Kentucky Geological Survey (Sixth Survey); W. R. Jillson, Director and State Geologist.
- 1932-34 Bureau of Mineral and Topographic Survey, University of Kentucky (Seventh Survey); Arthur C. McFarlan, Director and State Geologist.
- 1934-48 Division of Geology, Department of Mines and Minerals (Eighth Survey); D. J. Jones, State Geologist.
- 1948-58 Kentucky Geological Survey, University of Kentucky (Ninth Survey); A. C. McFarlan, Director, D. J. Jones, State Geologist.
- 1958-78 Kentucky Geological Survey, University of Kentucky (Tenth Survey); W. W. Hagan, Director and State Geologist.
- 1978-present Kentucky Geological Survey, University of Kentucky (Eleventh Survey); D. C. Haney, State Geologist and Director.

## KENTUCKY'S FIRST OFFICIAL GEOLOGIC INVESTIGATION

The year 1838 was a landmark date in Kentucky geology in that it recorded the first official State-sponsored geological investigation in the Commonwealth. As a result of intense agitation by a number of Kentuckians, particularly agriculturalists, the General Assembly of the Commonwealth of Kentucky, on motions introduced by Senator Cyrus Wingate and Representative James T. Morehead, authorized Governor James Clark to secure the services of someone to visit

the mineral regions and conduct a geological reconnaissance of the State (Townsend, 1931). William W. Mather, who had previously worked in Ohio and New York, was appointed State Geologist of Kentucky. He was the first to hold that title and was apparently the only staff member at that time.

### FIRST SURVEY

Although Mather outlined the way for the establishment of a Kentucky Geological Survey as a continuous scientific and developmental function of State government, positive action was not forthcoming for 15 years. His efforts were not in vain, however, because they provided documentation for proponents to periodically agitate and petition for legislative action. Finally, in 1854, Kentucky's General Assembly approved a bill to provide for a geological and mineralogical survey of the State. Dr. David Dale Owen, M.D., of New Harmony, Indiana, was appointed State Geologist; he organized and began what was designated in literature as the "First Survey," which was located in Frankfort.

Geological investigations by Owen and his staff began with the field season of 1854 and continued, weather permitting, until 1857, when Owen went to Arkansas to take up geological work for that state. Although Owen's work was more detailed than Mather's, it was, of necessity, largely preliminary and pioneering but was documented by much detailed data. Four published volumes contained regional observations of stratigraphy, structure, and areal geology; detailed measured stratigraphic sections; chemical analyses of rocks, minerals, and soils; the first topographic maps depicting parts of the State; and soil descriptions. Some of the reports were artistically and skillfully illustrated with meticulous pen-and-ink drawings by Owen himself.

After Owen's departure from Kentucky, Dr. Robert Peter, M.D., State Chemist, completed a number of unfinished manuscripts and saw them through the press.

Owen's assignment in Arkansas, his untimely death in 1860, and the forebodings of the War Between the States brought an end to the First Survey. As a whole, the reports of Dr. Owen were regarded as furnishing the basis on which detailed economic and scientific research could be founded (Shaler, 1877, p. 33).

### SECOND SURVEY

More than a dozen years passed before State-sponsored geologic investigations were conducted in Kentucky again. During the reconstruction period following the Civil War, the practical value and worth of state geological surveys in developing mineral resources of various types came to the attention of the General Assembly, and finally, in 1873, an act was passed establishing a new or, as it came later to be called, the "Second Geological Survey of Kentucky." Nathaniel S. Shaler, a native Kentuckian and at that time professor of paleontology at Harvard University, was appointed Director and State Geologist (publications issued during his tenure listed Shaler variously as State Geologist and Principal Geologist).

John R. Procter, former office assistant to N. S. Shaler, was appointed State Geologist and Director of the Kentucky Geological Survey in 1880; he also held the title of Commissioner of Immigration.

Procter was apparently an able administrative officer and politician, but lacked geological training and experience, except that acquired through his association with his predecessor. A capable staff was employed, but relatively little original geologic work was published, especially compared to the period under Shaler.



Geologists employed by the Kentucky Geological Survey in 1875. The two men on the right later became Directors of the Survey: John R. Proctor (far right, 1880-92) and Charles J. Norwood (1904-12).

Particularly useful for that time were a series of county surveys. A substantial portion of the geological publications of Proctor's administration, however, were reprints of earlier reports. Robinson (1927, p. 4) concluded that the Kentucky Geological Survey under Proctor was handicapped because Proctor was not a geologist, he was burdened with his immigration work and failed to give the Survey the time it needed, and funds appropriated for geological work were diverted to the Bureau of Immigration.

The combining of the two departments was obviously detrimental to the original purpose of the Survey, if not to both agencies. In 1893, after a series of resolutions and enactments, State-sponsored geological investigations in Kentucky were terminated once again.

### THIRD SURVEY

The late 1800's and early 1900's saw increased demand for pertinent information about the State's mineral resources, particularly fuels. Kentucky Geological Survey reports were out of print or out of date. Railroad lines extending into the mountainous counties were proposed, and the lack of a competent resource data base was hindering industrial development. Finally, after more than a decade since the termination of the Proctor era, a plan to reorganize and reestablish the Kentucky Geological Survey began to crystallize.

In 1904 the Kentucky General Assembly introduced and passed a bill providing for and authorizing the curator of the affairs and effects of the old geological survey to resume the geological, topographical, and agricultural survey of Kentucky. Thus, by legislative enactment, Professor

Ky. Geol. Survey  
in act. with Geom. Sullivan

May - 1889.

		Dr
Sats. 14.	So. R.R. expense fr. Chiloburg Ky. to Richmond Ky	1 00
Mon. 15	" Night Lodging at St. Nicholas hotel Richmond Ky.	1 50
" "	" Hire of Horse & Blankboard, fr. Richmond to J.S. Ballards Rock Castle Co. Ky. (See Voucher)	5 00
Sat. 25	" Mat. Ballard, for 2 1/2 days assistance in opening C. @ 10 <sup>00</sup>	2 50
Mon 27	" Dinner at Mrs. Jet Bowles	15
Fri. 31	" Horse, 1 da. Ballard	50
" 31	" Board at Ballards, J.S. fr. May. 14 - 16 June 1. @ 15 <sup>00</sup> per. mo. 15 <sup>00</sup> 16 <sup>00</sup> 17 <sup>00</sup> 18 <sup>00</sup> 19 <sup>00</sup> 20 <sup>00</sup> 21 <sup>00</sup> 22 <sup>00</sup> 23 <sup>00</sup> 24 <sup>00</sup> 25 <sup>00</sup> 26 <sup>00</sup> 27 <sup>00</sup> 28 <sup>00</sup> 29 <sup>00</sup> 30 <sup>00</sup> 31 <sup>00</sup> (Total 46 meals at 16% <sup>767</sup> and horse board 25) (Voucher)	7 92
" 31	" Salary.	

Facsimile of a travel-expense voucher submitted by a KGS geologist in May 1889. Keeping a geologist in the field in those days was somewhat less expensive than it is now.

Charles J. Norwood, Dean of the University of Kentucky's College of Mining and Metallurgy and the State's Chief Inspector of Mines, became the new State Geologist and Director of the Kentucky Geological Survey, without additional salary (Jillson, 1923, p. 24). The Survey headquarters became located at the University of Kentucky, Lexington. Norwood, who had experience in physics, geology, and mining, had served on the Kentucky Geological Survey under Shaler, and, by virtue of his office as Inspector of Mines for Kentucky, was the curator of the effects of the former Kentucky Geological Survey from 1893-1904.

#### FOURTH SURVEY

In 1912 the General Assembly of the Commonwealth of Kentucky passed

an act moving the Kentucky Geological Survey, together with its accumulated collections, records, maps, reports, and property, from the University of Kentucky in Lexington back to Frankfort, where it had been during the First and Second Surveys. The act specified that the State Geologist was not to be connected with any school or college as an instructor, in order that he might devote full time to the Survey, and further provided for an advisory board consisting of five members, one of whom was the Governor, was also stipulated (Hoeing, 1913, p. 9). In the same legislation, the State Geologist was authorized to enter into such cooperative arrangements with other State and Federal agencies that might be advantageous to the State, provided



that they were on a matching-funds basis.

Joseph B. Hoeing, a graduate engineer who had served under Shaler, Procter, and Norwood in various capacities as engineer (or topographer), cartographer, and assistant geologist, was appointed State Geologist in 1912 to head the reorganized Kentucky Geological Survey.

Hoeing held the office of State Geologist until 1918, when, because of legislative action combining the State Board of Forestry with the Kentucky Geological Survey, he resigned.

#### FIFTH SURVEY

The Kentucky Geological Survey was once again reorganized in 1918. The General Assembly, pledged to a policy of economy, retrenchment, and reform, enacted bills that abolished some State offices and consolidated others. One such bill abolished both the State Board of Forestry (and office of State Forester) and the Kentucky Geological Survey (and the office of State Geologist) and created in their places the Kentucky Department of Geology and Forestry and the office of Commissioner of Geology and Forestry; they also provided for a deputy commissioner. Under this arrangement, Governor Stanley appointed John E. Barton, former State Forester, to the newly created position of Commissioner of Geology and Forestry. Hoeing declined an appointment to the subordinate post of Deputy Commissioner and resigned as State Geologist. Thus, the new commissioner, an experienced forester, became the head of the geological as well as the forestry activities in Kentucky (Jillson, 1923, p. 32-33).

Barton apparently successfully carried on the office work attached to the new department, but as far as can be determined, did not embark on any specific program of geological investigations; this inactivity probably

reflected his lack of training in geology. However, he was instrumental in having a substantial manuscript of the Hoeing administration published in 1919.

Kentucky was experiencing an oil boom during this period. Exploration and development were expanding at an exceedingly rapid pace in several areas of the State. The demands upon the Commissioner of Geology and Forestry were greater and more technical than he could handle. Willard R. Jillson, then Assistant Professor in the Department of Geology at the University of Kentucky, was hired as an assistant geologist late in 1918 to assist with this work. The following year he was appointed State Geologist and Deputy Commissioner, Department of Geology and Forestry, under J. E. Barton.

Jillson was a prolific writer and tireless field investigator. Systematic gathering of subsurface records of drilling activities was initiated by him. Within a relatively short time, geologic publications, largely related to oil and gas exploration and development, were available from the Fifth Survey.

*The Geology of Kentucky*, one of the most outstanding single reports ever issued by the Kentucky Geological Survey, was published during this period. Authored by Professor A. M. Miller, Head of the Department of Geology at the University of Kentucky, and part-time employee of the Third and Fourth Surveys, the one-volume report was a comprehensive overview of the historical, physical, stratigraphic, structural, and economic geology of the Commonwealth, and stood as the basic reference on geology and mineral resources for more than a score of years.

The Fifth Survey was short-lived. The inability of two unrelated organizations to function efficiently under one head was indicated by the Procter Survey and demonstrated again in the Department of Geology and Forestry. Friction within the Depart-

ment led to its abolishment of the Department of Geology and Forestry and the reorganization of its offices. The Kentucky Geological Survey was made a separate department of State government, essentially along the lines of the Fourth Survey, and forestry work became a bureau in the Kentucky Department of Agriculture (Jillson, 1923, p. 35-36).

### SIXTH SURVEY

W. R. Jillson was appointed State Geologist and Director of the newly organized (Sixth) Kentucky Geological Survey by Governor Morrow in 1920. Jillson's policy and procedures differed somewhat from his predecessors'. His assistants, with the exception of the Director's Secretary and Chief Clerk, were classified as temporary employees, who were engaged for the summer field season of 2 or 3 months to perform special geographic mapping or geologic or mineral-resource investigations (Jillson, 1931, p. 3). Many assistants were experts in their fields, and brought much experience and a high degree of competence into the Survey work.

The progress of the Sixth Survey was disrupted by a fire in the Old Capital Building, where the Survey was housed, in February 1929. The fire did not reach the Survey offices; however, thousands of publications and other records were lost or seriously damaged.

Based on the amount of published data, the Sixth Survey was the most prolific one in Kentucky to that time. The staff turned out 43 volumes, 30 pamphlets (some of which were incorporated into the bound volumes), 24 reprints, and more than 325 maps. If the success of a geological survey is measured by the amount of mineral-industry activity, the Sixth Survey receives high marks, because there were marked increases in the production of several mineral commodities during the 1920's. Whether this growth was a reflection of

the economy of the time or the result of activity generated by the volume and wider distribution of new geological data is conjectural, but the new maps and reports certainly made both the citizens and potential developers more aware of the State's resource base and economic opportunities.

### SEVENTH SURVEY

In 1932 the direction and fortunes of the Kentucky Geological Survey abruptly changed. The Jillson Survey was terminated because of political and other conflicts. The Kentucky Geological Survey was moved to Lexington and was renamed the Bureau of Mineral and Topographic Survey of the University of Kentucky. Dr. Arthur C. McFarlan, Head of the Department of Geology at the University of Kentucky, was named State Geologist and Director of the Bureau, a position he held in addition to his academic duties.

A limited budget and Dr. McFarlan's concomitant administrative and teaching responsibilities at the Department of Geology severely restricted the growth of the Survey. Field investigations were relegated largely to weekends and academic recesses. However, McFarlan initiated a very ambitious project to prepare an updated handbook of Kentucky geology. The cooperation of industry geologists was solicited and received. Six brief mimeographed bulletins, all dealing with some aspect of petroleum geology in Kentucky, were printed by the Seventh Survey; these and several other manuscripts were to have been incorporated into the proposed handbook.

The Kentucky General Assembly abolished the Bureau of Mineral and Topographic Survey in 1934. This action put an end to the handbook of Kentucky geology as far as the Kentucky Geological Survey was concerned. However, some of the reports prepared by McFarlan and others during this

period were adapted for incorporation in *Geology of Kentucky*, which was later published independently by the University of Kentucky in 1943.

### EIGHTH SURVEY

The Seventh Survey lasted only 2 years. In 1934 the legislative enactment abolished the Bureau of Mineral and Topographic Survey and created a Division of Geology in the Kentucky Department of Mines and Minerals. Daniel J. Jones, who had many years of geological experience in Kentucky's oil fields, was named State Geologist to head the new division. The Department of Mines and Minerals, a State regulatory agency, was located on the University of Kentucky campus, where it had been for many years because of earlier legislative action. Consequently, the Survey offices remained in Lexington.

The 14 years of the Eighth Survey recorded the publication of 9 bulletins, 2 pamphlets, 10 reprints, and 13 cooperative ground-water reports.

### NINTH SURVEY

A new era in Kentucky geology began in 1948 when, by legislative action, the Kentucky Geological Survey was transferred from the Kentucky Department of Mines and Minerals to the University of Kentucky; this action removed the Survey from a State regulatory agency and placed administration and staff appointments again under the University system. As a result of recommendations from representatives of education, government, and industry, the Survey became a research bureau in the University, and was attached to the Department of Geology in the College of Arts and Sciences.

Concurrent with the legislative transfer of the Kentucky Geological Survey to the University of Kentucky was another act creating the Kentucky Agricultural and Industrial Develop-

ment Board. (The name was later changed to the Kentucky Department of Economic Development, the Kentucky Department of Commerce, and subsequently to the Kentucky Development Cabinet.) The Board was charged to prepare and promote programs of research and publicity and assist and coordinate activities involving the promotion and development of industry, agriculture, mining, and any of the other potential resources of the Commonwealth.

In November 1948, Norwood Hall, which housed the offices of both the Survey and the Department of Mines and Minerals, was destroyed by fire. All maps, publications, and records were consumed. The only thing remaining was a small well sample library that was housed in another building. As a result, most of the Survey's efforts in 1949 and 1950 were devoted to reproducing county geologic and structure maps that had been issued earlier and recovering copies of lost records from industry and other sources.

In 1949, the newly created Agricultural and Industrial Development Board of Kentucky entered into a cooperative agreement with the Kentucky Geological Survey to expand geologic and mineral resource investigations. (Partial funding of the Survey's budget continued through this agency and its successors during the Ninth and Tenth Surveys and the first part of the Eleventh Survey.) The Survey's staff was increased, and mineral commodity investigations were initiated. Full-time staff members were supplemented by University of Kentucky faculty members appointed on a part-time basis to serve in advisory and research roles. Field offices were opened in Benton, Henderson, Hopkinsville, and Paintsville (later moved to Pineville). The prime function of the field offices was to conduct geologic mapping in areas representing different geologic regions. At the same time, as



these field geologists became specialists in their regions, they represented the Survey, giving advice on problems in their localities and neighboring areas. Personnel resignations and budgetary constraints forced the gradual closing of all but the Henderson office, which continues to make a significant contribution to the Survey's activities.

The first move for the complete topographic mapping of Kentucky came as a result of interest manifested by the Kentucky Chamber of Commerce. A representative of that organization contacted Dr. Daniel J. Jones, the State Geologist during the Eighth Survey, to explore the possibility of initiating and supporting a program that would benefit not only the Survey but the entire Commonwealth. Some earlier maps were out of date, and some parts of the State had never been mapped topographically. A project to prepare new topographic maps for the State was recommended to and approved by the Chamber. Following a series of conferences with industry and State and Federal government agencies, appropriations were made and agreements approved for a matching-funds project between the State of Kentucky and the U.S. Geological Survey to completely map the Commonwealth topographically at a scale of 1:24,000. The program began in 1949 and used the latest photogrammetric and surveying methods. The State's liaison and supervision of the project was assigned to the Agricultural and Industrial Development Board by Governor Clements. When the last of the 763 topographic-quadrangle maps was printed in 1956, Kentucky became the first state to be completely covered by 7.5-minute, 1:24,000-scale topographic maps. D. J. Jones, the State Geologist, was one of the principal lobbyists and counselors for the project, and was honored by the U.S. Geological Survey for his contribution to the program.

In addition to the reprinting of older maps described previously, the Ninth Survey published 22 Bulletins, 15 Reports of Investigations, 8 Information Circulars, 11 Special Publications, 19 Reprints, 8 geology guidebooks, and 14 new maps.

### TENTH SURVEY

In 1958 the General Assembly of the Commonwealth of Kentucky modified the legislative action of 1948 by taking the Kentucky Geological Survey out of the Department of Geology and making it a separate bureau of geological research and information within the University. The offices of the Director and State Geologist became one position. This administrative reorganization created the Tenth Survey. Daniel J. Jones served as Acting Director and State Geologist from July 1 to August 14, 1958, when he retired and was replaced by Dr. Wallace W. Hagan, a well-known petroleum geologist from Owensboro, Kentucky, who had worked in industry and as a consultant.

The Kentucky Geological Survey continued as a non-teaching department in the University of Kentucky's College of Arts and Sciences until 1966, when University of Kentucky President John W. Oswald transferred administrative supervision of the Survey to the Executive Vice President, who, in turn, assigned general supervision to the Assistant Vice President for Research. Subsequently, administrative supervision of the Survey was assigned to the Vice President for Academic Affairs and general supervision to the Dean of the Graduate School and Coordinator of Research.

The 1958 General Assembly also designated the Kentucky Geological Survey as the State's cooperating agency with the U.S. Geological Survey for the ongoing ground-water, surface-water, quality-of-water, topographic-mapping, and mineral-investigations programs previously supervised and



sponsored by the Kentucky Department of Economic Development. The water investigations were a continuation of a broad program to inventory the water resources and their chemical character in all parts of the Commonwealth. Most of the investigators worked out of the Federal Survey's Water Resources Division district office in Louisville. The topographic mapping activity was a revision or map-maintenance program to supplement the project that saw Kentucky completely mapped by new 7.5-minute quadrangles at a scale of 1:24,000 between 1949 and 1956. Urban expansion, new highways, construction of major dams and reservoirs, and industrial and mineral-resource development made the map revision program imperative. A Federal office to coordinate this work was set up in Lexington, initially on the University of Kentucky campus. Cooperative mineral-resource investigations were centered in the Eastern Kentucky Coal Field. The combined cooperative topographic, water, and mineral program was considered by many to be a model program and was given favorable comment by the public in general.

These organizational changes placed the Kentucky Geological Survey in a more favorable position than it had enjoyed for more than a quarter of a century, and afforded it increased opportunity to serve the needs of the people of the Commonwealth.

The Tenth Survey is best known for the initiation and completion of a Statewide areal geologic-mapping project in cooperation with the U.S. Geological Survey; the project resulted in the publication of 707 multicolored, 7.5-minute, geologic quadrangle maps. Unprecedented in terms of time and money, it is, to date, the largest geologic-mapping project ever undertaken in the United States and represents approximately 660 man-years of geologic mapping. Because it

has stimulated a great increase in geological activity relative to coal, oil and gas, industrial minerals, geologic hazards, and urban planning, it is now obvious that this program was one of the most significant Statewide geologic undertakings in the history of the United States.

The project began in 1960 and was completed in 1978, making Kentucky the first state to be completely mapped geologically at a scale of 1:24,000 (Hagan, 1961; Cressman and Noger, 1981). The importance of the support of representatives of commerce, industry, government, and education in this endeavor cannot be overstated. Because the Ninth Survey had produced diverse and widespread economic benefits and established the Survey as a creditable agency, and because the Kentucky topographic mapping project had received such wide acclaim, many individuals and organizations across the State enthusiastically supported the areal geologic mapping project.

Publications of the Tenth Survey included a diverse list of reports on economic and regional geology and stratigraphy. Resource topics included oil and gas, coal, industrial limestones, industrial sands, miscellaneous clays and shales, gypsum, tar sands, and ground and surface water. Among the particularly useful and popular publications were a guide to Kentucky place names, a guide to Kentucky's rocks and minerals, compilations of production data on coal and petroleum, and bibliographies on coal and industrial and metallic minerals. Series 10 publications consisted of 5 Bulletins, 21 Reports of Investigations, 23 Information Circulars, 7 County Reports, 25 Special Publications, 49 Reprints, 4 Thesis Series, 21 geology guidebooks, a Statewide 1:250,000-scale oil and gas map, and 10 county oil and gas maps.

In the spring of 1978 the main Survey offices were moved from the



Geologists viewing a geologic map at the beginning of Kentucky's cooperative geologic mapping program with the U.S. Geological Survey. As a result of this program, begun in 1960 and completed in 1978, Kentucky became the first state (and still remains the only state) to have complete geologic map coverage at a scale of 1:24,000. From left to right in the photograph are A. D. Zapp, USGS; E. R. Branson, KGS; Dr. C. A. Anderson, USGS; and Dr. Wallace W. Hagan, State Geologist and Director of KGS.

Mineral Industries Building to Breckinridge Hall, also on the central University campus. At approximately the same period, the Director reached the University's compulsory retirement age. On July 1, 1978, Dr. Hagan was replaced by Dr. Donald C. Haney, former Chairman of the Department of Geology at Eastern Kentucky University.

#### ELEVENTH SURVEY

The Eleventh Survey began on a high plateau. A broad base of resource and technological data, much of it a direct result of the geologic mapping program, was available for Dr. Haney and the incoming Eleventh Survey to expand needed fuel-resource characteri-

zation and evaluation studies for the benefit of an energy-hungry State and Nation; these studies are an important step toward mineral self-sufficiency.

The organization was enlarged to include a special administrative unit to develop proposals and solicit funds for research projects in addition to those supported directly by the State. Studies have included continuity, quality, and characteristics of coal beds in the Eastern and Western Kentucky Coal Fields; characterizations of oil-shale, gas shale, and tar-sand deposits; identification and characterization of lignite resources; investigation of coalbed methane; an inventory of mined-out areas of western Kentucky; characterization of carbonate rocks for

coal-consuming and coal-producing industries; and an assessment of the potential for renewed coal mining on abandoned mine lands in Kentucky.

In 1983 the Kentucky Geological Survey completed the study of the coal resources of Kentucky begun during the Tenth Survey. The results of this project reveal 57.5 billion tons of remaining resource in eastern Kentucky; together with the 38 billion tons of remaining resource in the Western Kentucky Coal Field, the Commonwealth has an estimated remaining resource of nearly 95.5 billion tons. The Coal Resources Project greatly expanded the Survey's data base on coal geology.

Environmental considerations for resource activities have also been an important part of the State Geologist's research objectives. Projects undertaken cooperatively and independently have been hydrogeologic studies of the Eastern Kentucky Coal Field to provide baseline information on the quality and quantity of ground water before and after mining; hydrogeologic studies of the oil-shale areas to obtain baseline data to assist regulatory agencies and industry if this resource should be exploited; identification and characterization of ground-water aquifers supplying or having the potential to supply potable water in order to protect these waters from contamination from the injection of liquid wastes; and subsurface studies to define the presence, extent, and ages of faults in the Kentucky portion of the New Madrid seismic area and the possibility of recent movement along the Kentucky River and Rough Creek Fault Systems. A cooperative project is currently underway with the U.S. Geological Survey to study water quantity and quality in the Kentucky River basin, which provides water supplies for about one-third of the State.

Subsurface investigations, particularly in the areas of fuel and water resources, were enhanced by the

acquisition of a drilling rig and geophysical well-logging equipment. Resulting geophysical logs provide insight into the depth, thickness, and character of coal beds, aquifers, and aquicludes, as well as indications of ground-water quality and quantity.

A high-priority project of the Director of the Eleventh Survey has been computerizing the Survey's mineral-resource records to unify their storage and increase the speed and efficiency of data retrieval. Computer-scanning technology is also being used to store copies of all well information and provide a safer, more permanent repository than is provided by paper copies. Time requirements for tedious data searches and paper work have been dramatically reduced, and the general public benefits through better, more accurate, and more timely reports. In addition, use of the computer by the Survey administration helps manage the various and diverse projects undertaken by the Survey. The Coal Section has stored more than 22,000 open-file measurements of coal thickness data for nearly 50 beds in the computer. In addition, information on coal quality for both the Eastern and Western Kentucky Coal Fields is available through the computer. Approximately 82,000 of the Survey's more than 225,000 oil and gas well records are now on the computer, making it possible to plot an up-to-date map for many 7.5-minute quadrangles showing well locations and types of completion. The Water Resources Section is currently developing the Kentucky Aquifer-Research Database, which will include water-well drilling logs, inspection reports for public and private wells, and data from mining permits. Also, the computer has been used to perform statistical analyses for various projects, and has been used extensively for word processing.

Other projects and investigations have included the acquisition, storage,

and classification of engineering and geologic data for surface-mine design and reclamation; delineation and documentation of mining-related subsidence in the Eastern and Western Kentucky Coal Fields; surface and subsurface stratigraphic and structural studies; and assessments of barite, fluorite, limestone, sand and gravel, tar-sand, titanium, and zinc deposits.

In 1980 the Survey was taken out of the Kentucky Development Cabinet, and the Director was designated an *ex officio* member of the Kentucky Energy Cabinet, where he serves in an advisory capacity to various State and Federal agencies.

Symposia on geologic mapping, oil shales, and tar sands, hosted or co-hosted by the Kentucky Geological Survey, have attracted regional, national, and international attention. In celebration of its Sesquicentennial in 1988, the Survey held a series of seminars exploring the major areas of geologic research at the Kentucky Geological Survey. The seminars were conducted by nationally recognized authorities in their respective fields.

Public service is an important function of the Eleventh Survey. To keep the public better informed of its activities, progress, and goals, the Eleventh Survey began issuing Annual Reports at the close of each fiscal year to describe its diversified and comprehensive research program. It also published a 5-year plan that provides the framework for coordinating and implementing its goals. In addition, the public is invited to attend the Survey's Annual Meeting, held each fall to review current research projects.

In 1980 the Kentucky Geological Survey became the State affiliate of the National Cartographic Information Center. Its purpose is to organize cartographic data of local, regional, State, and national significance into a usable information system. Since the Survey's affiliate office opened, the

work has been expanded to catalog the availability of aerial photographs, satellite imagery, current and historic geodetic control, current and historic map information, and digital cartographic data from both public and private sources.

A new geologic map of Kentucky, prepared cooperatively by the Kentucky Geological Survey and U.S. Geological Survey, at a scale of 1:250,000, was printed by the U.S. Geological Survey in 1981. This map was compiled by photo-reducing and generalizing the 707 detailed geologic quadrangle maps that resulted from the joint mapping project completed in 1978. This map was the first large-scale geologic map of Kentucky to be published since the Sixth Survey and is probably one of the most accurate state geologic maps ever published in the United States. A 1:500,000-scale compilation of the map is also being prepared for printing.

The Kentucky Geological Survey's ongoing cooperative topographic-map revision program with the U.S. Geological Survey continues during the Eleventh Survey. In July 1986 the State Mapping Advisory Committee met for the first time. The committee compiled a ranked list of quadrangles in need of immediate revision and submitted the list to the U.S. Geological Survey. Input from this committee will continue to help decide the course for future topographic mapping in Kentucky.

Water-related cooperative programs with the USGS also continue. The programs include a Statewide network to collect surface-water data, assessment of surface-water resources, waste disposal, pollution control, planning and design facilities, and forecasting of water levels; a Statewide network of approximately 70 water-quality stations; determination of reaeration coefficients and travel times for Kentucky River Basin streams; determination of the geologic and hydrologic factors related to the



occurrence of high-barium concentrations in drinking-water supplies in eastern Kentucky; and an evaluation of the effects of petroleum production on surface- and ground-water resources in eastern Kentucky.

Publication sales, which reached record levels during the 1982-83 fiscal year, have declined recently in the wake of the oil-industry downturn. The Survey took advantage of the University of Kentucky's computerized typesetting capability, which resulted in more timely and more economical publications. Dissemination of resource information was also increased through the release of open-file reports.

One of the major goals of the Director of the Eleventh Survey was realized in January 1988 when the Survey moved into the new Mining and Mineral Resources Building on the University of Kentucky campus. The new building, which houses the Kentucky Geological Survey, the Department of Mining Engineering, the

Institute for Mining and Minerals Research, and part of the Department of Geological Sciences, provides the Survey, for the first time, with its own laboratory facilities for the first time, enlarges its computing capabilities, and increases space for the Well Record Library. At the same time, the Well Sample and Core Library is moving to new offices in the American Building adjacent to the University of Kentucky campus. The enlarged facilities will offer more than 60,000 square feet of storage space for rock materials, of which 10,000 square feet will be used for examination areas, a rock-processing laboratory, and office space.

The historical record of the Eleventh Survey is still being written. It has been in existence for only 10 years and much has been accomplished. Efforts by the Director to raise salary levels have enabled the Survey to employ more full-time professionals with graduate degrees than ever before. The new building, with its state-of-the-



Architect's rendition of the new Mining and Mineral Resources Building on the University of Kentucky campus, which was occupied by the Kentucky Geological Survey in January 1988. Not only did this building furnish excellent office space for KGS staff, but it also provided, for the first time, laboratory facilities with state-of-the-art equipment.

art laboratories, will allow the Survey to reach new horizons of research. The Survey has striven to maintain a proper balance between economic and scientific investigations, and between research and service. Attention is being given not only to the location of mineral deposits but also to the geologic environments in which they were formed. One of the results of continued progress in research and basic-data collection programs is increased demands for service from the public and private sectors. If the number of requests for information and service are a yardstick for evaluating the success of an organization, the Eleventh Survey will be awarded high marks.

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## LOUISIANA

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University Station, Baton Rouge, LA 70893. Phone 504-388-5320.

### HISTORICAL SEQUENCE OF ORGANIZATIONAL NAME:

Topographical and Geological Survey of Louisiana, 1869-72  
Geological and Agricultural Survey of Louisiana, 1892-1902  
Geological Survey of Louisiana, 1903-09  
Louisiana Soil and Geological Survey, 1914-19  
Bureau of Scientific Research, Minerals Div., Dept. of Conservation, 1931-34  
Louisiana Geological Survey, 1934-present

### NAMES AND TITLES OF ORGANIZATIONAL DIRECTORS AND DATES SERVED:

Frederick V. Hopkins, State Geologist, 1869-72  
Otto Lerch, Geologist in Charge, 1892; State Geologist, 1893  
William W. Clendenin, Geologist, 1894-97  
Gilbert D. Harris, Geologist in Charge, 1899-1909  
Frederick E. Emerson, Geologist, 1914-19  
Cyril K. Moresi, Geologist, 1931-34; State Geologist, 1934-40  
John Huner, Jr., State Geologist, 1940-46  
Paul Montgomery, Acting State Geologist, Apr.-Dec. 1946  
James M. Cunningham, Acting State Geologist, Dec. 1946-July 1947  
Gerard O. Coignet, Acting Director, July-Oct. 1947  
Leo W. Hough, State Geologist, 1947-77  
Harry L. Roland, Jr., Assistant State Geologist, Feb. 1977-July 1978  
Charles G. Groat, Director and State Geologist, July 1978-present

### HISTORY OF THE LOUISIANA GEOLOGICAL SURVEY

David E. Pope  
Senior Research Geologist

#### INTRODUCTION

While observations had been made on the topography, climate, fossils, and mineral resources of Louisiana by numerous persons in the latter part of the eighteenth century and first half of the nineteenth century, it was not until a chair of geology was created at the Louisiana State Seminary of Learning that any organized attempt was made by the State to determine what it contained in the way of mineral resources.

The study of geology was one of the first subjects to interest the leaders of higher education in Louisiana. When Louisiana State University opened its doors at

Pineville on January 2, 1860, under the name "Louisiana State Seminary of Learning," Francis W. Smith occupied the chair of Chemistry, Geology, Mineralogy, and Infantry Tactics. Since that date, the University has sponsored whatever geological research has been undertaken by the State, whether under the name of "Louisiana Geological Survey," or "Louisiana Soil and Geological Survey," or in cooperation with the Department of Conservation...

In conclusion, the senior author wishes to take this occasion to express his profound admiration for the pluck and scientific zeal which motivated his predecessors. In the long list which has been enumerated there are few who did not go to much extra effort, much personal expense, and who did not suffer much physical discomfort in attempting to present to the public a knowledge of the geology and mineral resources of our great state. These men, working with limited equipment, mostly

with limited transportation facilities, and with limited or no funds, have built up an important scientific literature comprising 81 papers and volumes with a total of more than 4200 pages; a large number of topographic and geologic maps, including the only colored geologic map of the state yet issued; and have been responsible for obtaining the cooperation of the Bureau of Soils in making our Parish soil maps. The work of these men has been in large part responsible for the great mineral industry which Louisiana possesses today, and the State owes them a debt of gratitude. It is to their memory that the present authors respectfully dedicate this account.

These are the first two paragraphs, and the last, of "The Contribution of Louisiana State University to the Development of Louisiana Geology" by Henry V. Howe and Cyril K. Moresi, published in the quarterly *Louisiana Conservation Review* of April 1933. Moresi would subsequently be appointed as the first official State Geologist under the legislative act of 1934 that established the modern state geological survey, and Howe would be named as Director of Research. Both had, in effect, unofficially performed these respective functions since 1931. The State Commissioner of Conservation had then established the Bureau of Scientific Research and Statistics, of the Department of Conservation, appointing Moresi as Bureau Geologist, and assigning him to work with Dr. H. V. Howe, Director of the Louisiana State University School of Geology, in making a geological survey of the state. Howe and Moresi then immediately began preparation of the *Geology of Iberia Parish*, published as Department of Conservation Geological Bulletin No. 1 in November 1931. This was the first of 42 geological bulletins thus far issued by the present survey, as well as many of other publications such as geological pamphlets, folio series, geologic maps, petroleum and mineral resources maps, atlases, resources information series, mineral and clay resources bulletins, paleontological studies, annual petro-

leum statistical reports, guidebooks, anthropological studies, and water resources bulletins and pamphlets--plus dozens of special reports, both published and unpublished, as the need has arisen.

Howe had come to Louisiana State University (LSU) in 1922, commissioned to rebuild a geology department that had expired 3 years earlier with the death of its immediately preceding lone professor. He built a department with a broad base that included geology, petroleum engineering, geography, and anthropology; in 1931, it was reorganized as the School of Geology. Howe also saw the need for a permanent state geological survey--the last active one had been defunct since 1909--and he successfully lobbied the state legislature and the Commissioner of Conservation (and later mayor of New Orleans) Robert S. Maestri, a powerful political ally of Governor, later Senator, Huey P. Long. Howe served as the Survey's Director of Research from 1931 to 1940, receiving no additional pay for this. It is interesting to note that all state geologists from 1931 to 1978 had been his students. He authored or coauthored 10 of the first 14 of the geological bulletins of the present survey. Thus, H. V. Howe could very aptly be described as the founder of the modern Louisiana Geological Survey. He also served on the State Mineral Board twice, once as its chairman. In 1960 he received the Sidney Powers Memorial Medal, the American Association of Petroleum Geologists' (AAPG) highest honor. He has received many other honors including honorary membership in the Society of Economic Paleontologists and Mineralogists, and has been named Boyd Professor, LSU's highest honor. A recent biographical note states, "Although it is not possible to credit Louisiana's petroleum industry to one man, Howe was a primary force in its development and it may be said



that, more than any other man, H. V. Howe built the Gulf Coast oil industry."

Howe's bibliography includes more than 90 titles on Gulf Coast stratigraphy and paleontology. He was still working on his ostracodes at the time of his death in 1973, although he had been "retired" for several years. His collections of bryzoans (over 1,000 specimens) and ostracodes and foraminifera (over 7,800 specimens) were donated to LSU, although the Smithsonian, the American Museum of Natural History, and other museums, requested his collections. In the 1920's Howe established a loan system for his students from his personal funds; and, during the Great Depression, he allowed students to live gratis in his home. He also pioneered geology field camps for the students, including the present camp south of Colorado Springs, Colorado, one of the finest in the nation. So, it is most appropriate that the present geoscience complex at LSU bears Howe's name (along with that of Richard J. Russell, one of Howe's early teaching recruits and former classmate).

In 1932, the first Geology Building at LSU was erected, largely with funds supplied by the State Department of Conservation, with the stipulation that space always be allotted for offices of the Louisiana Geological Survey. In 1939, the building was substantially enlarged, to 90,000 sq. ft., as a PWA (Public Works Administration) project. The Survey headquarters was then moved to the new section, where it remained until 1987. An adjoining building of 60,000 sq. ft., the Annex, was then completed and occupied, and the two structures named the Howe-Russell Geoscience Complex. Survey headquarters are now in the newest addition.

#### EARLY LOUISIANA GEOLOGY

Dr. Howe's predecessors, alluded to above, include a procession of more than

a dozen professors at LSU, some of whom served on early state geological surveys and some who did not, a few who served on the surveys but did not teach, and a number of early investigators. About 40 of the latter group are mentioned in varying detail by Gilbert D. Harris and Arthur C. Veatch in *A Preliminary Report on the Geology of Louisiana*, made in 1899 as their first report, under the direction of the State Experiment Station, operating under Louisiana State University and State Board of Agriculture and Immigration. The latter apparently had become involved because the state's rural areas were so sparsely populated that inducements were made in the form of land grants to attract immigrants, especially farmers. And so, initially the emphasis was at least as great on agriculture--with proposed investigations of soils, marl, and lime--as on the discovery and exploitation of ores and other minerals.

It will be recalled that in 1682 Robert Cavelier, *Seur de La Salle*, and his party of French and Indian explorers paddled down the Mississippi from Canada, and claimed for Louis XIV all of the land drained by the river and its tributaries. He named the new territory Louisiana. In 1699, the brothers Pierre and Jean Baptiste Le Moyne journeyed upriver from the Gulf of Mexico. Pierre, known as *Sieur d'Iberville*, became the first governor of the territory; his younger brother, the *Sieur de Bienville*, founded the city of New Orleans in 1718 and also became governor of Louisiana. And, of course, in 1803 President Thomas Jefferson concluded the Louisiana Purchase which included much of the land claimed by La Salle for France, from the Mississippi to the Rockies, almost doubling the territory of the United States at that time.

Some of the earliest recorded detailed exploration of the state relating to geology seems to have been in 1722 when a French Jesuit, Pierre François

Xavier de Charlevoix, explored and mapped the mouth of Mississippi River. He commented on the apparent recent age of the lower delta region and noted the "little islands" in the passes. These were undoubtedly the mudlumps, unique to the lower Mississippi River Delta. Some of the other early explorers who commented on various aspects of the Mississippi, the Five Islands (a series of emergent salt domes) of central coastal Louisiana, the salt domes, saline springs and wells of northern Louisiana, and other geological features of the state were: William Bartram, renowned naturalist, 1773; Major Amos Stoddard, in his *Sketches, Historical and Descriptive of Louisiana*, 1812; William Darby, in *A Geographical Description of the State of Louisiana*, 1816, 1818; Sir Charles Lyell, known as the founder of modern geology, 1845, 1846; and T. Wayland Vaughan, of U.S. Geological Survey fame, 1895, 1896.

In 1832, Richard Harlan published the first formal, systematic paper on the geology of Louisiana, *Notice of Fossil Bones found in the Tertiary Formation of the State of Louisiana*. The bones of a huge presumed reptile had been found near the Ouachita River in Ouachita Parish, in Eocene beds, for which Harlan proposed the name *Basilosaurus*. In 1838, the Frenchman M. Demeril recognized the bones to be from a cetacean, rather than from a reptile; and in 1839, the Englishman Richard Owen renamed the species *Zeuglodon cetoides*. An unusually good discovery of this 55-foot toothed whale has been made fairly recently at Montgomery Landing on the Red River in Grant Parish, also in Jackson Eocene beds; it now resides at the LSU Museum of Geoscience in Baton Rouge. The Montgomery Landing site is the best Louisiana location for fossil collecting but is being lost due to work on the river by the U.S. Army Corps of Engineers.

The work of Timothy A. Conrad with mollusks in 1834 and 1841 caused

the *Zeuglodon* find to be correctly placed in the Eocene. Conrad was associated with the New York Survey from 1836 to 1840. Although he has been described as melancholy, peculiar, unmethodical, slovenly and careless in his work to a point beyond endurance, and with a very poor memory (sometimes redescribing his own species), he contributed significantly, often at his own expense, to the early geological knowledge of the United States. His accomplishments in view of such deficiencies are no less than amazing. Also, the fact that he, as a paleontologist, was bitterly opposed to the doctrine of evolution is most unusual. He predicted that Darwin's "wild speculations" would soon be forgotten.

In 1860, Raymond Thomassy, a French hydraulic engineer, devoted the first whole book (264 pp.) to Louisiana geology, with emphasis on the Mississippi River, *Géologie Pratique de La Louisiane*. In addition to his observations on the Mississippi, its delta, and the mudlumps, he presented a series of maps illustrating the changes in the Louisiana coastline between 1684 and 1859, especially in the area of the present Balize Delta of the Mississippi. He was the first to describe the Five Islands as salt intrusions and to attempt to explain their origin (which he thought to be volcanic, and the mud lumps as well). Thomassy's monumental work has received very little recognition, possibly because it was written in French and has been translated into English in a very limited edition (five copies). Thomassy was proud, arrogant, ambitious, and an ardent French nationalist, all of which produced a noticeable bias in his work. On one occasion his arrogant comparison of the Mississippi with rivers of France led to a challenge from a Creole gentlemen over the honor and power of the Mississippi. Thomassy survived the duel but with a painful and

disfiguring facial injury to remind him of the incident.

Another early visitor to the Five Islands was Dr. Richard Owen. In 1865, he was serving as a colonel in the Union army stationed near Avery Island in Iberia Parish. He compared the Five Islands to dunes formed by wind and wave action on the southern shore of Lake Michigan. Owen had previously been State Geologist of Arkansas and then Indiana, while his older brother, David D. Owen, had served as State Geologist of Indiana, Kentucky, Arkansas, and Indiana again. The two were sons of Robert Owen, a well-known philanthropist and the founder of the communistic societies at New Lanark, Scotland, and New Harmony, Indiana.

Famous paleontologists who contributed to early Louisiana knowledge were Joseph Leidy (1866, 1884, 1889) and Edward D. Cope (1895), both describing Pleistocene mammals from Avery Island (then called Petit Anse or Petite Anse). Frank H. Knowlton described two species of palm wood from Rapides Parish in 1888. It is interesting to note that in 1976, while the state legislature was considering the naming of the state fossil, one of the legislators nominated Senator Edgar Mouton of Lafayette for that honor. After the Senator declined in deference to "age, rather than beauty," the (Miocene) petrified palm wood was declared the winner by acclamation.

During the period 1896 to 1920, A. F. Lucas published a series of six short papers on coastal salt domes including the Five Islands of Iberia and St. Mary Parishes. This is the same Captain Lucas of Spindletop fame. Spindletop Dome, drilled in 1901 by Lucas near Beaumont, Texas, ushered in the first prolific oil production of the Gulf Coast and the United States. He also served, at various times, as superintendent of salt-mining operations at three of the Five Islands.

In 1902, the Heywood brothers established Louisiana's first significant oil production, at the Jennings Dome in Acadia Parish. They were committed to drill two wells to 1,000 feet (305 m). When the first well proved non-productive, Scott Heywood made the astounding proposal that the second well be drilled from the bottom of the first. He had correctly deduced that production was to be found at a lower horizon. The age of the productive zone, very near the bottom of the "second well," was found to be upper Miocene by G. D. Harris, based on the bivalve *Rangia johnsoni*. Production rate for the Heywood Brothers, Jennings Oil Company No. 1 is not available, but the No. 2 well flowed at 7,000 barrels of oil per day. The oil sold for 13 cents per barrel. The landowner of the property drilled is said to have hurriedly locked all of his gates when he first heard that holes were to be drilled for oil. He didn't want his cattle to fall into the "holes" and break their legs.

Geology had been taught at LSU sporadically from 1860 to 1919 by 13 professors in sequence, prior to Howe, whose specialties varied from the four attributed above to Professor Smith to also include at times biology, botany, zoology, natural history, and even included a medical doctor and surgeon. Mostly, the early geological instruction consisted of mineralogy taught for a short duration by a chemistry professor; in fact, the eminent sugar chemist and chemical engineer Dr. Charles E. Coates taught mineralogy twice, 1904-05 and 1907-10. He also served as LSU's first football coach for the 1893 one-game inaugural schedule against Tulane University, a rivalry that has continued to the present. The multi-discipline backgrounds of most of these "geology" professors seems to emphasize two things: a prime dictum of those times was the importance of a liberal education, and trained geologists were indeed a rare breed in those days.



The pattern of geology instruction described above was broken, however, on several occasions. Dr. Frederick V. Hopkins, M.D. and surgeon, and professor of chemistry, mineralogy, and geology, had a relatively long tenure, apparently dividing his time from 1868 to 1884 between teaching and field work for the Topographical and Geological Survey of Louisiana; Dr. Otto Lerch, who conducted surveys from 1891 to 1893, apparently did not engage in teaching. Professor William W. Clendenin ably served on the Geological and Agricultural Survey of Louisiana, and also held the Chair of Botany and Geology from 1892 to 1898. He taught eight geology subjects: elementary geology, physical geology, economic geology, general critical geology, determinative mineralogy, meteorology, optical crystallography, and petrography. This marked the first attempt at LSU to give advanced technical training in this field of science. A. C. Veatch, who served with G. D. Harris on the Geological and Agricultural Survey, also taught five geology subjects in 1901-02, as professor of geology. Harris may also have taught in 1905-06, but the record is not clear. Dr. Frederick E. Emerson divided his time from 1913 to the time of his death in 1919 between the Louisiana Soil and Geological Survey and the teaching of six subjects during alternate semesters. There were no geology courses taught at LSU from 1919 until 1922 when Howe arrived.

It should be noted that the preceding narrative is by no means complete, only presenting a broad overview of the status of Louisiana geology, other than that of the surveys, prior to 1922.

#### **THE EARLY SURVEYS: 1841-1919**

The first known effort to secure state authorization to conduct a geological survey of Louisiana was initiated by John L. Riddell in 1839.

While this first attempt was unsuccessful, a second one in 1841 resulted in the appointment of the Geological Committee of the State of Louisiana, with Riddell as chairman. Other members of this legislative committee were Dr. W. M. Carpenter, Caleb G. Forshey, Dr. Josiah Hale, Dr. Thomas Ingalls, and P. E. Trastour. The results of their work were later turned over to the State Printer, only to be lost before publication, with no trace remaining to this day. This is most regrettable, especially since Riddell was a very astute scientist and well qualified in geology, plus botany, chemistry, physics, and medicine. Before coming to New Orleans in 1836, he had published on the geology of Ohio, partially as a result of his work with Dr. Samuel P. Hildreth of the early Ohio Survey. Subsequently he published on the geology of Trinity County, Texas (1839), and two papers on the Mississippi River (1846, 1850). This remarkable man had studied under the renowned first American geology teacher, Amos Eaton, at Renssaler School in Troy, New York. Riddell's first scientific lecture, "A New Theory of the Earth," was given there in 1829. Among his many varied accomplishments, it is of special interest that Riddell invented the stereoscopic binocular microscope in 1851. This can certainly be counted among the major contributions of all time to the study of micropaleontology. Riddell also seemed to have an eye for the ladies, these affairs causing him to "lose favor in several communities." On one occasion he "was obliged to leave, not only the house, but the town, because of the story which was circulated." But a local doctor came to his defense, and believe it or not, none of the newspapers would print anything of the affair.

The next attempt at a state geological survey was the result of an executive order by Governor Henry W. Allen, early in 1864. Judge John B.



Robertson of New Orleans was appointed to head a commission to make a "systematic investigation of the agricultural, mineral and manufacturing resources of Louisiana." He took with him "Mr. Charles Tripp, a competent mineralogist and metallurgist, Mr. John H. Jones, a skillful iron-master of thirty-five years practical experience, and Captain John Roy, of New Orleans, a most intelligent and practical machinist and artizan [*sic*]," and "explored various portions of the State, in search of iron and other minerals." This investigation lasted 16 months, and the results were reported to the state legislature in January 1867.

Prior to the conclusion of Robertson's investigations another state administration had been installed. The new governor, James Madison Wells, apparently had heard of petroleum exploration in Calcasieu Parish and asked the Judge, as his final effort, to proceed to this site of oil and gas seeps and report on it. Two companies were actively pursuing exploration there. Instead of finding commercial petroleum production at that time, a vast source of sulfur was discovered at shallow depths (about 200 feet, 60 m) in the salt cap rock of what is now known as the Sulphur Mines Dome. It was there, about 1900, that Herman Frasch developed the superheated-water method of mining the sulfur that bears the inventor's name. Oil was not found there in commercial quantities until 1926, considerably deeper (2,676 feet, 815 m).

Judge Robertson's 25-page report to the legislature was quite effusive, containing many exaggerations of mineral deposits and erroneous geological concepts, due to his lack of geological knowledge. Realizing this deficiency, in his report he called for a "full and complete survey" to be made by a "thorough and professional geologist." Also, in his conclusions, he recommended the establishment of a

"bureau of arts, agriculture and immigration, under the control of one commissioner." He further listed suggested duties of this bureau, one of which reads, "It should search out and develop mines and minerals, and should, under proper instructions, have control and supervision of all the mineral lands of the State." The gentleman's proposals proved to be quite advanced for that time as it was not until the legislative act of 1908 and subsequent amendments that the Conservation Department was established, with its commissioner to control the mineral activities, primarily oil and gas, of the state. It was not until 1938 that the State Mineral Board was established, by an act of 1936, to control mineral development of state-owned or controlled lands and water bottoms.

In May and June 1869, Dr. Eugene W. Hilgard made a general reconnaissance of the state--beginning in New Orleans--which traversed southwestern Louisiana to Lake Charles, then north to Mansfield, thence eastward to Winnfield, Harrisonburg, and Waterproof on the Mississippi, where the expedition ended. This former State Geologist of Mississippi made the 30-day, 625-mile (1,000 km) trip mostly on horseback, under the auspices of the New Orleans Academy of Sciences and the State Bureau of Immigration.

Hilgard was accompanied by Dr. J. R. Walker and Mr. F. Scott Miller, both Fellows of the New Orleans Academy. Various points and areas were examined and commented on: the south-central and western prairies; the "St. Landry Marble" (salt cap rock) exposed on what is now known as Pine Prairie Dome in Evangeline Parish; iron ores and lignite in the vicinity of the Dolet Hills near Mansfield; the Red River bottom lands; north Louisiana salines: King's salt works, Rayburn's lick, Price's lick, Drake's salt works, Cedar lick; the "limestone hill" near Winnfield (salt cap rock on the present

Winnfield Dome in Winn Parish); Vicksburg rocks; Grand Gulf rocks near Harrisonburg; loess at Sicily Island; and the Tensas River bottoms. Hilgard commented extensively on the soils and vegetation of most of these areas and correctly identified most of the formations encountered. He considered the salt to be Cretaceous because, at some of the domes, the salt intrusions had pushed fossiliferous Cretaceous rocks to the surface. He also thought the unfossiliferous "limestone" at the Winnfield and Pine Prairie domes to be Cretaceous. These domes are in alignment with the northwestern salines and known salt at coastal Avery Island. So, it was very easy for Hilgard to fall into the trap of postulating a north-northwest-south-southeast trending "Cretaceous backbone" extending diagonally across the state. This idea persisted until the surveys of Harris and Veatch at the turn of the century. Nevertheless, this was the first comprehensive survey of the state by a man trained primarily as a geologist, and it was excellent work for that time.

Hilgard made two shorter preliminary reports before his 44-page *Supplementary and Final Report of a Geological Reconnaissance of the State of Louisiana* was published in 1873 in New Orleans. He had also presented his findings before the 1869 Chicago meeting of the American Association for the Advancement of Science, along with the first geological map of Louisiana which apparently was never published.

Almost simultaneously with Hilgard's reconnaissance, similar work had been undertaken by LSU personnel. Legislative Act 72 of 1869 was "An act to provide for a topographical and geological survey of the State of Louisiana." An appropriation of \$1,000 was made to defray the traveling expenses of two professors of the then Louisiana State Seminary of Learning and Military

Academy. These professors were Dr. Francis V. Hopkins and Colonel Samuel H. Lockett. Under the act they were required "to spend not less than four months of every year in making jointly a topographical and geological survey of the State of Louisiana till the whole work is completed to the satisfaction of the legislature." Consequently, Hopkins was appointed as Louisiana's first State Geologist. His field work consisted of three trips in 1869 covering portions of 16 parishes; this resulted in three reports (1869, 32 pp.; 1871, 35 pp.; and 1872, 42 pp.). The first report is entitled the *First Annual Report of the Louisiana State Geological Survey*, while the second and third reports were those of the "Geological Survey of Louisiana." These reports were never published except as parts of the annual reports of LSU.

Colonel Lockett was an engineer (and Commandant of Cadets), and charged with making the topographical survey. He submitted four reports as the result of his work on the Topographical Survey of Louisiana for the years 1869 through 1872. These were also made a part of the LSU annual reports. His Fourth Annual Survey Report was accompanied by a large topographical map, the printing of which was paid for by Lockett. It was dated 1873, as was his last report, and was the first such published map of the state. The title block reads, "The Louisiana State University Topographical Map of Louisiana/Showing the Characteristic Features of the Surface of the State in Symbols and Colors . . . by S. H. Lockett, Professor of Engineering . . . Edition printed for W. H. Harris, Commissioner of Agriculture and Immigration, New Orleans, La." The scale is about 1 inch to 6 miles but is not specifically expressed.

Also, Professor Americus Featherman was appointed to the Chair of Modern Languages in 1869, and becoming interested in the work of

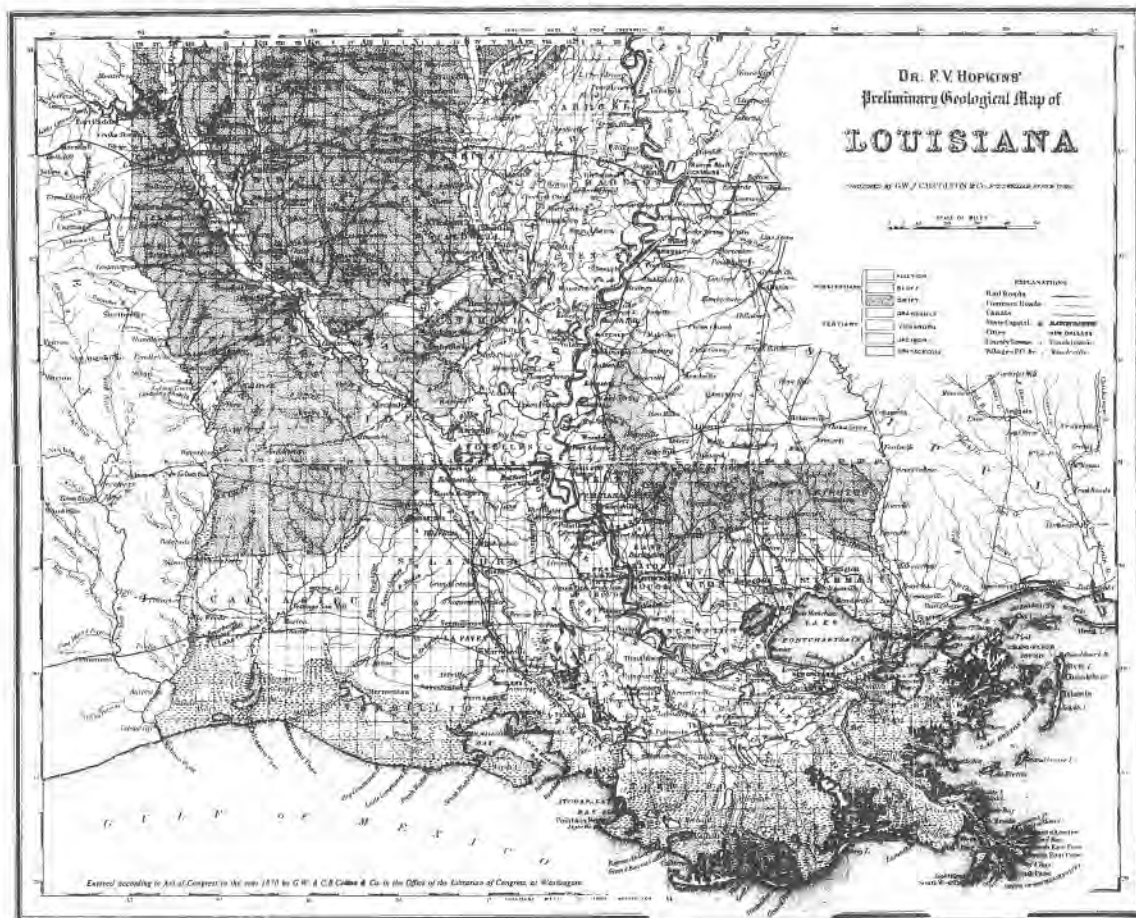
Hopkins and Lockett, undertook a botanical survey of the state. He too submitted three annual (botanical) survey reports, for the years 1869 through 1871, again included in the annual reports of LSU.

The first published geological map of Louisiana is dated 1870. Its title block reads, "Dr. F. V. Hopkins' Preliminary Geological Map of Louisiana/Published by G. W. and C. B. Colton & Co. No. 172 William St. New York." Across the top of this 12 x 14 inch (30.5 x 36.8 cm) map is inscribed, "La. State University, Baton Rouge, La. - Topographical, Geological, and Botanical Survey." It has a graphic scale of about 1 inch to 25 miles. This six-color map shows as Post-Tertiary (descending): Alluvion, Bluff, and Drift (Drift is stripped, not colored). It shows as Tertiary: Grand Gulf, Vicksburg, and Jackson. It also shows the following colored as Cretaceous: five spots (six salines plus "Limestone" at Winnfield) in the northwestern part of the state, plus (salt at) Petit Anse (Avery Island) and "Limestone" at the location of Pine Prairie Dome. The stipple pattern (Drift) covers virtually all of the Tertiary units, except for the ends of the relatively narrow, west-central, diagonal Vicksburg belt. The outcrop pattern is generally the same as our modern (1984, 1:500,000) geologic map, except that Hopkins' Jackson occupies a very large portion of the northwestern corner of the state. This is now divided into a narrow belt of Jackson, with the rest consisting of the Eocene Claiborne Group divided into four formations, and the undifferentiated Paleocene-Eocene Wilcox Group. There is also a very small amount of Paleocene Midway now recognized northwest of Shreveport. It should be noted that surface Tertiary beds older than Jackson are predominately clastic and largely unfossiliferous, which surely attributed to their lack of early recognition. Hopkins' map was the published result

of Hilgard's (unpublished, 1869) revised map which in turn, according to Hilgard, depended heavily on information supplied by Hopkins and Lockett.

Hopkins' reports, though more voluminous than Hilgard's, are not as astute since he was not trained primarily as a geologist. He sent his fossil collections to Professor Hilgard at "Mississippi University" for identification and evaluation, and he generally followed Hilgard's ideas, including apparently the "Cretaceous backbone" theory. Hopkins mentions in this second annual report that "I have traveled about thirteen hundred miles in a buggy, besides at least as much more by boat and rail, collecting fossils, and obtaining sections." He was accompanied on part of that trip by Colonel Lockett but apparently traveled alone on the other trips. Hopkins mentioned several times in his reports the preliminary nature of his reconnaissances and the need for more coverage and more detailed study. This was denied when funds dried up in 1872. It has been reported that the University ceased to operate temporarily that year; that the expenses of the last survey operations were paid out of the pockets of the principal investigators; and that these expenditures and salaries for that time were never repaid, either by the University or the State. In fact, a brief history of LSU published in its 1935 *Alumni News* states, "Still under the control of 'carpetbaggers' Louisiana was hopelessly in debt. For several years--from 1873 to 1877--the University was without funds..." Enrollment dropped to 31, then five cadets, in 1875. It is believed that the University President, Colonel David Boyd, also working without pay, used his personal funds (without repayment) to sustain the school during that difficult period.

The only other geological investigation of Louisiana, until 1892, was a brief reconnaissance by R. H. Loughridge, in



The first published geologic map of Louisiana, 1870, in six colors. Size of the original, 12" x 14"; scale about 1 inch to 25 miles. The most recent geologic map of the state, 1984, is in 28 colors; size, 42" x 44"; scale 1 inch to 8 miles (1:500,000).



1880, then acting as a special agent of the Tenth U.S. Census, under the direction of Professor Hilgard. The results of this were incorporated in Hilgard's 1884 *Review of the General Soils Map of the Cotton States* of that census. Dr. Loughridge, the Mississippi Assistant State Geologist, had earlier performed the chemical analyses related to Hilgard's 1869 reconnaissance, the funds for those analyses being derived from the sale of equipment used on that expedition.

The year 1892 ushered in the era of surveys under the State Experiment Station which lasted until 1909, when funds were again depleted. Act 115 of 1884 authorized the LSU Board of Supervisors to establish agricultural experiment stations, and Act 100 of 1888 gave legislative assent to grant money from the federal government to establish these stations. The largest of the stations was established in 1888 at Baton Rouge on the grounds of the state university. The geological surveys of 1892 to 1909 were conducted under the direction of this experiment station and in cooperation with the university. During the period 1892 to 1902, the survey was known as the Geological and Agricultural Survey of Louisiana, although its reports were issued under the cover of the "Geological Survey of Louisiana." Reports were issued as the *Geology and Agriculture of Louisiana*, Parts I through VI. Parts I and II (1892 and 1893) were by Otto Lerch; Parts III and IV (1896 and 1897) were by W. W. Clendenin; Part V (1899) was by G. D. Harris, A. C. Veatch, and others; and Part VI (1902) was by Harris, Veatch, and J. A. A. Pacheco. Succeeding reports of 1905, 1907, and 1909, by Harris and various authors, were styled as *Bulletins of the Geological Survey of Louisiana*. The Report of 1905 includes *Bulletins No. 1 through No. 4*--based on field seasons of 1903, 1904, and 1905--some of which are bound together, and some issued separately. The only copies

of the Report of 1907, *Bulletins No. 5 through No. 7*, now in possession of the Louisiana Geological Survey, are bound separately. The Report of 1909 consists solely of *Bulletin No. 8*. The covers of those bulletins issued separately bear the inscription of the "Louisiana Geological Survey," however, in all instances--single or multiple editions--the title pages refer to the Geological Survey of Louisiana, which is thus considered to be the valid designation for the surveys of 1903 through 1909.

Dr. Otto Lerch, a graduate of a German university, came to LSU in 1891 from the Texas Geological Survey where he had been employed for several years. His first report (Part I above, 51 pp.) is entitled *A preliminary report upon the Hills of Louisiana, North of the Vicksburg, Shreveport and Pacific Railroad*, while his second (Part II above, 105 pp.) is termed *A preliminary report upon the Hills of Louisiana, South of the Vicksburg, Shreveport and Pacific Railroad*. The latter extended south to the latitude of Alexandria, near the center of the state. These reports were the result of a total of about 3 months field work in 1892. He may have been the first to identify Claiborne Eocene beds in the state (Harris also recognized Claiborne in 1892). Lerch followed Hilgard's northwest-southeast trending Cretaceous, stating, "The cretaceous mountain chain trending diagonally across the State had divided Louisiana into two immense shallow basins, the Red river and the Mississippi basins of today." He also referred to the "immense upheaval at the close of the cretaceous." The second report was concluded with a six-page addendum, "Botanical Notes," furnished by Mr. Thomas Wayland Vaughan--who accompanied Dr. Lerch on this survey--plus two pages on grasses by Prof. S. M. Tracy, of the Mississippi Agricultural Station. Lerch's surveys were "undertaken mainly in the interest of agriculture." He signed the letter of

transmission of his first report as "Geologist in Charge," and the second as "State Geologist."

"The Geological and Agricultural Survey instituted in 1892 by the Stations under Dr. Otto Lerch, was discontinued for the want of funds." Thus begins the letter of transmittal of Part III above from the Experiment Station Director. However, funds were later found for Professor W. W. Clendenin to continue (simply as "Geologist") the work started by Lerch under the Experiment Station. Clendenin had come to LSU in 1892 and remained there until 1898. His Part III of the Geology and Agriculture was the result of 6 months in the field in 1894. This 88-page report, published 2 years later, is entitled *A Preliminary Report upon the Florida Parishes of East Louisiana and the Bluff, Prairie and Hill Lands of Southwest Louisiana*. Appended is a seven-page report on "The Principal Plants of Economic Value in the Florida Parishes and Southwest Louisiana," by W. R. Dobson, Botanist. Clendenin covered parts of eight Florida parishes and southwestern parishes in this report. He spent the summer of 1885 in the field and published the results in 1887 as Part IV of the Geology and Agriculture, *A Preliminary Report upon the Bluff and Mississippi Alluvial Lands of Louisiana*. Included with this 33-page report is an index of Parts I through IV of the Geology and Agriculture, and a 55-page appendix entitled "A Hand-Book of Louisiana giving Geographical and Agricultural Features together with Crops that can be Grown." This highly complimentary description was compiled and written for the State Immigration Association to entice additional farmers to the state; however, it does devote about seven pages to a concise geological description of the state, plus 17 pages describing the alluvial areas and other physiographic divisions. There was no

further work in the state, initiated internally, until 1899.

In 1892, G. D. Harris, while engaged in work on the Tertiary of southern Arkansas, had made a short visit to Bossier and Claiborne Parishes of northwestern Louisiana, "to see what help in the classification of deposits in Arkansas might be derived from fossiliferous sections farther south." The results of that visit are included in the *Arkansas Geological Survey, Annual Report, 1892*, volume 2, published in 1894.

In 1895, T. Wayland Vaughan, by permission of the Director of the U.S. Geological Survey, published a 25-page article in the *American Geologist*, entitled "The Stratigraphy of Northwestern Louisiana." He corrected some of Hilgard's and Lerch's erroneous ideas and proposed a new group of strata, the Sparta Sands (Claiborne Eocene), found in the lower Tertiary of the southern part of the subject area. He then published practically the same material in 1896 as U.S. Geological Survey Bulletin 142, adding a bibliography, a list of fossils with localities, and a description of several new molluscan species with figures.

In 1899, the surveys of Gilbert D. Harris and Arthur C. Veatch (and others) were begun under the direction of the State Experiment Station at LSU. This work continued until 1909 and was by far the most productive of the early surveys. Harris was the well-known professor of geology at Cornell, and Veatch was his former student. According to the letter of transmission of their first report (1899), the Director of the Experiment Station stated that Harris was "the recognized authority in this country in Tertiary geology," and that Veatch was "an acknowledged authority upon Quaternary geology." Harris had many other accomplishments; for instance, he was the founder of *Bulletins of American Paleontology* (1895), *Paleontographica Americana*

(1917), and the *Paleontological Research Institution* (1932). All are still flourishing.

The State Experiment Station had contracted for Harris to spend his summers working on the geology of the state. He was designated as "Geologist in Charge," bringing Veatch as his primary assistant, although several others also assisted over the next decade. Veatch was to remain, in full-time employment, and taught at LSU in 1901-02 as previously mentioned, before his departure in 1902. He left the state survey to join the U.S. Geological Survey, where he published a report on the geology and ground water of Louisiana as USGS Professional Paper 46 in 1906.

The 1899 report (Part V of the *Geology and Agriculture of Louisiana*, 354 pp.), entitled *A Preliminary Report on the Geology of Louisiana*, is generally attributed to Harris and Veatch. They jointly authored Section I of Part V (Historical Review) and Section II (General Geology); however, Section III is a collection of 9 special papers (4 by Harris, 2 by Veatch, and 1 each by H. Ries, A. Hollick, and G. F. Atkinson). The fact that only Harris and Veatch are listed on the title page of the volume could thus be somewhat misleading. A generalized listing of "Contents," following shows section III to be "By Various Authors."

Included between Sections I and II above is a small, colored foldout map (with a graphic scale of about 1 inch to 30 miles) entitled *Geological Map of Louisiana* with the supraheading "Geological Survey of Louisiana, Report, 1899." It bears no other identifying notations. Its general pattern is very similar to Hopkins' 1870 map, except that the northwestern part of the state is subdivided in a manner much closer to our present interpretation. The map units indicated are (descending): Eocene of doubtful horizon; Midway Eocene; Lignitic

Eocene; Lower Claiborne Eocene; Jackson Eocene; Vicksburg Oligocene; Grand Gulf Oligocene; Port Hudson Pleistocene; Loess and Loam, Pleistocene; Alluvion and very recent deposits. Spots of Cretaceous are shown in much the same pattern as by Hopkins, except that Petit Anse (Avery Island) is not included here. This is the first map to show Claiborne (or older) beds in the state, although both Harris and Lerch, working independently, had recognized Claiborne as early as 1892.

The 1902 report (Part VI) was, according to its Prefatory Remarks, practically a continuation of [Section] III of the report of 1899. It is entitled *A Report on the Geology of Louisiana*, and consists of 8 special papers (3 by G. D. Harris, 3 by A. C. Veatch, 1 by G. D. Harris and J. Pacheco, and 1 by R. A. Harris of the U. S. Coast and Geodetic Survey). The first of these special papers, "The Geology of the Mississippi Embayment with Special Reference to the State of Louisiana," is by G. D. Harris. This is important in placing Louisiana in the regional framework of the Gulf Coast. Facing the first page is a small foldout map entitled "Tertiary Deposits of the Mississippi Embayment," in 13 colors, representing Paleozoic through Alluvium. This 1902 map is signed by J. A. A. Pacheco. The scale, not indicated, is roughly 1 inch to 50 miles.

The succeeding reports of 1905, 1907, and 1909 were, in effect, a continuation of the special reports format begun in Section III of the 1899 report and continued as Part VI the Report of 1902. However, at this point, the *Geology and Agriculture* series (Parts I-VI) was dropped, although the surveys continued under the auspices of the State Experiment Station. The component parts of the succeeding reports of 1905, 1907, and 1909 were styled as *Bulletins*. No explanation is given for this.



The Report of 1905 is a volume of 514 pages consisting of Bulletins 1 through 4 on underground water resources and tide-gage work by G. D. Harris, A. C. Veatch, and others, and also on terrestrial-magnetism and meridian-line work by members of the U.S. Coast and Geodetic Survey. Some of these bulletins were also published separately, as indicated above.

The Report of 1907 consists of Bulletins 5 through 7, with Numbers 5 and 6, by G. D. Harris, on *Notes on the Geology of the Winnfield Sheet* (No. 5, 36 pp.), and *Cartography of Southwestern Louisiana, with Special Reference to the Jennings Sheet* (No. 6, 24 pp.). Bulletin No. 7 is also by Harris, assisted by C. J. Maury and L. Reincke. This 259-page bulletin is different from the rest in that many foreign references were made, as indicated by the title, *Rock Salt, Its Origin, Geological Occurrences and Economic Importance in the State of Louisiana, together with Brief Notes and References to all known Salt Deposits and Industries in the World*.

The final report of the "Harris Survey" was the 52-page Bulletin No. 8, Report of 1909, *Oil and Gas in Northwestern Louisiana, with Special Reference to the Caddo Field*, by G. D. Harris, I. Perrine, and W. E. Hopper.

Professor Harris had divided his time for 10 years between the Louisiana surveys and teaching at Cornell. Many of his survey assistants were students at Cornell. He obtained the cooperation of the U.S. Geological Survey, the U.S. Coast and Geodetic Survey, and the Bureau of Soils of the U.S. Department of Agriculture. Thus, he accomplished much with very small funds. Each of these federal organizations placed parties in the field, and thereby contributed support many times the \$2,500.00 which appears to have been the largest amount that Harris had available in any one year. It was through this arrangement that a great deal of extremely valuable topographic



Gilbert D. Harris, 1864-1952

and cartographic work was accomplished, and that the federal soils surveys were started in Louisiana; they continue to the present time.

The work of Harris was amazingly accurate, especially under the conditions of the times. His efforts, and those of his assistants, contributed not only significantly to the geological knowledge but greatly to the development of the natural resources of the state. The attitude of these tireless and astute workers is best expressed in the letter of transmission of the 1899 report in which the Director of the Experiment Station, William C. Stubbs, said of Harris and Veatch, "These two gentlemen have persistently followed their work through freezes and sunshine, over intolerable roads, impelled by an enthusiasm known only to lovers of science." Conversely, credit should also be given for the support rendered by the Director of the Experiment Station. Harris, in his letter of transmittal to Dr. Stubbs, in the Report of 1905 stated "... you have cheerfully, promptly, knowingly expedited all



matters relating to our State survey with no compensation whatever save the knowledge of seeing the right thing done at the right time." In his 1892 letter of transmission, Otto Lerch had expressed similar thanks to Stubbs.

Dr. Frederick E. Emerson came to LSU as Professor of Geology in 1913. He taught five regular courses plus a course in geologic and geographic field work, all given in the first semester. The second semester was devoted to soils surveys for the State Experiment Station. Under this arrangement, the survey was reestablished as the Louisiana Soil and Geological Survey. This survey issued no publications, perhaps due to lack of funds, but Emerson did publish three papers elsewhere dealing with Louisiana geology. He also wrote a textbook on agricultural geology that became a standard work on the subject. From the time of Dr. Emerson's death in 1919 until H. V. Howe arrived at LSU in 1922, the University was without the services of a geologist, and no further survey work was performed until 1931.

The Louisiana Department of Conservation did, however, issue bulletins on various subjects, some of them relating to geology. For instance, in 1921, their 65-page Bulletin No. 8 on *Louisiana Lignite, Its Occurrences and Utilization* was authored by a chemist, Robert Glenk. He referred to the early investigators and geologists, especially Lerch, Vaughan, Harris, and Veatch. Studies were also twice published on the large Monroe gas field in northeastern Louisiana, in 1921 (Bulletin No. 9 by H. W. Bell and R. A. Cattell, 99 pp.), and in 1925 (Bulletin No. 12 by W. H. Bell, 37 pp.); and in 1922, on the Haynesville oil field, Claiborne Parish (Bulletin No. 11 by W. W. Scott and B. K. Stroud, 126 pp.). In 1927, Bulletin No. 14, *The Clays of Louisiana (Shreveport Area)* by J. W. Whittemore, a ceramic engineer, was published. This 84-page offering was

the result of cooperation with the Louisiana State University and aided in the geological work by Dr. H. V. Howe. Whittemore followed this with other clay studies in 1928 on the Monroe-Ruston area (Bulletin No. 16, 189 pp.) and on the Alexandria area (Bulletin No. 19, 277 pp.)

### THE MODERN SURVEY

Although the present Louisiana Geological Survey was not officially established until 1934 under state legislative Act 131, it actually began to operate 3 years earlier. In 1931, the Bureau of Scientific Research and Statistics, of the Minerals Division of the Department of Conservation, was organized under the provisions of Act 45 of 1930. This bureau was charged with the scientific study of the all of the natural resources of the state and the compilation of the resulting data. Act 45 provided for the appointment of several research workers as required by the exigencies of the various divisions of the Department of Conservation. Accordingly, Commissioner Robert Maestri appointed Cyril Moresi to the position of geologist of the bureau, and detailed him to work with Dr. H. V. Howe, Director of the LSU School of Geology, in making a geological survey of the state. The two immediately began the preparation of the first geological bulletin of the present Louisiana Geological Survey. Iberia Parish was chosen as the subject of this report because of its vast resources of petroleum, sulphur, and salt, and its importance in the salt-dome literature of the world. Although Dr. Howe received no reimbursement from the bureau for his services, he gave the entire summer of 1931 and much of his time during the following 4 months to the preparation of this study. The results were published as Department of Conservation Geological Bulletin No. 1 in November of that year.



H. V. Howe, 1896-1973

Act 131 further implemented Act 45, relating to the mineral resources of the state, in calling for the Commissioner of Conservation:

To inaugurate a geological survey of the State of Louisiana; to authorize and direct the Commissioner of Conservation to cooperate with the Board of Engineers for the State of Louisiana and the United States Geological Survey to assist in making topographical quadrangles, with contours, of the State of Louisiana; to impose a special fee for drilling wells for oil, natural gas, sulphur, or other minerals, in order to raise revenue for the purpose of carrying out the provisions of this Act; and to repeal any and all laws in conflict herewith.

The funding provision thus effectively created a permanent state geological survey.

Moresi, at the time of his appointment as Geologist for the Bureau of Research and Statistics in 1931, was a graduate student at LSU. He continued to work toward his

master's degree, which he completed in 1932. His thesis, the *Geology of Lafayette and St. Martin Parishes*, was published in July 1933 as Geological Bulletin No. 3, again with Howe serving as senior author. In October 1933, Moresi was transferred to New Orleans, then headquarters for the Department of Conservation.



Cyril K. Moresi, 1907-56

After being named State Geologist in 1934, Moresi continued to maintain his headquarters in New Orleans. James M. McGuirt, a doctoral candidate at LSU, was appointed as Assistant State Geologist, with headquarters at the LSU School of Geology. So apparently McGuirt served as the Survey's operations functionary, from 1934 to 1938, while Moresi served as administrator of the Survey and liaison to the Department of Conservation. Dee

David Gooch followed McGuirt as Assistant State Geologist, serving from 1938 to 1940.

Although the administrative office of the Survey was in New Orleans during that time, its research division was always located in the Geology Building at LSU. The LSU School of Geology contributed the assistance of its faculty to aid the Survey. This group included in addition to Howe, Dr. Richard J. Russell, Dr. R. Dana Russell, Dr. Fred B. Kniffen, Professor Benjamin C. Craft, and a number of graduate students. Morton B. Stephenson was the cartographer, and W. D. Chawner and C. F. Dohn were assistant geologists. Dr. Harold N. Fisk arrived in 1936 and was assigned to the research division of the Survey until his appointment to the LSU faculty the following year, and he continued his work for the Survey until 1940. It was in the 1936 Louisiana Geological Bulletin No. 10, the *Geology of Grant and LaSalle Parishes*, that Fisk described his four Pleistocene terraces--corresponding to the major interglacial stages--the Prairie (youngest), the Montgomery, the Bentley, and the Williana. Fisk continued to serve at LSU until 1948 when he became Chief of Geological Research for the Humble Oil and Refining Co. (now Exxon). His most famous work was done for the Mississippi River Commission of the U.S. Army Corps of Engineers, published in 1944 as *Geological Investigations of the Alluvial Valley of the Lower Mississippi River*. This is still considered to be the classic work on the lower Mississippi Valley.

Moresi continued as State Geologist until 1940. During the 1931-40 period, a total of 17 bulletins were published--7 bulletins on the geology of 15 parishes, 5 on Louisiana micropaleontology, 1 on the lower Mississippi River Delta, 1 on the origin of cap rock of Louisiana salt domes, 1 on contributions to the Pleistocene history of the Louisiana

Florida parishes, and 2 bulletins on water supply and resources. The latter 2 were the result of an agreement in December 1937 with the U.S. Geological Survey to investigate the water resources of the state. This eventually led to the Louisiana Survey's publication of a total of 5 geological bulletins plus 49 additional bulletins or pamphlets on water resources, extending to 1975.

In 1940, Moresi was replaced as State Geologist through no fault of his. A "reform" governor, Sam Houston Jones, had been elected to rid the state of the spoils system and the scandals that had prevailed for some time. It will be recalled that the 42-year old Senator Huey Long was assassinated in 1935 in the new 34-story state capitol building that he had caused to be built. The spoils system was already in effect; the scandals erupted after Long's death (Governor Long had been impeached and acquitted in 1929). Governor Richard Leche had resigned and was sent to prison in 1940 for defrauding the state of \$31,000 on a truck sales agreement. He served 3½ years of a 10-year sentence, and was later pardoned by President Harry S. Truman. The President of LSU, Dr. James Monroe Smith, was convicted of embezzlement. He had been playing the stock market with University funds, he said, to help the school's financial position. When this was discovered, he decided to take a vacation in Canada. George Caldwell, the contractor that built the original geology building, was convicted of fraud. These are a few of the most notable aberrations of those times. Although neither accused nor suspected of any wrongdoing, Moresi lost his job in the house-cleaning process. He then became a partner in a prosperous brick-making business, using Louisiana clays, of course.

John Huner, Jr., who had received his Ph.D. from LSU in 1939, was appointed to succeed Moresi as State

Geologist in 1940, serving until 1946. His dissertation, *The Geology of Caldwell and Winn Parishes*, was published as Geological Bulletin No. 15 by the Conservation Department in 1939.



John Huner, Jr., 1912-

Huner, as well as all subsequent state geologists, was stationed at the Survey headquarters at LSU. He had no assistant state geologist, but divided the state into four areas, with a geologist in charge of each of these districts. The first four District Geologists were all graduate students: L. C. Aycock, Tom E. Leroy, Percy M. Lyons, and James L. Martin. A cartographer, G. O. Coignet, and two secretaries completed the regular staff, although a number of students were employed part time in various technical capacities. Graduate students, aided by members of the Survey and the LSU School of Geology faculty were also employed to carry out field research. In

keeping with its chief function--to aid directly or indirectly in the discovery and exploration of the mineral resources of the state--the Survey began to work very closely with the Minerals Division of the Department of Conservation; for the most part, it carried out all of the technical work of that division. It thus was necessary to compile, investigate, and interpret various geological data, such as electric logs, lithologic logs, well samples, field data and geophysical data, and to formulate innumerable related maps and reports.

The Survey also assisted the State Mineral Board in submitting many detailed reports concerning state leases under consideration, thus aiding in obtaining considerably higher bids for these leases. During one 18-month period, a total of 77 such reports was submitted. Assistance was also rendered in attempting to develop mineral resources on lands of state institutions. Many oral and written reports were also given to the state's Attorney General Office, concerning state-owned or controlled lands and water bottoms previously leased, in an effort to determine if these leases were being sufficiently developed. As a result, more than 500,000 acres were returned to the state in a year and a half because of lack of development.

Investigation of the ground-water resources continued under Huner. This was especially beneficial in areas of Rapides, Grant, and Vernon Parishes, where large U.S. Army cantonments were located. A sand and gravel survey, published as Department of Conservation Bulletin No. 19, by T. P. Woodward and A. J. Gueno, Jr., in 1941 also was of considerable help in the construction of military camps and roads, and to the State Highway Department. During Huner's 6-year tenure as State Geologist, six geological bulletins were published by the Survey, in addition to the cooperative work cited above. It is thus seen that this work for



the Conservation Department and the Mineral Board occupied most of the time of the Survey staff. Attrition during the World War II years left the Survey considerably understaffed at times.

A highly qualified ceramics engineer, Dr. Paul E. Cox, was added to the staff in 1946. He conducted numerous tests with Louisiana clays to attempt to encourage a ceramics industry in the state.

Huner moved from the Survey into geological consulting in 1946, and is still active in this work today, in Baton Rouge.

The period April 1946 to October 1947 was one of rapid turnover in the management of the Louisiana Geological Survey. Paul Montgomery served as Acting State Geologist from April 1946 to December 1946. James M. Cunningham served in the same capacity from December 1946 to July 1947. Both had recently received master's degrees from LSU, and both went into the oil industry after their brief time at the helm of the Survey.

G. O. Coignet served next, from July 1947 to October 1947, as Acting Director of the Survey. He was trained as an electrical engineer, classified by State Civil Service as a Geological Engineer, and ordinarily performed the duties of cartographer. He also served as editor for many of the Survey's publications during his tenure from 1937 to 1973. He had worked for the U.S. Coast and Geodetic Survey and the State Highway Department before coming to the Louisiana Geological Survey, and was an outstanding cartographer. Coignet designed the original offshore blocks in the Gulf of Mexico off the coast of Louisiana in the late 1940's, and the U.S. Geological Survey accepted his work as the basis for their grids of the lease blocks. He also compiled the first published separate oil and gas map of the state in 1941. This has been updated eight

times, the last being in 1981. Coignet's last update, in 1973, was with C. Petit Stanfield and Edward L. McGehee, Jr. These two followed in succession, as chief cartographers, upon Coignet's retirement. Petit has been the only woman to serve in that capacity, from 1973 until her retirement in 1982.

Coignet could not be designated as Acting State Geologist since he was not a geologist, so he was named Acting Director of the Survey. He returned to his duties as Chief Cartographer with the arrival of Leo Hough. He retired in 1973 and expired in 1985.

Leo W. Hough served as State Geologist from October 1947 to February 1977. This is, of course, the longest tenure by far of any State Geologist in Louisiana. He is now retired and living in Baton Rouge. He is an Honorary Member of the Association of American State Geologists.



Leo W. Hough, 1913-

Hough received his master's degree from LSU in 1937. He worked as geologist with the U.S. Soil Conservation Service and the State Highway Department before coming to the Survey. A total of 17 geological bulletins, 20 water resources bulletins, and 27 water resources pamphlets, plus numerous other publications, was

issued by the Survey under his administration.

The geological work required of the Survey by the State Mineral Board and the Office of the Commissioner of Conservation continued to mount due to the burgeoning petroleum industry. The Survey had evolved into two distinct sections, an economic section and a research section, and in August 1973 the economic section was removed from the Survey and made a section of the Department of Conservation under the Commissioner of Conservation. Arnold C. Chauviere, an LSU graduate, who had served as Assistant State Geologist since 1964, was then named (the first) Chief Conservation Geologist; he and the other economic geologists were moved to the State Land and Natural Resources Building in downtown Baton Rouge. This section continues to be housed at that location. Chauviere became Assistant Commissioner of Conservation in October 1974 and retired in 1980.

The State Mineral Board had ceased to call on the Survey for geological assistance in 1964 when they developed their own geological section under their newly hired (from Humble) Chief Geologist, James P. Spillers, another LSU graduate. When the Mineral Board began to operate in 1938, they had their own geologist, William A. Romans, a then recent LSU graduate, who remained there only until 1941, despite his outstanding work. From that date until 1964 the Mineral Board had depended on the Survey for its geological work.

With the removal of the Survey's economic section (in 1973), the research section was left at the LSU location. This reduced staff and often lack of sufficient funding for the Survey somewhat curtailed the geological research and the publication of the results. Hough was fortunate in having Dr. Grover E. Murray and Dr. Clarence O. Durham, Jr., of LSU, to each serve as

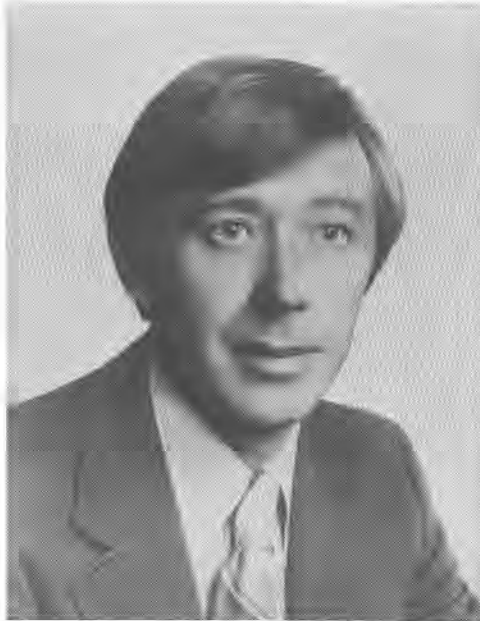
the Survey's Director of Research for the periods 1948 to 1955 and 1955 to 1964, respectively. Each was also, in turn, Chairman of the LSU Department of Geology, and each authored publications of the Survey. Murray became Vice President of LSU, then President of Texas Tech. He has received the AAPG Powers Medal and many other honors including being named an LSU Boyd Professor. In 1961, he published the *Geology of the Atlantic and Gulf Coastal Province of North America*. This 692-page tome is still the premier reference on that province. Hough was also ably assisted by Harry Roland, who served as Assistant State Geologist, beginning in June 1974.

Harry L. Roland, Jr., a 1952 LSU geology graduate, could be considered Acting State Geologist from February 1977, with Hough's departure until July 1978, with the arrival of Dr. Charles G. Groat, the present State Geologist. Roland's title was never officially changed from Assistant State Geologist, even though he was acting in the capacity of State Geologist for nearly a year and a half. He reverted functionally to Assistant State Geologist upon Groat's arrival. He retired in August 1986, and died in January 1988. Roland was a cofounder and the first President (1979-80) of the Baton Rouge Geological Society, Inc.

## THE PRESENT AND THE FUTURE

Charles G. "Chip" Groat, current President of the Association of American State Geologists, arrived at the Louisiana Geological Survey via the Texas Bureau of Economic Geology and the University of Texas (U.T.) at El Paso. He had received his Ph.D. from the University of Texas in 1970, thus becoming the first non-LSU graduate to head the modern Louisiana Survey. He was an Associate Director of the Texas Bureau before going to U.T., El Paso as Chairman of its geology department. Groat is designated as Director of the

Louisiana Geological Survey and State Geologist. In addition to these duties, he is Assistant to the Secretary of the Department of Natural Resources (DNR), and Director of the Coastal Management Section of DNR. He is currently Councilor of the Energy Minerals Division of the American Association of Petroleum Geologists, and also teaches a course in economic geology at LSU.



Charles G. "Chip" Groat, 1940-

The recent emphasis of the Louisiana Survey has been considerably altered by the large number of federal grants that have been secured since Groat's arrival. No geological bulletins, per se, have been published, although two are in preparation. Instead, there have been numerous shorter reports prepared as required by the various grants, plus other projects. Many of these reports have been published elsewhere. These grants are administered by LSU through its Office of Research, with the University taking a sizeable percentage of each grant in overhead levies. A signed agreement of

December 1981 (Memorandum of Understanding) between the Survey and LSU outlines the procedure, responsibilities, and liabilities of both parties. Under this arrangement, a very sizeable portion of the funding for the Survey is obtained, and many of the present Survey personnel are paid with this grant money, thus alleviating much of the state's financial burden in the operation of the Survey. It should also be noted that with the many programs in progress, the Survey's personnel has increased dramatically, numbering nearly 80 for the past several years.

Another significant development was the removal of the State Survey from the Department of Conservation, to place it under the Office of the Secretary of DNR. This was accomplished by executive order of the Governor, under the state constitution of 1974, implemented by the reorganization plan of February 1977. This was obviously a notable improvement, since it removed the research-oriented Louisiana Geological Survey from the Department of Conservation, a regulatory-oriented organization.

In order to assist in the operation of the grants and their programs, a position of Assistant Director of the Survey was established, paid by university funds. This position was occupied by Virginia Van Sickle for about 2 years, until March 1988, when a new state administration was installed. Van Sickle was then appointed as Secretary of the State Department of Wildlife and Fisheries, taking leave from the Survey. She had, in recent years, previously taken leave from the Survey to serve as Deputy Secretary of Wildlife and Fisheries for about 1 year. Dr. Don G. Bebout had assisted with the administration of these grants during his 3-year tenure as Director of Research. He came to the Louisiana Survey from the Texas Bureau of



Economic Geology in 1979 and returned there in 1982.

Some of the projects of the Louisiana Geological Survey now in progress include the following: aggregate exploration, artificial reef program in the Gulf of Mexico, coastal and wetlands protection, coastal and wetlands research, statewide flood control, geologic mapping, geologic review of industry operations in wetlands, geomorphology, injection wells for hazardous waste, lignite studies, microseismic monitoring, Outer Continental Shelf technology and newsletter, Quaternary geology, salt dome studies, sedimentology, soil conservation, subsurface studies, and water resources studies. Survey personnel have also recently participated in the following: the American Association of Petroleum Geologists Stratigraphic Cross Section project; the AAPG COSUNA Gulf Coast Region Correlation Chart; the Geological Society of America DNAG Lower Mississippi Valley Quaternary Geology project; the GSA geological map of North America; the U.S. Geological Survey Quaternary map of the United States; assisting the British Broadcasting Corp. in its television series, "The Making of a Continent," in reference to the Mississippi Embayment; and a feasibility study of the proposed superconducting super collider federal project.

Survey programs have changed as the needs of the state have changed. While the early years emphasized geologic mapping, research in the traditional geological disciplines, and resources, activities in recent years have concentrated on environmental issues and alternate energy resources. Coastal land loss emerged as a major state concern in the early 1980's and the Survey responded by developing extensive coastal research and coastal protection programs. Water resources and the need to maximize the

production of the state's remaining oil and gas resources are presently becoming major issues. As state funds increasingly track defined state needs, it becomes even more critical that Louisiana Geological Survey programs are directly responsive to what the governor and legislature perceive as priority issues. It is equally important that the Survey anticipate state needs and educate both government officials and the public about them. This necessitates placing a strong emphasis on education and information dissemination. Traditional programs will not be lost to the future, but, their objectives will become increasingly mission oriented.

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## MAINE

Maine Geological Survey, Maine Department of Conservation,  
State House Station 22, Augusta, ME 04333. Phone 207-289-2801.

### HISTORICAL SEQUENCE OF ORGANIZATIONAL NAME:

Geological Survey, 1836-38  
 Scientific Survey (under Maine Board of Agriculture), 1861-62  
 Topographic Survey Commission, 1899-1905  
 State Survey Commission, 1905-11  
 State Geologist (?), 1914-16  
 Maine Public Utilities Commission, 1916-19  
 Maine Water Power Commission, 1919-20  
 State Geologist, 1929-32  
 Maine State Planning Board, 1934(?) -37  
 State Geologist, 1937-43  
 Maine Development Commission, 1943-55  
 Department of Development of Industry and Commerce, 1955-57  
 Division of Geological Survey, Department of Economic Development, 1957-69  
 Division of Science, Technology, and Mineral Resources, Department of  
 Economic Development, 1969-71  
 Division of Science, Technology, and Mineral Resources, Forestry Department,  
 1971-73  
 Bureau of Geology, Maine Department of Conservation, 1973-77  
 Maine Geological Survey, Maine Department of Conservation, 1977-present

### NAMES AND TITLES OF ORGANIZATIONAL DIRECTORS AND DATES SERVED:

#### State Geologists

Charles T. Jackson, 1836-38	Joseph C. Twinem, 1931-32
Charles H. Hitchcock, 1861-62	Freeman F. Burr, 1934 (?) -42
Leslie A. Lee, 1903-08	Joseph M. Trefethen, 1942-56
Franklin C. Robinson, 1908-10	John R. Rand, 1956-59
C. Vey Holman, 1910-11 (?)	Robert G. Doyle, 1959-79
Freeman F. Burr, 1914-20	Walter A. Anderson, 1979-
Lucius H. Merrill, 1929-31	present

### THE MAINE GEOLOGICAL SURVEY

By Woodrow B. Thompson

#### INTRODUCTION

Tracing the history of the Maine Geological Survey has proved to be a more complex task than expected. Much is known about recent years, and the Surveys of the 1800's are well documented. However, events of the early

1900's had to be reconstructed from obscure, out-of-print government reports. Sometimes a single sentence in a legislative journal, or a line in a budget sheet, may be the only public record that the State of Maine employed a geologist during a certain year. The Maine Geological Survey as we know it, with a full-time staff and field program, has existed only since the 1940's. In previous years the State hired just one or two geologists at a time. However,

these individuals contributed to the growth of earth science research in Maine and thus are included in the following history.

#### **THE JACKSON AND HITCHCOCK SURVEYS: 1836-38 and 1861-62**

Mineral resources were important to the early settlers of Maine, who exploited rock quarries, ore minerals, and clay deposits. The legislature soon recognized the significance of these resources in Maine's economy and, in 1836, authorized the first geological survey of the state. The Board of Internal Improvements contracted with Charles T. Jackson, a prominent physician and naturalist from Boston, to conduct the survey.



Charles T. Jackson, Maine's first State Geologist (portrait from Merrill, 1906).

Limitations of funding, short field seasons, and modes of transportation restricted Jackson's field work to coastal areas and a few river and overland routes. He carried out his investigations between 1836 and 1838

and published the results in a series of three annual reports. Jackson's *First Report on the Geology of the State of Maine* (Jackson, 1837) was accompanied by a separate atlas of plates. This atlas is now a scarce collector's item, more in demand for its art work than geologic content. Jackson is said to have compiled a single copy of a bedrock map of Maine encompassing all of his work. It was discovered in a Boston bookstore in the 1870's, but its present location is unknown (Trefethen, 1947).



Charles H. Hitchcock, Director of the second geological survey of Maine (photo from Merrill, 1906).

Jackson was also commissioned in 1836 to conduct a geological survey of the public lands in northern Maine, which were jointly owned by Maine and Massachusetts. The principal motive for these expeditions apparently was to gather information on the geography and natural resources near the Maine-Canada border, the location of which was being disputed with England. Reports on this work were published in 1837 and 1838.

Merrill (1924) criticized Jackson's reports as merely "recording a large number of disconnected observations," but conceded that he faced difficult logistical problems in quickly covering such a large remote area with extensive soil and forest cover. Jackson's surveys helped guide future geological work in the state, and the references to mineral occurrences in his reports probably encouraged prospecting and development of these deposits.

In 1861, the Maine legislature authorized a "Scientific Survey" to be carried out for the Board of Agriculture. Ezekiel Holmes, a naturalist from Winthrop, and Charles H. Hitchcock, professor of geology at Amherst College, were appointed to direct this survey. It comprised a variety of natural history investigations, but chiefly Hitchcock's geological studies. The findings of Hitchcock and other members of the Scientific Survey were included in the Sixth and Seventh Annual Reports of the Maine Board of Agriculture, published in 1861 and 1862.

Hitchcock accomplished an impressive amount of work during his 2 years as State Geologist. His reports described the bedrock and surficial geology of Maine, including mineral resources. According to Toppan (1932), one of the most important contributions was the delineation of Devonian strata. There is also much information on features related to glaciation, although the glacial theory was relatively new in the early 1860's. Hitchcock compiled the first widely circulated map of the bedrock geology of the state, which is contained in several editions of Colby's *Atlas of Maine* beginning in 1885.

#### YEARS OF UNCERTAINTY: 1899-1942

Following the Hitchcock survey, Maine did not have a State Geologist or geological survey for the remainder of the 19th century. The United States Geological Survey (USGS) carried out a

few projects in the state, including investigations by Nathaniel S. Shaler in coastal areas and George H. Stone's pioneering work on Maine's glacial deposits. Around the turn of the century the Maine legislature authorized three types of geologic and topographic projects: river basin studies, topographic mapping, and minor work on bedrock geology. The evolution of cooperative state-federal programs during the early 1900's is a little-known chapter of the Maine Geological Survey's history. The developments summarized below were reconstructed from records in the State Archives.

In 1899, the legislature created the Topographic Survey Commission to administer a cooperative state-federal topographic mapping program. Legislation passed in 1901 enlarged the scope of this commission by giving them supervisory power over both topographic and geologic work. Their report for 1901-02 indicated that the USGS had already completed several 15-minute quadrangle maps (which sold for only 5 cents each!), established a number of stream gauging stations, and begun geologic studies in eastern Maine. The first mention of a State Geologist appeared in the commission's 1903-04 report, which stated that Leslie A. Lee was both Chairman of the Commission and State Geologist. (Lee was a professor of geology and biology at Bowdoin College.) However, the actual geologic work was done entirely by the USGS, including quadrangle reports and economic studies by George O. Smith, Edson S. Bastin, and others.

The name of the Topographic Survey Commission was changed to the "State Survey Commission" in 1905, in recognition of its broadened responsibilities. Lee continued as State Geologist until his death in 1908, when he was succeeded by Franklin C. Robinson (professor of chemistry and mineralogy at Bowdoin College). In 1909, the legislature created the State

Water Storage Commission, whose duties included working with the State Survey Commission and USGS in topographic mapping "in so far as it related to the collection of data bearing on the water powers and water storage reservoirs of the state" (P.L. 1909, Chap. 212). Robinson died in 1910, and later that year C. Vey Holman was appointed as State Geologist and Commission Chairman.

The State Survey Commission was abolished in 1911, its duties being transferred to the Water Storage Commission. This agency was chaired by the Governor, but hydrographic work was supervised by Cyrus C. Babb, who was appointed USGS District Engineer for Maine. Babb published annual reports on Water Storage Commission activities for the years 1910-13, including the first bibliography of Maine geology (Babb, 1913). Topographic and geologic mapping by the USGS is thought to have continued under Babb's direction, but there is no record of a State Geologist during this period.

In 1913, the state dissolved the Water Storage Commission and transferred its duties to the new Public Utilities Commission (PUC). The PUC's first annual report (for 1915) described the durable state-federal topographic mapping co-op, which somehow survived being bounced from one agency to another since 1899. The report also noted that the USGS had paid for all geological work in Maine during 1913-15, except for an investigation of peat deposits.

The PUC awakened Maine's interest in conducting its own mineral resource inventory. Their report for 1916 listed Freeman F. Burr as geologist under the engineering staff. Burr presented an account of the work on peat resources, which he had begun in 1914 under prior authorization from Governor Haines and the Water Storage Commission. Burr's report also

described feldspar deposits and other mineral occurrences that the PUC had directed him to study in 1916. His remark that he covered "approximately 2,000 miles by train, 600 miles by automobile, and 250 miles on foot" gives some idea of the effort involved in this study (Burr, 1917).

Burr was again listed as staff geologist in the PUC report for 1917 but was not included in the 1918 roster. The Commission probably employed him in 1918, because in that year the Executive Council granted the PUC permission to send "Mr. F. F. Burr, its Geologist" to a conference with the USGS and other state geologists in Washington, D.C. The PUC was deeply involved with railroads and other modes of transportation, regulating utilities, and coping with all sorts of litigation. Their report for 1919 said that all work related to water resources and topography had been turned over to the newly created Maine Water Power Commission.

The Water Power Commission's first annual report, for 1919-20, contained brief sections on topography and geology, in addition to the river basin studies that were a high priority during the expansion of hydroelectric power. Freeman Burr reappeared as the Commission's geologist, and the legislation creating the Commission directed it to cooperate with the USGS in hydrographic and geological surveys, as well as topographic mapping. The report noted that the State's appropriation for continuing the mapping co-op was so small (\$5,000 per year) that 15-minute quadrangle coverage of Maine would not be completed until the year 2005!

A summary of Burr's investigations of economic rocks and minerals, and peat as a potential fuel source, was included in the Water Power Commission's first report. Burr argued in favor of establishing a State Geologist position in order to collect and communicate information on mineral



resources, and to publish "educational matter." However, his appeal failed to yield immediate results. The Commission's second report (for 1921-22) no longer listed Burr on the staff roster. It remarked that a State Geologist had not been hired, and even the USGS had done no work in Maine during the past 2 years. The Water Power Commission itself was abolished in 1925. The legislature restored to the PUC the authority to continue the topographic mapping co-op, and the State Geologist position was still in limbo.

In 1929, the Governor appointed Lucius H. Merrill to be State Geologist for 2 years. Merrill was a professor of biochemistry at the University of Maine in Orono for many years prior to becoming State Geologist. He and his assistant, Edward H. Perkins of Colby College, published the *First Annual Report* on the geology of Maine (Merrill and Perkins, 1930). This was the first of the modern series of State Geologist reports. It described several investigations of Maine's bedrock and surficial geology, including such diverse topics as earthquakes and glaciomarine clays.

Joseph C. Twinem followed Merrill as State Geologist from 1931 to 1932 (Toppan, 1932). He was an instructor in the Civil Engineering Department of the University of Maine. Twinem's report, like Merrill's, comprised a variety of studies. It also contained an updated bibliography of Maine geology (Twinem, 1932). Twinem was listed as State Geologist on the Preliminary Geologic Map of Maine, which was compiled by Arthur Keith and published in 1933. This was the first bedrock map of the state since the one by Hitchcock. Keith was described on the map as "Assistant State Geologist of Maine, 1932, and Geologist, U.S. Geological Survey." The compilation was based on his work for the USGS during 1925-31 and information from other state and federal sources.

The record of State-sponsored geologic work during the next decade is very fragmentary. Trefethen (1947) said that Freeman Burr was State Geologist from 1932 to 1942. However, legislative records show that a deficit in state revenues forced the State Geologist's salary to be suspended for 2 years effective March 31, 1933, and then suspended for another 2 years beginning March 30, 1935. During at least part of this hiatus, the resilient Burr was associated with the Maine State Planning Board. (This agency was absorbed into the Maine Development Commission in 1937.) A publication dated 1934 indicated that Burr was "assistant in charge of construction" for the Planning Board (Burr, 1934). The Board's organizational chart showed a Conservation Division encompassing wildlife, forestry, and geology. Burr co-authored a bulletin on the mineralogy of Maine that was published by the Planning Board in early 1936 (Burr and Weed, 1936), and maps bearing his name in this bulletin are dated as early as August 1934.

Some of the slack in the mid-1930's was taken up by the Maine Technology Experiment Station at the University of Maine. This organization conducted an extensive survey of gravel deposits and their suitability for road construction. As part of the road materials survey, E. H. Perkins prepared a bulletin on the glacial geology of Maine, together with the first surficial geologic map of the state. Both of these products were published in 1935. Perkins had been an Assistant State Geologist under Merrill and Twinem. Although his reconnaissance map was very generalized, it provided a useful overview of Maine's spectacular esker systems.

Freeman Burr was finally appointed to be official State Geologist in April 1937 and reappointed in March 1940. The duration of these two appointments is not known, and Burr apparently did not publish anything

during this period. Legislative records indicate that he was salaried at least through June 1939, and Trefethen (1947) said that he retired from the position in 1942.

#### YEARS OF GROWTH: 1942-88

Joseph M. Trefethen held the post of State Geologist from 1942 until 1956. He was a professor of geology at the University of Maine and was headquartered at the campus in Orono. In 1943, his position was made part of the Maine Development Commission; then in 1955 it was incorporated into the new Department of Development of Industry and Commerce. By 1945 Trefethen had assembled a staff of eight persons. From this time onward the group was known as the "Maine Geological Survey" (MGS), although the name remained unofficial for over two decades.

During his tenure as State Geologist, Trefethen greatly increased the number and variety of geological investigations in Maine, including cooperative projects with the USGS. The results were published in annual reports and a new MGS bulletin series. There were major studies of granite pegmatites and metallic mineral resources, and a renewed emphasis on commodities such as limestone, peat, and clay deposits. At first this activity was spurred by the demand for strategic minerals during World War II, but Trefethen promoted the benefits of such work to the post-war economy. He also initiated an in-depth study of the relationship of Maine's coastal geology to clam production. This cooperative effort with the Maine Department of Sea and Shore Fisheries was among the first of its type in the country (Trefethen, 1951).

John R. Rand became State Geologist in 1956 and held the position until 1959. In 1957, the name of the Department of Development of Industry and Commerce was changed to simply



Dr. Cornelia Cameron (left) of the U.S. Geological Survey and MGS assistants sampling a peat bog for the Maine Peat Resource Evaluation Program (1982).

"Department of Economic Development" including the Division of Geological Survey. This was the first legislative approval of a distinct geological agency in Maine state government. Rand hired geologists from institutions such as Harvard and MIT to produce bedrock maps based on their summer field work in Maine. He thus established a mutually beneficial connection between the MGS and academia that persists to the present day as the foundation of the Survey's geologic mapping program.

Rand also continued the investigation of Maine's mineral resources. He published a series of maps and reports locating granite quarries and mineral deposits in Maine. To further publicize the state's resources, sets of economic rocks and minerals were distributed to schools.

Robert G. Doyle succeeded Rand as State Geologist in 1959. During his 20



MGS geologist Craig Neil (right) and U.S. Geological Survey technicians installing a monitoring well for the Significant Sand and Gravel Aquifers project (1985).

years in office, Doyle continued the Survey's work on mineral resources, including geophysical studies as well as basic geologic mapping. Interest in the state's mining potential was fueled by detailed MGS reports (Special Economic Studies Series) on ore deposits in eastern Maine, and zinc-copper mines were opened at Brooksville in 1968 and Blue Hill in 1972. The Survey's bedrock mapping program thrived during the 1960's and 1970's with both state and federal geologists working in Maine. In 1967, the Survey published a new 1:500,000-scale bedrock map of the state, the chief compilers of which were Doyle and Arthur M. Hussey, II.

The Maine Geological Survey experienced major changes in structure and program orientation during Doyle's tenure as State Geologist. Some of these changes resulted from reorganization of State agencies. In 1969, the Division of Geological Survey became the "Division

of Science, Technology, and Mineral Resources," including both a State Geologist and Assistant State Geologist. The legislature transferred this division from the Department of Economic Development to the Forestry Department in 1971 and then to the Bureau of Geology in the new Department of Conservation in 1973. Finally, the Bureau of Geology officially became the Maine Geological Survey in 1977.

MGS programs began to diversify during the 1970's in response to development pressures in southern Maine, increased environmental concerns, and the tremendous need for information on the state's coastal and surficial geology. The Survey commenced reconnaissance-level surficial quadrangle mapping and an air-photo inventory of coastal geology. Much of this work was done with limited project funds, necessitating quick coverage of large areas.

In 1979, Walter A. Anderson (who had been Doyle's assistant) was appointed State Geologist. The MGS has greatly expanded through the 1980's, with the establishment of divisions for bedrock and surficial geology, cartography and information services, hydrogeology, and marine geology. Anderson's development of the Survey staff has enabled the MGS to broaden its services to include many activities besides geologic mapping. Much of the Survey's work is oriented toward today's pressing land-use issues, including radioactive waste disposal, groundwater protection, and coastal management. However, basic geologic mapping and data collection are still essential sources of information for decisions in these matters.

The Maine Geological Survey maintains close research ties with the USGS (particularly the Water Resources Division in Augusta), The University of Maine system, and other State agencies such as the Maine Department of Environmental Protection. Experience

has shown that a coordinated multi-disciplinary approach, involving government and university workers with knowledge of mutually related fields, is the best means of tackling complex geologic problems. Funding from various federal sources has been obtained for many projects in recent years, including peat resource inventory, landslide studies, investigations of neotectonics and sea-level changes, and offshore marine research. Presently, the Survey is developing a computerized geographic information system (GIS) to spatially handle the growing amount of earth science data.

In 1985, the MGS published two new geologic maps of the state: an updated bedrock map, edited by P. H. Osberg, A. M. Hussey, II, and G. M. Boone; and the first surficial geologic map of the state in 50 years, edited by W. B. Thompson and H. W. Borns, Jr. Detailed bedrock and surficial quadrangle mapping are continuing,

because the reconnaissance nature of much earlier work is inadequate to meet current planning needs or provide a full understanding of Maine's geologic history. Sand and gravel aquifers have received much attention during the last decade, with detailed aquifer mapping supplemented by acquisition of subsurface data from well drillers, test borings, and seismic profiles. A similar effort is needed along the coast to generate accurate, large-scale geologic maps for planning purposes.

Along with several other State Geological Surveys, the MGS is observing its sesquicentennial during 1987-89. The occasion is being marked by publication of bulletins containing articles on recent geologic research in Maine. These papers will provide an overview of many different aspects of Maine geology and help define research priorities for years to come.



Maine Geological Survey staff in 1988. Front row, L to R: Joseph Kelley, Woodrow Thompson, Walter Anderson (State Geologist), John Williams. Back row, L to R: Catherine Stultz, Robert Marvinney, Stephen Dickson, Patricia Seaward, Craig Neil, Cheryl Fiore, Michael Foley, Thomas Weddle, Robert Tucker, Bennett Wilson, Robert Johnston, John Poisson.



## FUTURE OUTLOOK

Considering the rapid development and population growth in Maine, the need for geologic data will remain strong. The Maine Geological Survey plans to continue its basic mapping program, which will be facilitated by 1:24,000-scale topographic maps that are newly available for a large percentage of the state. In the field of hydrogeology, much remains to be learned about Maine's bedrock aquifers, which provide water for most rural homes. The Survey's Marine Geology Division is placing a high priority on exploration of the offshore zone, where direct observation, remote sensing, and sediment sampling are providing new data on the character and resource potential of the sea floor.

Technical assistance to its varied clientele is expected to remain a very important function of the MGS. This service will be enhanced by the Survey's recent affiliation with the National Cartographic Information Center. However, an enlarged in-house cartographic and GIS capability are deemed crucial to making new geologic maps and reports available to the public in the "Information Age." A parallel effort is underway to generate educational publications that will be useful to teachers, tourists, and others interested in the geologic history and resources of Maine.

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## MARYLAND

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### HISTORICAL SEQUENCE OF ORGANIZATIONAL NAME:

Geological Survey of the State [of Maryland], 1834-42  
Maryland Geological and Economic Survey, 1896-1941  
Department of Geology, Mines and Water Resources, 1941-64  
Maryland Geological Survey, 1964-present

### NAMES AND TITLES OF ORGANIZATIONAL DIRECTORS AND DATES SERVED:

Julius T. Ducatel, Geologist, 1834-42  
William Bullock Clark, Superintendent and State Geologist, 1896-1917  
Edward Bennett Mathews, Superintendent and State Geologist, 1917-43  
Joseph T. Singewald, Jr., Director and State Geologist, 1943-62  
Ernst Cloos, Acting Director, 1962-63  
Kenneth N. Weaver, Director and State Geologist, 1963-present

### A HISTORY OF THE MARYLAND GEOLOGICAL SURVEY

By James P. Reger

#### HISTORICAL DEVELOPMENT

##### The First State Geological Survey: 1834-42

The 1830's marked the rise of state geological surveys, with seventeen official surveys being established. Maryland was preceded by only four other states in establishing a survey, but claims credit for being the first to fully recognize the importance of a topographic map base on which to represent the geology of the State.

The first attempts to initiate an official survey of Maryland failed, but as sentiment grew for public financing of internal improvements, legislation was proposed to address the need for better maps. In 1833 the General Assembly passed two resolutions authorizing the appointment of a "competent Engineer" to prepare a plan for a complete map of the State and an assistant engineer to make the necessary geological studies and report

on the expediency and probable cost of a geological survey of the State.

John Henry Alexander was appointed Engineer, and Julius Timoleon Ducatel was appointed his assistant. They worked together on a reconnaissance of the State during the summer of 1833 and on December 27 presented a preliminary report and recommendations to Governor James Thomas.

As a result of their report, legislation was passed in February 1834 to establish the first Geological Survey of Maryland. Alexander and Ducatel were appointed to the posts of Topographic Engineer and Geologist, respectively. Alexander's duties were to gather information and to conduct surveys that would enable him to make a "perfect and complete map of the State." Ducatel's duties were to make a complete and detailed geological survey of the entire State.

Alexander, with the help of the U.S. Coast Survey, developed a Federal-State cooperative plan for surveying and mapping. This plan was not immediately adopted, however, and



State Geologists of Maryland. Left to right, top row: Julius T. Ducatel, 1834-42; William B. Clark, 1896-1917; Edward B. Mathews, 1917-43. Bottom row: Joseph T. Singewald, Jr., 1943-62; Ernst Cloos, 1962-63; Kenneth N. Weaver, 1963-present.

Alexander performed his work as best he could, while frequently being directed by the Legislature to conduct special surveys for canals, railroads, and other internal improvements. He recommended that work on the new State map be suspended until it could be undertaken in cooperation with the U.S. Coast Survey. However, several years passed before a form of Federal-State cooperation was finalized.

Eventually convinced of the impossibility of conducting the topographic survey under existing conditions, the frustrated Alexander resigned in 1837 but continued his work without pay

(and without further interruptions). He still prepared maps for Ducatel's reports, as well as several county topographic maps on which geological data were placed and which subsequently were published in annual reports of the Geologist. Although his resignation meant the official preparation of a State topographic map ceased, Alexander did succeed in compiling a topographic map at a scale of 1:200,000 and contour intervals of 50 and 100 feet. Prior to Alexander's map, hachures had been used to depict topographic features such as mountains. This map was never published in full size, but two

manuscript copies were prepared, complete with geologic boundaries and localities for many mineral products. The date of this map is not stated, but it was probably completed shortly prior to 1840.

In 1841, Alexander again urged adoption of the cooperative mapping program with the Coast Survey. Implementation had been hindered heretofore because the Coast Survey had been largely concerned with surveys north of Maryland. The general southward extension of such surveys made it possible for the first time to enter into active cooperation with the Federal government.

In contrast to Alexander's situation, Ducatel was able to begin his geological investigations immediately upon his appointment. Eventually, he visited almost the entire State. For the first 4 years, he conducted surveys on the eastern shore and in southern Maryland. The pace of his work was incredible, in that during that time he produced maps and reports for fourteen counties. During those same years, he also studied the coal and iron deposits of the Frostburg Basin in Western Maryland. From 1838 to 1840, Ducatel shifted his attention westward, conducting surveys of five more counties and reporting on the geology, mineral resources, physical geography, and soils.

Ducatel presented his last report in 1840. The report was prefaced by a letter to the Governor, in which a plea was made for an extension of time for the proper completion of the work. His appeal to the Governor and legislature went unheeded. Public and political pressures for retrenchment in the expenditure of public monies prevailed, and the survey came to an end by an act of the General Assembly in February 1842.

### The Years Without A Survey: 1843-95

The termination of the first geological survey was followed by a period of little activity in geological work. From time to time, privately supported investigations were made of various aspects of Maryland geology, but little systematic work was undertaken.

In 1848, the General Assembly established the position of State Agricultural Chemist for the benefit of Maryland farmers. James Higgins, M.D., was appointed to the post. During his term in office, 1848-58, little of scientific interest was accomplished, because the work was intended, by law, to be of more immediately practical value than scientific.

Philip T. Tyson succeeded Dr. Higgins in 1858. Perhaps more than anyone else during this period, Tyson recognized that geological investigations were essential to any proper interpretation of the soils of the State, and, accordingly, did much to classify and describe the geological formations. That Tyson placed great importance on geology is evident in his first report in 1860. The report contained the first detailed, full color geologic map of the entire State (scale 1:600,000) as well as several chapters that dealt with the mineralogy and geology of Maryland. Tyson's second report, in 1862, again gave considerable attention to geology, especially the State's mineral resources and their geographical distribution.

With the outbreak of the Civil War, government funding for the Agricultural Chemist ceased, and this survey also came to an end.

For the next 34 years, there were no State-funded geological surveys in Maryland. However, a number of individuals and institutions made contributions during that time. For example, the Maryland Academy of Sciences was founded in 1855, with



Philip Tyson as its first President. One year later, the Maryland Agricultural College was incorporated by the State. However, the most significant precursor to a new State survey was the establishment in 1883 of a Geology Department at The Johns Hopkins University, when Dr. George H. Williams joined the faculty as an instructor of mineralogy. His appointment marked the beginning of a period of geological investigations in Maryland that has continued to the present. Almost from the first, the members of the Geology Department carried on their investigations in close cooperation with the U.S. Geological Survey, frequently as part-time members of the Survey's staff, so that the reports of investigations received wide publicity.

In the early 1890's, two joint ventures between academic institutions and the Federal government involved limited geological investigations. In 1890, a soil survey of the State became a joint enterprise of the Maryland Agricultural College, the U.S. Department of Agriculture, and The Johns Hopkins University. Under somewhat similar arrangements, a Maryland Weather Service was established in 1891, with Hopkins geology professor William Bullock Clark chosen to be its Director. The Weather Service was sponsored by the Maryland Agricultural College, the U.S. Weather Bureau, and The Johns Hopkins University. In both instances, Hopkins provided free laboratory space.

**Era of the Modern Survey:  
1896 to the Present**

The Maryland Geological and  
Economic Survey: 1896-1941

A bill for the reestablishment of a State Geological Survey was introduced into the General Assembly in January 1896 and signed by Governor Lloyd Lowndes on March 19. The official name was the Maryland Geological and

Economic Survey, but it was more commonly to be known as the Maryland Geological Survey. The new Survey was placed under the direction of a commission composed of the Governor, the State Comptroller, the President of The Johns Hopkins University, and the President of the Maryland Agricultural College. Chosen to be the first State Geologist and Superintendent of the Survey was Dr. William Bullock Clark, Professor of Stratigraphy and Paleontology at Hopkins. Clark promptly selected Dr. Edward Bennett Mathews, Professor of Mineralogy and Petrography, to be the Assistant State Geologist. Both Clark and Mathews held joint appointments with the State and The Johns Hopkins University.

Great geological activity in many areas characterized the tenure of Dr. Clark in the period 1896-1917. Fundamental geologic studies highlighted this period, including many of the now classic Systematic Reports. Additionally, many county geologic maps and some mineral commodity reports were published.

The Geology Department at Johns Hopkins provided office and laboratory space, as well as faculty and graduate students as part-time staff for the Survey. Clark was later to write that affiliation with the University was mutually advantageous: graduate students in his department obtained practical experience in the field and in the laboratory, and the State, for its part, obtained scientific guidance and the use of excellent libraries and laboratories at little or no cost to the State.

In 1898, the Survey was authorized to establish a Highway Division, with Dr. Harry Fielding Reid, Professor of Geological Physics, as its head. The scope of the Survey was extended to conduct an investigation of road construction in Maryland, to classify road-building materials, and to study their distribution. Dr. Reid's compre-

hensive reports on the highways of Maryland had much to do with increased appropriations for modern roads. A few years later, when an appropriation of \$5 million for a system of arterial highways had been made, a separate board known as the State Roads Commission was created, and in 1910 all highway work was transferred to it. Even then, however, the roads were constructed under the supervision of the Chief Engineer of the Survey.

Work on the forests of the State was carried on by the Survey from its early years. Out of this work, there grew in 1906 a State Board of Forestry, with its membership nearly the same as that of the Geological Survey, and with Dr. Clark as its Executive Officer.

The Survey was also active in the determination of the State's boundaries. In 1900, Maryland and Pennsylvania agreed to appoint a two-man commission to supervise a survey and re-marking of the Mason and Dixon Line. Maryland's commissioner was Dr. Clark. Dr. Mathews prepared a history of the Line, which had been surveyed originally in 1763-69, and followed it by a report on the development of the counties of Maryland and their boundaries. Some years later Dr. Mathews directed the precise definition of the Maryland-Virginia boundary.

After Dr. Clark's death in 1917, Edward Bennett Mathews was appointed State Geologist, as well as Director of the Maryland Weather Service. Mr. Edward W. Berry, Professor of Paleontology at Hopkins, was made Assistant State Geologist. Dr. Mathews carried on many of the former policies, but the emphasis changed, at least in the earlier years, to mineral resources, with reports on coal, fireclays, molding sands, feldspar, chrome, and manganese. Little was published in the 1930's with the notable exceptions of several county geologic maps, a new State geologic map, and Volume XIII, edited by Ernst Cloos,

dealing with the structural geology in crystalline rocks of Maryland.

In 1923 a general reorganization of the government of Maryland became effective, and the various State bureaus were put under the direction of the regents of the University of Maryland. The Geological Survey was an exception to this, however, because of the recognized advantage afforded the State by the Survey's association with The Johns Hopkins University. This association was continued without important changes in personnel, and a three-member advisory committee, chaired by the President of Hopkins, was appointed to give general oversight to the work of the Survey.

#### The Department of Geology, Mines and Water Resources: 1941-64

The Department of Geology, Mines and Water Resources was created by the State in 1941 by combining the functions of the Geological Survey, the State Bureau of Mines, the Water Front Commission, and the Water Resources Commission. Although the new Department now had regulatory-management responsibilities in the fields of gas and oil wells, mining, and water resources, its major function remained scientifically oriented. For the first time in its history, the Maryland Geological Survey, as it was still popularly known, was not an independent agency, having now become a member agency of the newly formed Board of Natural Resources.

Dr. Joseph T. Singewald, Jr., Professor of Economic Geology at Johns Hopkins, became State Geologist and Director of the Survey following the departure of Dr. Mathews in 1943. Singewald was no stranger to the organization, having been associated with the Survey since 1911 and a member of the Hopkins faculty since 1913. For the first few years after his appointment, he was the only full-time professional staff member at the

Survey. Geological investigations were conducted chiefly, as in the past, by the faculty and students of the Geology Department at Hopkins.

Two pieces of legislation, passed over a decade apart, had a major impact on the work of the Survey: the Water Appropriations Act of 1933 and the Well Drillers Law of 1945. Convinced by the drought of 1930 of the fallacy that water resources were inexhaustible, the Legislature passed the 1933 law, thus creating the Water Resources Commission. This Commission had the responsibility for issuing permits or otherwise imposing restrictions for appropriating any surface and ground waters for any use other than for purely domestic or farm purposes. When this regulatory function was transferred to the Survey in 1941, the need was recognized to conduct geological and hydrological investigations that would provide the basis for sound decisions regarding water appropriations.

A cooperative agreement with the U.S. Geological Survey for investigations of surface-water resources had been in force since 1924. In 1943, a somewhat similar arrangement was made with regard to ground-water investigations. In 1945, Dr. Robert M. Overbeck was hired as a ground-water geologist, the first full-time professional staff position not affiliated with Johns Hopkins University. He worked in conjunction with five hydrologists from the USGS. More than any other accomplishment, the growth of this program highlighted Dr. Singewald's tenure as Director of the Survey.

As State Geologist, Dr. Singewald was an outspoken advocate of the conservation of water, minerals, soils, and native vegetation, and it was due in large part to his efforts that the Well Drillers Law of 1945 was passed. The 1933 law requiring commercial or industrial property owners to obtain permits to appropriate ground waters

had been completely ignored and not a single permit had been applied for up to June 30, 1945. The 1945 law addressed the issue of licensing well drillers and also required drillers to obtain permits before drilling any water well. In order to increase compliance with the 1933 law, the 1945 law also prohibited a driller from drilling a well (i.e., by not issuing a drilling permit) for an owner requiring an appropriation permit until that appropriation permit had been obtained. Furthermore, the information obtained automatically through this law, from the well-permit applications and the well-completion reports, represented a wealth of data on the ground waters of the State that otherwise would have been lost or only incompletely collectible at great expense of time and money. The permitting system for well drillers and water appropriations was one of the earliest such programs in the nation.

As an outgrowth primarily of the State-Federal cooperative programs, the increased emphasis on water-resources investigations spawned a new publication series, the Bulletin. From 1944 to 1963, 27 Bulletins were published, 17 of which dealt with water resources of the various counties of the State. Maryland was one of the first states to have complete areal coverage by ground-water and surface-water reports.

Among the functions transferred to the Survey in 1941 were those of the Water Front Commission, whose responsibility it had been to recommend to the Legislature plans and policies for protecting the State's shorelines and waterways against erosion and to cooperate in carrying the Legislature's plans into effect. In 1947, Mr. Turbit H. Slaughter, assisted by his wife Edwardine, began conducting the first quantitative study of shoreline erosion and accretion along the entire shoreline of the Chesapeake Bay and its tributaries. Their work laid the

foundation for creating a full-time shore erosion program at the Survey in 1963.

Other significant legislation developed with the Survey's support during Singewald's tenure included Maryland's first strip-mining law in 1955 and an oil and gas law in 1956, which provided needed implementation of the 1945 Well Control Act in the control of the wells themselves and provided some control over the spacing of wells to prevent excessive wasteful drilling.

Dr. Singewald retired from the Survey in 1962. Dr. Ernst Cloos, Chairman of the Geology Department at Hopkins since 1952, now also became the Acting Director of the Survey. During his brief tenure, Dr. Cloos was instrumental in establishing a full-time Shore Erosion Program and in broadening the scope of activities of the Survey.

Up to this time, every State Geologist and Director of the Survey had held a joint appointment in the Department of Geology at The Johns Hopkins University. In 1963 that tradition was broken as Dr. Kenneth N. Weaver was appointed full-time Director and State Geologist. (However, he had earned his Ph.D. from Hopkins in 1954.) Thus ended nearly 68 years of direct staff affiliation with the University, although the Survey did remain on the campus.

Dr. Weaver was still in his first year of office when the Survey underwent another reorganization and name change.

#### The Maryland Geological Survey: 1964 to Present

In a 1964 reorganization of the Board of Natural Resources, the name of the Department of Geology, Mines and Water Resources reverted to the Maryland Geological Survey, and its regulatory and management functions in regard to water resources were transferred to a new Department of

Water Resources. The Survey retained regulatory authority over gas and oil well drilling. The Maryland Bureau of Mines, which still had regulatory control of coal mining, kept its attachment to the Survey but operated as an independent Bureau in Western Maryland. In light of this reorganization, one of Dr. Weaver's first accomplishments was establishing a plan for the long-range development of the Survey.

Through the end of the 1960's, five new series of publications were started, as there was a revival of studies in basic geology, mineral resources, and shore erosion. In 1968, the Survey published the sixth Geologic Map of Maryland--the first since 1933.

Yet another reorganization within State government occurred in 1969 when the Survey became a member agency of a new Department of Natural Resources. In that same year, the Division of Archeology was added to the Survey, following enactment of the Maryland Archeological Resources Act of 1968, and Mr. Tyler Bastian was appointed as first State Archeologist. This Division was established to coordinate archeological activities in the State, including the issuance of permits for archeological investigations on State lands.

In 1976, the Bureau of Mines and the oil and gas regulatory function of the Survey were transferred to the newly formed Energy and Coastal Zone Administration, thus leaving the Survey with no regulatory authority except permitting of archeological excavations on State lands. However, in 1987, the authority to issue permits for oil and gas wells was returned to the Survey.

Since the mid-1960's, the Survey has experienced fairly rapid growth. Having had a full-time professional staff of four geologists in 1964, the Survey grew to 14 professional and support staff by 1969. Today, in 1987,



Council, Land Reclamation Committee, State Topographic Mapping Committee, Outer Continental Shelf Policy Committee, and geological matters involving the Department of Energy's high-level nuclear waste storage program.

The Maryland Geological Survey Commission advises the Director on any matters within the Survey's jurisdiction. The Commission is composed of five Maryland citizens who have an interest in or knowledge of geological matters and who represent the various geographic regions of the State. Members are appointed by the Governor for rotating 5-year terms.

#### **General Direction Program**

The Survey carries out its mission through five programs that were set up in 1972. The General Direction Program, headed by the Director and Deputy Director, is responsible for budgetary and fiscal matters, personnel, publications office, general office management, and overall supervision of the Survey's four scientific programs.

#### **Hydrogeology and Hydrology Program**

Projects of the Hydrogeology and Hydrology Program are generally carried out under the auspices of the U.S. Geological Survey-Maryland Geological Survey Cooperative Agreement. Through this agreement funds budgeted by the State and participating intrastate agencies are generally matched by the Federal government. These co-ops have been in effect since 1943 for ground-water studies and since 1924 for surface-water studies.

The Program is responsible for the maintenance of a Statewide water-data network and the investigation of the hydrologic and geologic characteristics of Maryland's water resources. The water-data network provides information on minimum, maximum, and average stream flows for the planning

of water supply and sewage facilities, water-power projects, dams, bridges, and other public and private works; and ground-water levels in selected wells throughout the State. This network allows monitoring of the hydrologic effect of long-term changes in pumpage, land-use patterns, and precipitation.

In addition to the Statewide network activities, specific projects are undertaken to determine ground-water and streamflow characteristics and rates of replenishment. Applied research projects of this type are often supported by funds from County or State cooperators. Examples of recent projects include the hydrologic effects of underground coal mining in western Maryland, simulation of ground-water flow and base flow in weathered crystalline rocks in the Piedmont, and evaluation of the water-supply potential of Coastal Plain aquifers.

#### **Environmental Geology and Mineral Resources Program**

The Environmental Geology and Mineral Resources Program encompasses areas of geological research; geologic mapping; topographic map compilations and periodic revision; environmental geology applications; mapping of present and potential mineral resources, mined lands, and mineral zoning; monitoring current activity of extraction of minerals; and the general dissemination of earth-science information about Maryland. A relatively new approach in environmental mapping is the Mineral Resources and Mined-Land Inventory Maps and maps of Geologic Factors Affecting Land Modifications. In recent years there has been renewed interest in physiographic mapping. Studies such as these provide the basic framework for outlining and managing the land and mineral resources of the State and generate the geologic information necessary for wise land-use decisions.

This Program has long placed emphasis on geologic mapping. Since 1975, nineteen 7.5-minute quadrangle geologic maps have been published (1:24,000 scale), and eighteen more are in various stages of preparation. During that same period, new or revised geologic maps have been published (1:62,500 scale) for nine of Maryland's twenty-three counties, and four more county maps are nearly completed, in part due to recent participation in the U.S. Geological Survey COGEOMAP program.

Another long-standing tradition is the compilation of county topographic maps at a scale of 1:62,500. Revisions are made periodically to keep pace with changing cultural and geographic features, such as highways, urbanization, reservoirs, and public lands.

The Program also coordinates with agencies of the State and Federal governments regarding geological aspects of oil and gas exploration in Maryland and Federal Lease sales on the mid-Atlantic outer continental shelf. In 1987, the Program was reassigned responsibility for issuing drilling permits for oil and gas wells in the State.

Since 1982, the State affiliate of the National Cartographic Information Center (NCIC) has also been attached to this Program. This office handles numerous requests from the public and County and State agencies for information concerning maps, aerial photography, satellite imagery, and other cartographic products.

### **Coastal and Estuarine Geology Program**

Having grown out of the shore erosion program initiated in 1963, the Coastal and Estuarine Geology Program has evolved faster than any other program of the Survey. Through the early 1970's, the Program was devoted almost exclusively to measuring erosion along the Atlantic

and Chesapeake Bay shorelines and to providing technical assistance to property owners experiencing shore erosion problems. During the years 1973-76, the Chesapeake Bay Earth Science Study (CBESS) was the focal point of the Program. This project's goal was to conduct the first comprehensive overview of the physical, chemical, and biological processes affecting the sediments on the Bay bottom.

In 1978, the Program received a real "shot in the arm" through participation in the 4-year EPA Chesapeake Bay Study (CBS). The federal funds provided allowed the great expansion of both the Coastal and Estuarine Geology Program and the CBESS project, and at the conclusion of the CBS, state executives agreed to continue funding the Program at approximately the same level.

The Program continues to conduct the first Baywide comprehensive scientific examination of the physical and chemical characteristics of the Bay bottom. Results of these studies aid in managing the Bay resources by contributing to decisions regarding beach restoration; dike disposal, overboard disposal, and land disposal of dredge soil; potential sites for new oyster bars; placement of shore erosion-control structures; the siting of major facilities along or near the shores of the Chesapeake Bay; delineation of shoaling areas which will aid in placement of marinas; identification of sediment source areas and effects of agricultural practices and urban development; and determination of the role of benthic organisms in the exchange of dissolved chemical species across the sediment-water interface. An extension of the Program's work is an investigation of the geologic history of the Bay.

The Program maintains and operates the *Discovery*, a 49-foot research vessel for use in the Chesapeake Bay and in the Maryland

waters on the continental shelf. The boat is equipped for seismic surveys, a variety of sediment sampling methods, and computer-assisted navigation for continuous plotting of position.

#### **Division of Archeology**

The Division of Archeology is mandated by law to coordinate archeological activities in Maryland, encourage archeological research and preservation, publish reports on Maryland archeology, and enforce regulatory sections of the Archeological Resources Act of 1968. The State Archeologist was appointed in 1969. The Division maintains a reference library, records all known archeological sites and investigations in the State, and curates an extensive collection of historic and prehistoric artifacts from all sections of the State. It also publishes a newsletter.

In 1975, the State Highway Administration began funding projects staffed by Division archeologists to perform field reconnaissance, testing, and mitigation for historic and prehistoric archeological remains in proposed highway rights-of-way.

The Division of Archeology conducts an Annual Field Session under the sponsorship of the Archeological Society of Maryland. The session focuses on one particular site and provides a forum whereby members of the general public are introduced to archeological field methods under the supervision and instruction of professional and amateur archeologists.

The Division is under the direction of the State Archeologist, who also serves on the Governor's Science Advisory Council and on the Scientific Council of the Maryland Academy of Sciences. The Division also maintains close liaison with the Archeological Society of Maryland, the Maryland Historical Trust, and the Council for Maryland Archeology.

An Advisory Committee on Archeology, composed of five citizen archeologists, counsels the Director of the Maryland Geological Survey on archeological matters.

#### **SIGNIFICANT LANDMARKS AND ACCOMPLISHMENTS**

**1833**--General Assembly passed resolutions concerning a map of the State; J. H. Alexander appointed Engineer and J. T. Ducatel appointed Assistant Engineer.

**1834**--Legislation established the first geological survey of the State; J. H. Alexander appointed Topographic Engineer and J. T. Ducatel appointed Geologist. (Survey terminated in 1842.)

**1859**--First State Geologic Map published by State Agricultural Chemist (1:600,000).

**1893**--Second State Geologic Map published by Geology Department at Johns Hopkins University under the auspices mainly of the USGS (1:500,000).

**1896**--General Assembly established State Geological and Economic Survey; William Bullock Clark named State Geologist and Superintendent of the Survey.

**1896**--Cooperative program initiated with USGS for investigation of surface-water resources; terminated in 1909.

**1897**--Third Geologic Map of Maryland published as part of Volume I (1:1,000,000).

**1898**--Highway Division was created in the Survey; remained in Survey until 1910 when transferred to new State Roads Commission.

**1907**--Fourth Geologic Map of Maryland published as part of Volume VI (1:500,000).

**1917**--Edward Bennett Mathews named State Geologist and Superintendent of the Survey.

**1924**--Cooperative program with USGS in surface-water investigations reinstated.

1933--Fifth Geologic Map of Maryland published (1:380,160).

1933--Water Appropriations Act becomes law.

1941--Survey combined with other agencies to form Department of Geology, Mines and Water Resources; Department became a member agency of the Board of Natural Resources.

1943--Cooperative program with USGS in ground-water investigations began.

1943--Joseph T. Singewald, Jr., named State Geologist and Director of the Department of Geology, Mines and Water Resources.

1945--Well Drillers Law passed by General Assembly.

1945--Cooperative topographic mapping program initiated with USGS.

1949--First commercial gas well drilled in Maryland (Garrett County).

1955--First strip-mining law enacted.

1956--Oil and gas law enacted.

1962--Ernst Cloos named Acting State Geologist.

1963--Shore Erosion program initiated.

1963--Kenneth N. Weaver named State Geologist and Director of the Survey.

1964--Name changed to Maryland Geological Survey, as water-resources regulatory functions were assigned to another agency.

1968--Sixth Geologic Map of Maryland published (1:250,000).

1969--Survey became member agency of the new Department of Natural Resources.

1969--Division of Archeology created within the Survey.

1971--Cooperative topographic mapping program with USGS reinstated.

1976--Bureau of Mines transferred to the Energy Administration; left Survey with no regulatory functions except for archeological permits.

1982--Survey became State affiliate of National Cartographic Information Center of USGS.

1984--*Ecphora quadricostata* became Official State Fossil by legislative Act

(name changed to *E. gardnerae* in 1987).

1986--Survey moved to its new and permanent headquarters at 2300 St. Paul Street, Baltimore.

1987--Regulatory authority reassigned with respect to oil and gas well drilling.



Official State Fossil of Maryland, *Ecphora gardnerae* (Miocene).

## FUTURE PROJECTIONS

The Maryland Geological Survey will be observing its 100th anniversary in 1996, and the Survey is looking toward its next 100 years with great expectations. Three new publications have been proposed as special commemorative editions: a new State geologic map at a scale of 1:100,000, an up-to-date and detailed report on the geology of Maryland, and an expanded version of the Survey's history.

The size of the Survey, both in terms of personnel and physical plant, is not expected to change appreciably. What we do will probably not change as much as how we do it. For example, our new laboratory facilities will add greatly to our analytical capabilities. Increasing the use of computers may eventually lead us in the direction of computer-assisted mapping and geographic



information systems, among other applications.

We believe that quantity and quality of water resources will continue to be subjects of great concern well into the next century of the Survey's history. Much emphasis in the past had been placed on quantity aspects of both surface and ground water. In the future, quality of water (especially ground water) will take increasingly large efforts on the Survey's part. Data developed through long-term studies and monitoring of water quality will be needed to address continuing problems of pollution of ground water from all sources.

Applied research on geological aspects of the Chesapeake Bay and Maryland's coastal waters will continue to occupy a high priority position. Studies of the geochemistry of the bottom sediments will be emphasized to try to get a better understanding of the

flux of trace elements and nutrients between the sediments and the water column.

For the foreseeable future, the direction of the Maryland Geological Survey will continue to be primarily one of applied geological studies and mapping aimed at providing for the geological information needs of the State of Maryland and its citizens. Public service has been and will continue to be the Survey's ultimate role--service by seeking out and providing information on earth resources of the State to aid in the wise and orderly development of these resources for the benefit of the State. Geologic mapping, mineral-resource studies, aquifer evaluation and modeling (including quality modeling), Chesapeake Bay studies, and archeological evaluations will surely continue to be important activities of the Maryland Geological Survey.

## MASSACHUSETTS

Executive Office of Environmental Affairs, 100 Cambridge Street, 20th Floor,  
Boston, MA 02202. Phone 617-727-9800.

### HISTORICAL SEQUENCE OF ORGANIZATIONAL NAME:

Survey of the Geology and Natural History of Massachusetts, 1830-39  
Department of Public Works, 1971-82  
Office of Environmental Affairs, 1982-present

### NAMES AND TITLES OF ORGANIZATIONAL DIRECTORS AND DATES SERVED:

Edward Hitchcock, Geological Surveyor, 1830-33 and 1837-39  
Joseph A. Sinnott, State Geologist, 1971-present

### HISTORY OF GEOLOGY IN MASSACHUSETTS

Joseph A. Sinnott

Massachusetts may be credited with the first fully-supported state geological survey, authorized by the legislature in 1830. Governor Levi Lincoln supported this program with these words to the legislature:

Much knowledge of the natural history of the country would be thus gained (by a geological survey) especially the presence of valuable ores, the extent of quarries, and of coal and the advancement of domestic prosperity would be discovered, and the possession and advantage of them given to the public.

Money was appropriated annually for salary and expenses, and for publication. The Reverend Edward Hitchcock, professor of natural science and chemistry and later president of Amherst, was chosen to make the survey. He published prodigiously on botany, chemistry, geology, mineralogy, physics, and religion, and wrote an *Elementary Geology* that went through thirty editions. Hitchcock had the confidence of the legislature and accomplished much to foster the principle of government support to science.

With the success in Massachusetts, twenty states east of the Mississippi

organized geological surveys in the next several years, with the major purpose of locating and describing mineral resources, facilitating road and canal routes, and collecting mineral, rock, and ore specimens for public display and distribution to academies and colleges for educational purposes. Not only was there the prevalent thought that the geological surveys would be of economic and educational value, but that science could be of economic and educational value and of such usefulness as to merit government support.

Formidable volumes and maps were published in the 1830's and not redone until B. K. Emerson (USGS Employee) in 1916 released a full color bedrock map. Both maps were done in the "horse and buggy" era but reflect the quality work and the ominous amount of time required to produce such a product.

A cooperative mapping program between the U.S. Geological Survey and the State Department of Public Works began in 1936 which resulted in early aerial photos and completion of quadrangle maps. Before undertaking a new statewide map a geophysical program was born which resulted in an aeromagnetic map for each quadrangle as well as a radiometric and gravity map.

Someplace in the middle of all this the author became/was appointed State Geologist in 1971 and remains to this date--1988. Historians will have to decide, based on semantics, whether J. A. Sinnott was the first State Geologist in the Commonwealth but to Edward Hitchcock belongs the honor of running the first Geological Survey.

In the modern era of energy crisis and environmental awareness, a statewide surficial geologic map is nearing completion at a scale of 1:125,000. The only subject remaining to be mapped will be ground-water aquifers. The Commonwealth was fortunate in having the intelligence and leadership of U.S. Geological Survey employees E-An-Zen and Byron Stone as project leaders.

The last staff meeting of geologists working in the Environmental field numbered forty bodies. It should be noted that of the forty, not one is mapping. Such is the nature of change.

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- George F. Hanson, Historical Directory of State Geological Surveys, AASG 1972 E. A. Noble, Editor.
- Gordon B. Oakeshott, Origin-Development of the State Geological Surveys, 1971 Reprinted from Journal of the West, Vol. 10, No. 1

## MICHIGAN

Michigan Geological Survey, Department of Natural Resources, P.O. Box 30028,  
735 E. Hazel Street, Lansing, MI 48909.

### HISTORICAL SEQUENCE OF ORGANIZATIONAL NAME AND DIRECTORS:

#### First Geological Survey

Douglass Houghton, State Geologist, 1837-45

#### Second Geological Survey

Alexander Winchell, State Geologist, 1859-62

#### Michigan Geological and Biological Survey

Alexander Winchell, State Geologist, 1869-71

Carl Rominger, State Geologist, 1871-85

Charles E. Wright, State Geologist, 1885-88

M. E. Wadsworth, State Geologist, 1888-93

Lucius L. Hubbard, State Geologist, 1893-99

Alfred C. Lane, State Geologist, 1899-1909

Roland C. Allen, State Geologist, 1909-19

Richard A. Smith, State Geologist, 1919-20

#### Geological Survey Division, Department of Conservation

Richard A. Smith, Division Chief and State Geologist, 1920-46

Gerald E. Eddy, Division Chief and State Geologist, 1946-51

Franklin G. Pardee, Division Chief and State Geologist, 1951-52

William L. Daoust, Acting State Geologist, 1952-54

William L. Daoust, Division Chief and State Geologist, 1954-64

#### Geological Survey Division, Department of Natural Resources

Gerald E. Eddy, State Geologist, 1964-71

Arthur E. Slaughter, State Geologist, 1971-76

#### Division of Geology, Department of Natural Resources

Arthur E. Slaughter, State Geologist, 1976-77

#### Geological Survey Division, Department of Natural Resources

Arthur E. Slaughter, State Geologist, 1977-81

R. Thomas Segall, State Geologist, 1981-present

### A BRIEF HISTORY OF THE MICHIGAN GEOLOGICAL SURVEY

#### GENESIS

At 12:00 noon on January 26, 1837, Michigan achieved statehood and at 2:00 p.m. that same day, the fledgling legislature introduced and approved a bill which proposed a thorough geological study of the state. Thus this bill, subsequently to become Act 20, created our first Geological Survey and

also the first department of the State created by statute.

The bill authorized and directed Governor Stevens T. Mason, with the advice and consent of the Senate, to appoint:

A competent person whose duty it shall be to make an accurate and complete geological survey of this state, which shall be accompanied with proper maps and diagrams, and furnish a full and scientific description of its rocks, soils and minerals, and of its botanical and geological productions . . . . and provide specimens of the same . . .



An appropriation of some \$3,000 was recommended to carry out the above work during the first year, and on February 23, 1837, Governor Mason signed the bill into law.

As a result of this legislation, Dr. Douglass Houghton, who had conceived and planned the survey, and persuaded individual members of the legislature to commit money and time to this undertaking, was appointed Michigan's first State Geologist. The Michigan Geological Survey's early accomplishments are inextricably linked with the work and personality of Dr. Houghton.

At the time of Houghton's appointment in 1837, fewer than 24,000 people of European descent lived in Michigan, most in the region of present-day Detroit or at isolated trading stations along the Great Lakes. The shorelines were only roughly charted, the northern two-thirds of the state was an unsurveyed wilderness, and practically nothing was known of the state's interior. Easterners viewed Michigan as an unhealthy land dominated by bogs and sand hills, its Upper Peninsula too cold and "fit only for savages." Indeed, the Survey was in part created to dispel those beliefs and to bring more settlers to the state.

### **THE EARLY YEARS: 1837 to 1900 INVESTIGATION AND DISCOVERY**

#### **The First Geological Survey**

After his appointment as State Geologist, Douglass Houghton organized the Survey into geological, zoological, botanical and topographical departments. To cut costs and keep the new Survey on schedule, yet maintain high standards for collecting and reporting data, Houghton devised a plan to combine the existing federal linear survey with the Michigan Geological Survey. In 1844, Houghton and the commissioner of the General

Land Office signed contracts to conduct a joint linear and geological survey. This was the first instance of such cooperation between the federal government and a state survey.

Under Dr. Houghton's direction the Survey prepared and presented seven annual reports to the Michigan Legislature which would form a basis for the future understanding of the Michigan Basin. The most noteworthy geological contributions of the Houghton-directed Survey include the determination of the stratigraphy and structural setting of the Michigan Basin, confirming the extent of Michigan's copper deposits, defining Michigan's coal basin, and bringing attention to the importance of deposits of natural brines, gypsum, peat, marl, clay, limestone, iron ore and gold.

In 1845, Houghton, at age 36, drowned in Lake Superior when his boat capsized in a gale. His accomplishments included serving as Mayor of Detroit, Professor of Geology at the University of Michigan; founding member and president of the Association of American Geologists (which later became the American Association for the Advancement of Science). At the time of his death, he had been nominated for Governor of Michigan.

After Houghton's death, the Michigan Geological Survey was suspended. Houghton's assistant, Bela Hubbard, along with William Burt, a surveyor with the General Land Office, continued to survey and explore the mineral region of the south shore of Lake Superior. They described masses of iron ore near Menominee. Their discoveries prompted Charles Jackson, Josiah Whitney and John Foster to begin active reconnaissance of the public mineral lands of Michigan's Upper Peninsula Lake Superior Land District (16,000 square miles). Their efforts were assisted by John Locke, William Mathers, Charles Whittlesey and James Hall. Hall, one of Houghton's



Dr. Houghton sitting in red chair (oil painting on wood). Donated in 1951 to the State Geological Survey by Dr. Houghton's grandson, Edward Houghton Morgan. Presumed to be the only life portrait for which Houghton ever sat. By Alvah Bradish, 1835.

students while teaching Natural History at the Rensselaer Scientific School, later became State Geologist of New York. Reports prepared from these expeditions were published in 1851. By 1855, more than 80 percent of the copper produced in the United States came from the Lake Superior Land District. Active mining for iron ore in the Upper Peninsula had begun earlier in 1848.

### The Second Geological Survey

In the late 1850's petitions from across the state were received by the Michigan Legislature requesting further investigations into salt resources. On February 15, 1859, Act 206 established the formation of a second Geological Survey to complete the survey suspended in 1845. Dr. Alexander Winchell, then Professor of Geology at the University of Michigan, was appointed as State Geologist.

Winchell conducted extensive field work from 1859-62, but published only one report. The publication includes a massive accumulation of geological facts including: a general account of the geology of the state (the first orderly overall description of the geology of the Michigan Basin), thorough descriptions of the coal, gypsum and salt deposits of the Lower Peninsula and the iron deposits of the Upper Peninsula. Many of the geological observations were based on the earlier work of Douglass Houghton. The report also summarized the economic progress of the non-metallic mineral industry in Michigan.

Winchell was responsible for the accumulation of a massive fossil collection. Based on observations related to these fossils and correlations with oil-bearing strata in Canada and Ohio, he believed oil could be found in Michigan.

The work of the second Survey was suspended in 1863 when the legislature failed to appropriate funds for its continuation. The state treasury was

under severe strains due to the military expenses of the Civil War.

### The Third Geological Survey to 1900

By the year 1869 a strong public demand had arisen for a resumption of the Geological Survey. Legislation was passed in March 1869 to establish a third Geological Survey, but the Act made no provision for zoological or botanical investigations as did those of 1837 and 1859. In April of that year Dr. Winchell was for the second time appointed as State Geologist under the direct supervision of a Board of Geological Survey. The Board was an *ex officio* body consisting of the Governor, the Superintendent of Public Instruction, and the President of the State Board of Education.

Dr. Winchell's second administration of the Geological Survey was destined to be, like the first, short-lived. Dr. Winchell wished the Survey's investigations to concentrate on the Lower Peninsula and to progress in a scholarly direction. It was the wish of the Board of Geological Survey that the thrust of the Survey's duties should be in the development of the iron and copper deposits of the Upper Peninsula.

The Board signed independent contracts with Major T. B. Brooks to survey the Marquette Iron District, and Professor R. J. Pumpelly to survey the Copper Region.

Frequent heated debates and political friction between Dr. Winchell and the Board resulted in his resignation as State Geologist in 1871. The Board appointed Dr. Carl Rominger to continue the survey of that part of the state not included in the investigations of Major Brooks and Professor Pumpelly.

During the years 1872-76 Dr. Rominger was engaged practically alone in the work of the Survey. The results of his researches are embodied in Volume III of the Survey's reports. Most important is his discussion of the

geological structure of the Lower Peninsula, confirming and carrying further the views and work of Houghton and Winchell, as to the "basin structure" of the Michigan Region. His work also includes a careful and elaborate monograph on the fossil corals of Michigan. This work remains today the classic treatise of fossil corals of the Michigan Basin.

Dr. Rominger accompanied both Major Brooks and Professor Pumpelly during stages of their surveys. Results of these investigations were delayed for political reasons by the Board of Geological Survey and not published until 1895. This delay is felt to have slowed the development of Michigan's early mineral industry.

Dr. Rominger continued as State Geologist until May 1885, when he was succeeded by Charles E. Wright, who had been Commissioner of Mineral Statistics. Wright remained State Geologist until his death in March 1888. During Wright's tenure he engaged the Survey in making sketches and maps of the topography to illustrate geologic phenomena of the Upper Peninsula. Wright also collected and identified some 3,300 rock specimens.

Following Wright's death, Dr. M. E. Wadsworth, Director of the State Mining School was appointed as State Geologist. Under Dr. Wadsworth's direction, the Survey at last secured offices of its own. Up to that time the Survey had had no offices other than the private offices or homes of the various geologists. With Wadsworth's leadership the Survey became an organized and more efficient branch of state government. Wadsworth made arrangements with the USGS that enabled the State Survey to devote most of its time and resources to economic geology, while leaving the more purely scientific studies, particularly paleontology, to the USGS.

After Dr. Wadsworth's resignation in 1893, the Board appointed Dr. Lucius

L. Hubbard as State Geologist and Dr. A. C. Lane as Assistant State Geologist. Under Dr. Hubbard the Survey was thoroughly reorganized and all ties to the College of Mines and the University of Michigan were severed. The Board felt that while the Survey's connection to these institutions was beneficial to the schools, it was detrimental to the Survey.

Up to this time the achievements of the third Survey were mainly of exploration and progress in the Upper Peninsula, aside from the lonely work of Dr. Rominger. To eliminate duplication of studies being done by the USGS, Dr. Hubbard stopped work in the Iron District by the Michigan Survey. He continued work in the Copper District and Isle Royale and directed Dr. Lane to begin extensive research in the Lower Peninsula. Resulting publications prepared by these men on the geology of the Keweenaw Peninsula and Isle Royale, salt and gypsum, petroleum prospects, deep paleozoic borings in the Southern Peninsula, and copper deposits of the Upper Peninsula are still used as references and are considered to embody the highest characteristics and quality of geological work.

In 1899 Dr. Hubbard resigned and the Board elected Dr. Lane as his replacement. Under Dr. Lane's direction the Survey headquarters were moved from Houghton in the Upper Peninsula to the capital in Lansing in the Lower Peninsula. Survey publications began to take a more diverse nature as interest in the geology of the Lower Peninsula increased, and the legislature again attached provisions for zoological and biological responsibilities to the duties of the Geological Survey. During Dr. Lane's service as State Geologist, the first thorough topographic survey of Michigan was initiated.



## THE MIDDLE YEARS: 1900 to 1950 PRODUCTION AND CONSOLIDATION

### The Third Geological Survey

If the years prior to 1900 can be thought of as the years of Investigation and Discovery, then the interval from 1900 to 1950 must surely be viewed as the years of Production and Consolidation. Dr. A. C. Lane continued his work commenced prior to the turn of the century, but resigned as State Geologist in 1909 to accept a professorial position at Tufts College.

R. C. Allen succeeded Dr. Lane as State Geologist and under his leadership, numerous papers were published detailing the geological investigations taking place at the time. Much of this work was on the Paleozoics of Michigan, individual county geologic reports, and the surface geology of Michigan, including a new map of surface geologic formations. A study of the Monroe Formation, which led to the discovery of significant glass sand deposits, was also completed. This information later proved to be of extreme value during World War I when the United States was cut off from supplies of German optical glass.

At about this time the Survey inherited the duties of the Commissioner of Mineral Statistics and began issuing reports on metallic and non-metallic minerals. An annual appraisal of iron mines was established in cooperation with the Board of State Tax Commissioners. From these two information sources Michigan was able to provide adequate source data on strategic minerals available in the state to the National Defense War Minerals Council, both before and during World War I.

The onset of World War I saw a great curtailment of the Survey's activities, mainly due to lack of funds and manpower. However, the topographic branch of the Survey continued to

work on the topographic survey of the state and at this time (1915) they finally completed the relocation and marking of the permanent boundary line between Ohio and Michigan.

At the conclusion of the war the Survey enjoyed a modest expansion. More precise geological investigations were instituted and appraisals of copper mines as well as iron mines were planned and executed. The reconstruction of industry after the war led to the demand for geologists and in 1919 R. C. Allen resigned to become Vice-President of the Lake Superior Iron Ore Association.

Richard A. Smith, Assistant State Geologist under R. C. Allen, was appointed State Geologist and Director of the Geological Survey. He continued many of the projects initiated by his predecessor including: exploration of the iron formations of the Upper Peninsula, studies of the Ordovician shale group, and completion of the inland lakes survey. A soil and land economic study was undertaken in cooperation with the Department of Agriculture, as was an economic survey of the clays and shales of Michigan.

In 1921 the Michigan Department of Conservation was created and the powers and duties of the Survey were transferred to this new department. The new department did not include topographic or land surveys which had been transferred to other divisions of state government.

### The Oil and Gas Industry in Michigan

Although the first oil well in Michigan was drilled near Port Huron in 1886, it was not until the middle 1920's that serious oil exploration got underway. While it is true that many "local use" oil and gas wells dotted southeast Michigan, both before and after the initial discovery, it was not until the discovery of the Saginaw Field in 1925 that Michigan became a

commercially producing oil state. From this point forward, through the late 1920's and into the early 1950's, the Southern Peninsula saw a proliferation of relatively shallow oil and gas fields.

The burgeoning oil industry placed a severe strain on the limited resources of the Survey and the need for regulation was met by Act 65 of the Public Acts of 1927 which mandated the issuance of drilling permits and provided for regulations governing petroleum exploration, operation and development, and penalties for violations of the act. Under this act, Michigan's first permit was issued to the Logan Oil Company for the Logan No. 1 well in Logan Township, Mason County.

The work of the Survey continued to increase as the search for oil grew. In 1927 and 1928, the Survey established its first field offices to administer Act 65. At this time the Petroleum Section of the Survey was created. In 1929 the duties of the Supervisor of Wells were extended to include operation of producing wells and the collection of statistics of oil and gas production. Michigan had become an oil producing state of the first order east of the Mississippi.

In 1929, with the onset of the "Great Depression", Michigan, with its new found oil industry, was ranked first in the production of salt, bromine, calcium chloride, and magnesium sulphate, and second in iron ore, portland cement, gypsum and amorphous graphite. A law passed in 1929, for the joint cooperation of the Department of Conservation and the USGS to take and utilize aerial photographs for the production of base maps and surveys, put Michigan on the leading edge of a technique which is still in use today. Satellite mapping is simply an extension of this early development.

The depression took its toll with the Survey as it did with all facets of industry and government, but never-

theless the oil industry continued to grow, and with it the responsibilities of the Survey. More new field offices were established and new services were provided on the geologic, technical and advisory problems of the industry. Oil and gas field reports, maps and well records were made available to the public, as office technical and clerical personnel increased. By 1935 exhaustive reports on the geology of several of the larger oil fields had been printed and published. From 1935 through 1938 Survey work continued to increase, aided somewhat by the various depression-spawned projects such as PWA, WPA, and, CCC. New field offices continued to be established, or old offices shifted to new locations, as developments necessitated.

In 1939 two developments of significance to the growing oil and gas industry occurred: (1) the state of Michigan was admitted into membership in the Interstate Oil Compact Commission, and (2) the old oil and gas act, Act 65 of the Public Acts of 1929, was superseded by Act 61 of the Public Acts of 1939. This is the authority under which oil and gas is presently regulated, though it has been amended and revised a number of times in the intervening years. This new law repealed all existing oil and gas legislation and introduced many new features to prevent surface and subsurface waste. It also provided for an advisory board of six persons knowledgeable in oil and gas matters to aid and advise the Supervisor of Wells in his deliberations.

By 1940 the Survey had accumulated a large library of well cuttings which were washed, cleaned, and stored. These were available to outside interests as well as Geological Survey personnel, and each month all new well logs were typed, mimeographed, and made available to the public at a nominal price.

## World War II

During the years encompassing World War II, work went on at the Geological Survey, influenced and directed in considerable degree by the war. Decreased personnel carried an ever-increasing work load. In some respects, the oil and gas industry declined because of war-time restrictions and shortages of materials, especially steel, hampering expansion of exploration and of producing and refining facilities. In the mid-1940's, the western Michigan area reopened as a producing district after having remained dormant since 1930. By the late 1940's, oil and gas operations increased slightly although new discoveries did not add materially to new reserves.

In 1946, R. A. Smith, after seeing the Survey through the aftermath of World War I, the depression years, and World War II, took his well-earned retirement after 26 years, the Geological Survey's longest tenured State Geologist. Though retired, R. A. Smith continued to maintain a presence at the Survey and to give sound advice and counsel to his successor, Dr. Gerald E. Eddy.

Dr. Eddy took over a Survey that had been hard hit by the war just ended, and his first order of business was to see to the regrouping of the Survey as a functional instrument of state resources policy. This he did while continuing to foster the development of the shallow oil "play" in the Southern Peninsula. He was also instrumental in pioneering the new aerial geomagnetic surveys and geochemical and radioactivity surveys which were just entering into the geologist's lexicon at this time.

### Helen Martin - A Vignette

As is so often the case when narrative treatment of a subject is arbitrarily broken into segments, some matters or individuals of uncommon

status, bridge those breaks and must therefore, be treated outside the chosen framework. This is surely the case with women in the Geological Survey in general, and Helen Martin in particular.

Helen Martin (1889-1973), with the Survey for nearly 30 years between the years 1917 and 1958 (with an 11 year break), was one of our most productive colleagues--geologist, geologic researcher, compiler of geologic maps, historian, writer, editor, lecturer, conservationist, and teacher. She authored five books, was responsible for the compilation of six geologic maps, and published numerous papers and short articles.

Well informed on Michigan's natural resources, and greatly interested in conservation, Ms. Martin often included these subjects in her lectures and writings. One of the few women geologists of her time, she helped to pave the way for those women geologists who have followed. Her work has been an inspiration to many, and her lifelong devotion to geology and conservation has contributed greatly to the Survey and to the people of Michigan.

## MATURITY: 1950 TO PRESENT RESOURCE REGULATION AND MANAGEMENT

### The Third Geological Survey

During the 1950's the Survey would be under the direction of State Geologists Franklin G. Pardee (1951-52) and William L. Daoust (1952-64). This time period saw a gradual decline in oil and gas activity in the Michigan Basin. This decline was to turn around dramatically in 1957. During this year the Albion-Scipio Field was discovered. To date this field has produced over 125 million barrels of oil and qualifies as a major world oil field. The rapid expansion of this field, and further discoveries in the Trenton-Black River

Groups statewide, placed heavy demands on the services of the Survey. Information and regulatory requests reached an all-time high during 1959.

In 1964, Gerald E. Eddy returned as State Geologist after having served 12 years as Director of the Department of Conservation. In 1965 the Survey's annual budget exceeded \$600,000, which ranked it 17th among the State Surveys in the United States. Over half of this budget was committed to carrying out oil and gas conservation statutes. Regulatory activities engaged in by the Survey became a point of controversy, and a somewhat adversarial relationship developed with the oil and gas industry. Despite some difficulties, the Michigan Survey remained in the forefront of oil and gas regulatory and conservation endeavors, and it was looked to by many other State Surveys as an example of forceful, yet progressive regulatory practices.

During the 1960's, the Survey would complete a cooperative mapping project with the USGS. This project, begun in the 1940's, remapped the iron ore ranges and provided an extensive geomagnetic survey of the Upper Peninsula.

On November 15, 1968, Act 353 placed the Michigan Geological Survey under the direction of the newly created Department of Natural Resources. The next several years would see a number of laws enacted whose aim was conservation, responsible management, and protection of the state's natural resources. Acts covering mine reclamation, sand dune mining, mineral wells, and coal mining would all be in place within 10 years.

Arthur E. Slaughter, State Geologist (1971-81), supervised Survey activities through a time of its greatest expansion. The 1970's would see the rapid development of the Silurian Reef play in the Michigan Basin. Michigan's oil production would increase 300 percent, while its gas production would

leap 600 percent. Controversy over drilling in the Pigeon River State Forest and the potentially tragic gas blow-out in Williamsburg, Michigan brought a great deal of publicity and notice to the oil and gas industry in the state. Public demands for changes in procedure and regulatory methodology brought about changes in the Survey. In 1973, regional geologists were appointed to act as the State Geologist's voice in regional field offices. At this time environmental impact statements and field reviews on drill sites were initiated.

As exploration of the "Niagaran Trend" expanded, so did the requests for information and services of the Survey's Oil and Gas Section. The Survey also saw many of its skilled and knowledgeable employees leave public service for positions in the booming oil and gas industry.

In 1981, R. Thomas Segall was appointed State Geologist. That same year over 500 mineral producers were operating in Michigan at over 750 sites, with an annual production value of \$980 million. Also, over 125 oil and gas operators were active in the state, drilling over 966 wells. Of these wells, 427 were producers. In 1982, oil and gas production for Michigan was valued at \$1.5 billion. By 1987, 47 percent of Michigan's total mineral production would be from oil and gas (crude oil, 28 percent and natural gas, 19 percent). The beginning of 1988 saw Michigan's total number of issued permits to drill for oil and gas exceed 40,000. Of this total, 36,000 have been drilled, resulting in 14,105 oil wells and nearly 2,904 gas wells. Over 1,046 billion barrels of oil and 2.8 billion cubic feet of natural gas have been extracted from Michigan wells. It is calculated that 20,000 jobs are directly related to Michigan's oil and gas industry.

The late 1980's have seen a downward trend in the price of crude oil and natural gas. This price downturn has slowed petroleum exploration and



production in Michigan, as well as throughout the nation. While slightly less affected than other oil-producing states, growth of the hydrocarbon industry in Michigan has been stunted by the uncertainty of future price economics. Despite this, the productive capacity of the state has been expanded with the discovery of the deep gas pay zones of the Ordovician Prairie du Chien Group.

At present, work at the Survey is mostly concerned with oil and gas related matters, compliance action, and industry monitoring. In addition to these activities the Survey continues its work in mineral management, ground-water studies, mapping, publications and geological research. Most recently, the Sesquicentennial Bedrock Geology Map of Michigan was released, the first updating of this map in 50 years.

One of the biggest tasks of the 1980's has been the modernization of the Survey. In the early 1980's, the Survey began a new era of information management with the acquisition of computers and microfilm equipment. In 1981, the Survey began a statewide oil and gas database on a mainframe system, storing information on production, subsurface data, and permits. That same year, a comprehensive project of microfilming was started on well logs, drillers logs, permit files, production reports, and old publications. These new information systems allow more space for files, better security, and faster turnaround time on filling requests for information and copies.

In the mid-1980's, electronic data management was expanded to include a dedicated word processing system, acquisition of numerous microcomputers, and use of an integrated software program. An annual well status report and the *GeoPulse* publication are two of the many products generated from microcomputer, and recently, a statewide ground-water database has been implemented.

The Survey also began a geographic information system on computer, and digitized base maps of Michigan are produced in cooperation with Land and Water Management Division of the DNR. Geologic maps are presently being produced by computer, including the new bedrock geology map. Currently, there are plans to improve and expand the electronic information systems and microfilming of files.

## EPILOGUE

The Michigan Geological Survey has existed for more than 150 years. During that time, the majority of the state's geology and mineral resources have been explored and documented.

The Geological Survey has been directly involved with the discovery of iron ores, copper lodes, salt, gypsum, coal, potash, limestone, sand and gravel deposits, water supplies, brines, and petroleum. The Survey has added wealth to the State, both monetarily and scientifically. It has encouraged responsible exploration for, and extraction of, minerals and other geologic resources through regulation and management programs, and it has endeavored to conserve hydrocarbons, soils, natural areas, and supplies of potable groundwater. Information generated by the Survey is released in the form of publications, maps, and reports. This information is shared for its interest and scientific value, and is used by the citizens and industries of Michigan.

Those who have worked for the Survey have given Michigan a valuable legacy, and future generations will continue to benefit from their work. New methods of exploration, expanded demands for mineral resources, and the ever changing market for their uses, keeps the Michigan Geological Survey actively involved in prudent development and insightful management of Michigan's minerals and ground-water resources.

## MINNESOTA

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2642 University Avenue, St. Paul, MN 55114-1057. Phone 612-627-4780.

### HISTORICAL SEQUENCE OF ORGANIZATIONAL NAME AND NAMES AND TITLES OF ORGANIZATIONAL DIRECTORS AND DATES SERVED:

A. H. Hanchett, State Geologist, 1864-65  
 H. H. Eames, State Geologist, 1865-67  
**Geological and Natural Survey of Minnesota, 1872-1916**  
 N. H. Winchell, Director, 1872-1900  
**Minnesota Geological Survey, 1911-present**  
 W. H. Emmons, Director, 1911-44  
 F. F. Grout, Acting Director, 1944-47  
 G. M. Schwartz, Director, 1947-61  
 P. K. Sims, Director, 1961-73  
 M. S. Walton, Director, 1973-86  
 P. C. Grew, Director, 1986-present

### HISTORY OF THE MINNESOTA GEOLOGICAL SURVEYS AND STATE GEOLOGISTS

By G. B. Morey, Associate Director

#### INTRODUCTION

The history of organized geologic research in Minnesota spans about 160 years. The activities of various geographic and geologic surveys in Minnesota prior to 1872 were described by N. H. Winchell in 1872 and again in 1884. In 1872, the Geological and Natural History Survey of Minnesota was organized and it vigorously pursued its mission until 1900. Its history was summarized in a brief biography of N. H. Winchell, the first Director, by F. G. Davenport in 1951. The Geological and Natural History Survey continued as a department within the University of Minnesota until 1915 or 1916, but the Minnesota Geological Survey was organized in 1911 to take over its geological functions. The history of the Minnesota Geological Survey to 1960 was described by G. M. Schwartz in 1964 with emphasis on the many contri-

butions of the small cadre of professors and students in the Department of Geology at the University. The histories of Winchell, Davenport, and Schwartz should be consulted for additional details regarding earlier geological surveys in Minnesota. In summarizing these works, as well as the history of the geological survey during the last 25 years, I have taken a somewhat restricted approach in the interest of brevity and have focused on leadership rather than programs.

In the following discussion I have arbitrarily divided the various geological surveys in the state into four chronological periods. These are the reconnaissance period that ended around 1860, the pioneer period that ended with the completion of the work of the original Geological and Natural History Survey in 1900, the academic period that extended from the creation of the Minnesota Geological Survey in 1911 to approximately 1960, and a modern period that covers advances made by the Geological Survey over the past 25 years. Additionally, a few remarks about the future are included.

### THE RECONNAISSANCE PERIOD

In the late 17th and early 18th centuries the interior of the North American continent was a great wilderness waiting to be explored. The northern part of that wilderness was penetrated by French- and English-speaking explorers, fur-traders, missionaries, and adventurers, who used lakes and rivers as their means of access. Several of these travelers published accounts of their adventures upon their return to Europe. Of that literature, a surprising amount refers to that part of North America we now call "Minnesota." Minnesota was a major turning-back point for most travelers from the east or south. The Great Lakes waterway, an important transportation route for traders and missionaries from the east, terminated on Lake Superior at Grand Portage and near the present city of Duluth. Similarly the main canoe route from the south, up the Mississippi River, either ceased at the Falls of St. Anthony, in what is now Minneapolis, or if pushed farther was lost in the small streams and lakes of northern Minnesota. Although the Minnesota River extends westward for several hundred miles from its confluence with the Mississippi, it too was lost in a boundless prairie which for most travelers was too arduous or too fruitless to cross. Because it did not seem worth the effort to go on, many of the early travelers simply stayed for a time in what was to become "Minnesota." Thus, several published accounts include fairly useful descriptions of geological and biological phenomena of "Minnesota."

Among the many early accounts, perhaps the most useful was Father Hennepin's description of the discovery and naming of the Falls of St. Anthony on the Mississippi River in 1680. Hennepin's description of the falls at that time was so precise that in 1877 Newton Horace Winchell was able to

use it to determine the rate of upstream migration of the falls from the junction with the Minnesota River, and thus was able to calculate the time that had elapsed since the retreat of glacial ice.

After the American revolution, the United States War Department organized and funded numerous expeditions to explore and map the country west of the Mississippi River. The confluence of the Mississippi and Minnesota Rivers was a frequent starting point, and the explorations of Lieut. Z. M. Pike (1805), Major S. H. Long (1817), Lewis Cass (1820), H. R. Schoolcraft (1832), and Lieut. James Allen (1832) led to considerable knowledge regarding the geography of Minnesota. However, because their main thrust was to produce reports and maps primarily for military purposes, these expeditions were designed to cover as much ground as possible in the shortest amount of time. In spite of their rapid pace, several of the exploration parties to or through Minnesota during the period 1805-45 were accompanied by naturalists such as W. H. Keating, J. N. Nicolett, G. W. Featherstonhaugh, G. C. Beltrami, and George Catlin, to name a few, who described the natural historical phenomena incidentally encountered along the travel routes. The work of these naturalists was neither comprehensive in scope nor was it systematically organized, but their reports were avidly read and they most likely inspired many settlers to move to "Minnesota."

It is interesting to note that one of the first "geologic maps" of Minnesota was published in 1845 as part of a larger map entitled *Geologic map of the United States and adjacent parts of Canada*. The map was compiled by Sir Charles Lyell in 1841 and 1842 and was included as an appendix to his account of his epochal *Travels in North America*. Much of the information used by Lyell was derived from the earlier work of others, including a geologic report on

the Lake Superior basin published in 1829 by H. W. Bayfield, a Royal Navy hydrographic surveyor. Bayfield included with his observations those published earlier by H. R. Schoolcraft in 1820 and J. J. Bigsby in 1824.

The end of the reconnaissance period is marked by the publication of a report by David Dale Owen in 1852 on the geology of the area that ultimately became parts of Wisconsin, Iowa, and Minnesota. This report was notable in several respects. First, the survey was carried out under the auspices of the Treasury Department rather than the War Department. Thus Owen's work was premised on economic rather than military concerns. He was charged with obtaining information that could be used to identify public lands that had some mineral potential. The mineral lands were to be classified as such so that they could be withdrawn from public sale by the U.S. Government Land Office in Washington, D.C. The report is also notable in that Owen was given sufficient time to prepare a scientific evaluation of the territory, to collate and correct previous studies, and to integrate them with his own work. The work of the Owen survey firmly established that extensive tracts of exposed bedrock occur only in the northeastern and southeastern parts of the state, a problem that would continue to plague geologic investigations for the next 100 years. Despite the limited exposure, Owen personally established, on paleontological grounds, the correct ages of most of the bedded rocks exposed in southeastern Minnesota, and his colleague J. G. Norwood produced the first comprehensive description of the Precambrian rocks in northeastern Minnesota. Without doubt their combined efforts provided the principal foundation upon which later geologic studies of the state were to be built.

The style and design of the Owen report, a quarto volume consisting of

638 pages and 92 plates and maps, received considerable favorable comment after it was published. It became the prototype for a series of scientific publications produced under the War Department and the Department of Interior during the latter part of the 19th century. For example, the reports of so-called Great Surveys of the American West as published over the years by F. V. Hayden, J. W. Powell, Clarence King, and G. M. Wheeler, as well as the early reports of the U.S. Geological Survey, owe much of their format to the precedents set by the Owen survey report.

### THE PIONEER PERIOD

Minnesota was admitted as the 32nd state to the Union May 11, 1858. The first effort by the state to institute a geological survey of its own was made later that year. No organization was established, but the first Legislature did order the reprinting and binding of the Minnesota parts of a geologic report on the Territory of Wisconsin prepared during the years 1854 and 1858 when it included the eastern part of Minnesota.

A second attempt to establish a regular geological survey occurred 2 years later in 1860 when the Legislature adopted a resolution that authorized two commissioners, Charles L. Anderson and Thomas Clark, to produce a plan for a geological survey and to report on the geology of the state. Although a plan for a geological survey was prepared, it was rejected by Governor Alexander Ramsey because he believed that the financial burdens such a survey would impose were too great for a young state. In 1864 the Legislature authorized Governor Stephen Miller to appoint and direct a state geologist. Aug. H. Hanchett was appointed to that position, and he in turn appointed Thomas Clark, who had been one of the "commissioners" of the resolution of 1860, as his assistant. Both submitted reports for 1864. Clark's



report contained some valuable information concerning the northern part of the state, but the Legislature quickly realized that Hanchett was neither intellectually suited nor wholly devoted to his work, and he was dismissed.

After passage of a more general geologic act by the Legislature in 1865, Governor Stephen Miller appointed Henry H. Eames as the second State Geologist. Eames made two brief annual reports for the years 1865 and 1866. The first was devoted to a tour made by him through the region north of Lake Superior, where Eames had been convinced *a priori* of the occurrence of vast mineral resources. His claim to have found a major gold deposit near Lake Vermilion was followed during the next 2 years by the formation of numerous mining companies and expenditure of thousands of dollars in the search for Eames' gold. The Governor, several ex-Governors, other officers of state government, and the brother of the State Geologist were the chief owners and operators of one of these mining companies. No gold was found, and the rush soon collapsed. The Legislature became disenchanted with Eames, refused to appropriate money for additional work, and terminated his services. At the same time, the Legislature also terminated the position of "State Geologist," and to this day it is not an official position within state government. Although the Vermilion gold rush was a failure, it did lead indirectly to the discovery of the vast iron ore deposits of northern Minnesota and the ultimate opening of the Vermilion iron range some 20 years later.

Even though the Eames fiasco angered the Legislature, that body did continue to fund other geologic projects. In 1865, N. C. D. Taylor was authorized to search for copper in the St. Croix Valley. He in turn collaborated with Professor James Hall, a well-known

geologist and paleontologist from New York State, to produce an optimistic report that led to a brief flurry of exploration activity and a number of small "mines" or "glory holes." In the same year Hall also visited southwestern Minnesota where he established the presence of Cretaceous strata and the relative ages of many of the other rocks exposed there. In 1866 the Legislature paid for publication of a report by Charles Whittlesey on his geographic and geologic observations made in Minnesota under private and federal auspices during the 1850's. In 1870, Professor Alexander Winchell of the University of Michigan was engaged to examine and report on salt springs lands in the state in order to determine whether it was worthwhile for the Legislature to appropriate money to aid in their economic development.

The work of Taylor, Whittlesey, Hall, and A. Winchell clearly showed that scientifically sound geologic information about the state's natural resources could contribute to its economic well-being. Thus, in late 1871 or in early 1872, Governor Horace Austin and the Legislature jointly asked the President of the University of Minnesota, W. W. Folwell, to prepare a law formally establishing a Geological and Natural History Survey, an organization which would be placed within the institutional structure of the University. Although the primary purpose of the Survey was to undertake a geologic study, the law also provided for botanical, zoological, and meteorological studies, and a natural history museum. There is no doubt that the Survey was placed within the University so that its work could be conducted in a thoroughly scientific manner. The proponents of this institutional arrangement also believed that the University would shield the Survey from strong political and economic pressures that could compromise the integrity of its work.

From Folwell's view, the presence of the Survey within the University would greatly strengthen the academic aspects of the institution by making it the center of all natural history collections and studies in the state.

The enabling act creating the Geological and Natural History Survey of Minnesota was introduced by Senator George Pillsbury, passed by the Legislature, and approved by Governor Austin on March 1, 1872. There was an appropriation of \$1,000 per year to carry out the provisions of the act. In July of that year, Newton Horace Winchell (formerly of the University of Michigan, the Eastern Region of the New York Geological Survey, and the Ohio Geological Survey) was asked to direct the Survey, a post which he occupied until 1900 when he retired to devote the remainder of his life to the study of ethnology and archeology in the state. On March 1, 1873, the Legislature recognized that the Survey could not operate on its existing appropriation. Therefore it authorized an annual appropriation of \$2,000 to be supplemented by income from the "salt springs lands" first investigated by A. Winchell. The Salt Lands Act directed that the lands were to be held in trust by the University's Board of Regents with the proceeds to be used to support the activities of the Geological and Natural History Survey. This fund contributed more than \$132,000 to the operation of the Survey from 1872 to 1900. Monies from that fund are still used today for partial support of the Minnesota Geological Survey, as well as several life science departments in the University.

At the time he was appointed Director of the Geological and Natural History Survey, Winchell also was appointed Director (Curator) of the University's General Museum of Natural History. During his first year at the University, Winchell also served as an instructor in geology, mineralogy,



N. H. Winchell, First Director, Geological and Natural History Survey of Minnesota, 1872-1900.

zoology, and botany. After a Department of Geology and Mineralogy was formally established in 1874, Winchell was appointed Professor and Chairman. In 1878, at his request, he was relieved of his instructional duties to devote the bulk of his energies to the Geological Survey. However he continued as Chairman of the Department until 1897 and as Director (Curator) of the Museum until 1899. Although Winchell served the University in several concurrent administrative positions, the Department, the Geological Survey and the Museum were separate entities with their own functions and needs. Clearly, Winchell was a man of great energy, as well as ability.

The first report of the Geological and Natural History Survey was published in December 1872. It was written entirely by Winchell and included the results of a reconnaissance

survey along railroad rights-of-way from September 1 to November 12, a geologic map of the state, a historical sketch of past geologic work in the state, and comments on various aspects of the natural history.

Over the 28 years of its active life, the Geological and Natural History Survey published nearly 12,850 pages of material in 24 Annual Reports, 6 volumes of the Final Report, 10 Bulletins, and 11 miscellaneous publications. The sheer volume of completed work attests to dedicated Survey employees who rendered services well beyond the call of duty. At its peak of activity in 1891, no other state organization had a staff equal to that in Minnesota. The list is truly formidable, including U.S. Grant, A. C. Lawson, Charles Schuchert, E. O. Ulrich, and H. V. Winchell, as well as N. H. Winchell himself. During the course of the Survey's work, the Vermilion and Mesabi iron ranges were discovered and mapped within the limits of the existing technology as were a number of other mineral commodities. Through that effort, Winchell and his colleague U. S. Grant laid the groundwork for one of the great successes of classic geology--unraveling the stratigraphic succession in the enigmatic Precambrian basement of the Canadian Shield in the Lake Superior region.

The work of the Geological and Natural History Survey was designed to aid the state in exploiting all its natural resources--soils, minerals, rocks, and water. Thus, its hallmark was "economic researches carried out in a scientific manner." Moreover the Survey did its work in a very economical manner. The cost of the Survey from 1872 to 1899 was \$146,357. Deducting the \$132,609 derived from the salt lands fund, the Geological and Natural History Survey cost the state just \$13,748 in general funds. The magnitude of the effort can be judged when one realizes that Minnesota

occupies an area of 84,068 square miles. Thus, the Geological and Natural History Survey described the geology of Minnesota for a little more than \$1.75 per square mile.

### THE ACADEMIC PERIOD

After Winchell resigned as Director in 1900, and with the publication of the last volume of the Final Report in 1901, the Board of Regents of the University decided to discontinue geologic investigations. However, botanical and zoological studies were continued by the Survey under the direction of a State Botanist and a State Zoologist until approximately 1916 when their duties were taken over by the University's Museum of Natural History. Annual expenditures for these biological studies ranged from \$2,000 to more than \$21,000 per year and totaled somewhat more than \$180,000, some \$34,000 more than had been spent in the previous 28 years. However it seems that the Geological and Natural History Survey did support some geologic work after 1900, because a paper published in 1910 contains the footnote "published by permission of the Geological and Natural History Survey."

Very little geologic information was produced by the state during the first 10 years of the 20th century. However, the U.S. Geological Survey started several major projects that led to the publication of two monographs describing the Vermilion and Mesabi iron ranges in considerable detail. These monographs, which built on the earlier work of Winchell and Grant and totaled some 780 pages, served as the factual basis for the now classic description of the Precambrian geology of the Lake Superior region, by C. R. Van Hise and C. K. Leith, published by the U.S. Geological Survey as Monograph 50.

What geologic studies the state did sponsor were directed by Professor C. W. Hall, who was Chairman of the Department of Geology and Mineralogy

from 1897 until he was forced to retire because of illness in 1910. President Vincent of the University then asked William Harvey Emmons of the U.S. Geological Survey and the University of Chicago to assume the Departmental Chairmanship. As a condition of his acceptance, Emmons insisted that a state geological survey be put on a firm and continuing basis. He wanted a state geological survey, not only because of the prestige it would provide but because such an organization would provide a means of obtaining federal money for geologic research that otherwise would not be available. Consequently, in early 1911, the Board of Regents recommended that the Legislature appropriate funds to establish the Minnesota Geological Survey, an organization to be closely connected with the Department of Geology over the next 50 years. The legal basis for that recommendation came from the Revised Laws of Minnesota, 1905, which instructed the Board of Regents to continue all work legislated as of that time. The University requested, and the 1911 Legislature allotted, \$6,500 for the work of the Minnesota Geological Survey. Because the geologic studies of the Geological and Natural History Survey had not been formally terminated by law, both the Geological and Natural History Survey and the Minnesota Geological Survey existed as departments in the University from 1911 until 1916.

Emmons assumed duties as Chairman of the Department of Geology and Mineralogy and Director of the Minnesota Geological Survey in late 1911 and continued in both positions until his retirement in 1944. His appointment as Director led to the start of what can be called the academic era of the Minnesota Geological Survey. Under Emmons' administration, the Survey was given a permanent home in Pillsbury Hall on the campus and a staff



W. H. Emmons, First Director, Minnesota Geological Survey, 1911-44.

drawn from the faculty of the Department of Geology and Mineralogy. At no time were there any full-time employees on the Survey staff except possibly for a short time prior to World War I, when the U.S. and Minnesota Geological Surveys conducted several cooperative projects in the areas of economic, Pleistocene, and ground-water geology. Even with the cooperative projects, the Survey never had much money. Appropriations from the Legislature varied from year to year, totaling only \$249,380 from 1911 to 1944. Most of the state funds were used to support research by the faculty and their students. Because the objectives of the Survey were necessarily economic, much of the research it funded in the Department during that period was in the areas of igneous petrology, mineralogy, and economic geology. Accordingly, it is no wonder that these fields formed the backbone of the



departmental curriculum until well after World War II.

Although he was Director of the Survey, Emmons did very little hands-on work on the geologic problems of Minnesota; in fact, the record shows that he was author or coauthor of only five publications about the state. He contributed to the Survey mainly through his administrative ability and his enthusiasm and interest in Survey projects. Nonetheless, during Emmons' 33 years of leadership, the combined staff of the Department of Geology and Mineralogy and the Minnesota Geological Survey became internationally recognized. In addition to Emmons, the faculty included F. F. Grout, J. W. Gruner, G. M. Schwartz, C. R. Stauffer, and G. A. Thiel. These men supervised most of the Survey's major projects until they retired in the late 1940's to the 1950's. They and their graduate students published 21 Minnesota Geological Survey Bulletins totaling over 3,600 pages, as well as hundreds of additional articles and reports totaling thousands of pages in national and international journals on various aspects of Minnesota geology.

During much of his tenure, Emmons left most of the day-to-day operations of the Survey to Professor Frank F. Grout, who received his doctorate from Yale University in 1917. Because Grout probably knew more about the geology of Minnesota than anyone else at that time, he became Emmons' principal source of advice and counsel. The two formed an excellent team for many years. After Emmons retired in 1944, Grout was appointed Acting Director of the Survey, an interim appointment because he was only 4 years away from retirement himself. When he retired in 1948, Grout had been at the University and the Survey almost continuously for 48 years. His contributions to all aspects of the geology of Minnesota are awesome. His bibliography includes at least 50

major publications, no small feat when one remembers that Grout taught full-time and wrote several internationally recognized textbooks. However, Grout was best known in Minnesota as a quiet but extremely effective teacher who trained hundreds of students in the art of field mapping in the Precambrian.

George M. Schwartz was appointed Director of the Survey in 1947 and served in that position, as well as Professor in the Department of Geology and Mineralogy, until his retirement in 1961. Like several others in the Department at that time, Schwartz had received his Ph.D. degree from the University of Minnesota under Emmons and Grout and worked on Minnesota geology for much of his professional career. Thus it is not surprising that the Survey operated under Schwartz's leadership very much as it had done under previous administrations. Also as before, the budget was painfully small, totaling for 15 years a little less than \$265,000.

Despite a lack of financial support, Schwartz had a major impact on the direction of geologic research in the state. Even before the start of his tenure as Director, he was an internationally recognized economic geologist. He almost alone met some of the more pressing needs of the state through pioneering works in engineering and urban geology, especially in the Minneapolis-St. Paul and Duluth metropolitan areas. In that regard he was some 30 years ahead of his time.

It was apparent soon after Schwartz became Director that the iron ore deposits of the state had been all but depleted during World War II. Schwartz realized that if Minnesota was to continue as an iron ore producer, new resources would have to be found and they would have to be found in parts of the state where the glacial cover prohibited the use of conventional mapping techniques. Because the bedrock of about 90 percent of the state



G. M. Schwartz, Second Director, Minnesota Geological Survey, 1944-61.

needed to be explored, Schwartz recognized that the part-time efforts of faculty and their graduate students could not produce enough information. Therefore in 1947 he initiated a cooperative agreement with the U.S. Geological Survey to produce an aeromagnetic survey of the state. That work continued until the late 1960's. Although the aeromagnetic program did not delineate any new iron-ore resources, it did reveal much about the geologic framework of the bedrock underlying the thick mantle of Quaternary glacial materials. Because of the need for good base-map material for the aeromagnetic maps, Schwartz was also instrumental in initiating a modern topographic mapping program in the state.

Interwoven with the operation of the Survey during that period was the development by Professor A. O. Nier of the Department of Physics of one of the world's major tools for geologic

research, the mass spectrometer. Nier and Professor S. S. Goldich of the Department of Geology and Mineralogy then used the device to resolve some complex chronometric problems in the state and adjacent areas. The entire scheme of rock formations that Winchell and Grant had started to put in stratigraphic and paragenetic order 50 years earlier was carefully reevaluated. Many long-held premises proved to be erroneous, and Goldich and Nier found it necessary to redefine and quantify the Precambrian time scale. Their research, published in 1961 as Minnesota Geological Survey Bulletin 41, has had a profound effect on geology in that it proved what every geologist already suspected was true--geologic time was long, and within that expanded interval there was sufficient time for a vast multiplicity of events. Although it was modified from time to time, the Goldich-Nier classification scheme was commonly used in the Lake Superior region and adjoining parts of Canada until it was replaced in the late 1970's by schemes proposed by an international scientific committee.

### THE MODERN PERIOD

The Department of Geology and the Minnesota Geological Survey were one and the same for the 50 years between 1911 and 1961. A remarkable amount of geology was completed, but as one can imagine, not in a very organized or programmatic mode. Thus even though the part-time arrangement shared by the Department and the Survey produced many internationally acclaimed researchers, it did not produce the kinds of information needed by the state to meet the demands of major resource and policy issues. As an example, the state in 1960 was still using a very slightly modified version of the bedrock geologic map first published in 1932, a fact that greatly inhibited mineral exploration for commodities other than iron ore. Other areas of geology had become

equally stagnant. Several advisory committees from both within and outside the University raised this issue and questioned the ability of the Survey to continue to serve the needs of the state with only a part-time staff. Therefore, upon Schwartz's retirement in 1961, Paul K. Sims, a graduate of Princeton University and a geologist with the U.S. Geological Survey, was appointed full-time Director. The Survey again became a separate department administratively, although it did retain a close working relationship with the Department of Geology and Geophysics, as one of the units within the School of Earth Sciences.



P. K. Sims, Third Director, Minnesota Geological Survey, 1961-73.

Under Sims's leadership the Survey's budget increased from \$64,360 in 1961-62 to more than \$250,000 in 1972-73. The additional funds made it possible to build for the first time since the days of Winchell a permanent, full-

time staff devoted entirely to working on geologic problems in the state. As new staff were added, Sims initiated programs in the areas of Pleistocene and Paleozoic stratigraphy and industrial minerals, especially aggregate resources and kaolin clay deposits. A new 1:250,000-scale bedrock map series that was to cover the entire state was started in 1965. Although mapping started in the Paleozoic strata of southeastern Minnesota, it soon focused on the Precambrian rocks and mineral resources of northern Minnesota. That part of the mapping program was augmented by a gravity mapping program, also at a scale of 1:250,000, which was started in 1965.

The bedrock mapping programs benefited greatly from the availability of modern topographic maps, aeromagnetic data, and a sound geochronometric framework. The Survey also benefited from the availability of a large number of part-time professionals, not just from the Department of Geology and Geophysics, but also from many other academic institutions, most notably the University of Minnesota at Duluth. During several summer field seasons, as many as 30 people, equivalent to 10 full-time positions, worked part-time on various geologic projects. Consequently, 1960 to 1972 was a period of geologic productivity not seen in the state since the peak days of the Winchell survey in the early 1890's. This work led to the publication of a volume entitled *Geology of Minnesota: A Centennial Volume* to mark the 100th anniversary of the Geological Survey in 1972. In addition to 60 separate reports organized in 9 chapters, the volume of 632 pages also includes a new geologic map of the state at a 1:1,000,000 scale, the first published since 1932. This map is unique in that it was one of the first attempts in the United States to use aeromagnetic and gravity data systematically to interpret the bedrock

geology in the drift-covered parts of the state.

Sims strongly believed that increasing demands on our national resources and the need for new geologic materials required accelerated research and mapping in support of mineral exploration, especially in the northern part of the state. Unfortunately, the political leadership from that part of Minnesota concluded that several departments in the University, including the Geological Survey, had tied themselves too closely to "mining interests." Thus, in 1973, the Legislature eliminated several mineral-resource-related programs at the University. The program of the Survey was drastically curtailed, and Sims returned to the U.S. Geological Survey where he continues to do major research on the geology of the Lake Superior region.



M. S. Walton, Fourth Director, Minnesota Geological Survey, 1973-86.

Sims was succeeded by Matt S. Walton, a consulting engineering geologist and former Professor of Geology at Yale University with experience in the Alaskan Branch of the U.S. Geological Survey and in mapping the Precambrian geology of the Adirondack Mountains for the New York Geological Survey. Under Walton's leadership the Survey's budget increased from \$150,000 in 1974 to nearly \$2,000,000 in 1985, including grants and contracts. The increase in funds reflects a major change in the way the Survey is perceived in Minnesota. It is increasingly recognized as an organization that can and does provide a wide range of geologic information in a scientific and unbiased manner and in a form that citizens can use in making a variety of decisions.

The increased funds made it again possible to expand the permanent professional staff to a current level of 20 geologists. As that growth occurred, the Survey developed its own sources of expertise and consequently relied less extensively on the Department of Geology and Geophysics for support. The close relationship that had existed previously also was strained when the Survey was moved to an off-campus location in 1971 in order to give other programs of the School of Earth Sciences more space.

Several major themes have dominated the Survey's scientific programs since Walton assumed leadership in 1973. First, Walton emphasized that only about 10 percent of the state could be adequately mapped by conventional geologic mapping techniques, and further progress in understanding the geology of Minnesota would depend on techniques of subsurface geology. Therefore Walton initiated a program to collect logs, and where possible, cuttings and samples from water-well drillings, engineering test borings, and mineral exploration holes throughout the state. That program has produced a



subsurface data base running to more than 250,000 logs of various kinds.

Walton also recognized that a subsurface geologic mapping program using water-well data could produce only limited results at best, mainly because wells are only coincidentally sited at scientifically critical locations. Thus an entirely new effort would be required if the state is to achieve a systematic understanding of the buried geology. Consequently, a major program of low-level, high-resolution aeromagnetic mapping that was designed to cover the entire state in 10 years was started in 1979. The program has been supported throughout its history by the Legislative Commission on Minnesota Resources and has achieved national and international recognition. In the program, aeromagnetic data are supplemented by scientific drilling of a limited number of test holes each year. The locations of these holes are dictated almost entirely by the high-resolution aeromagnetic data. They are designed to make possible the systematic translation of the geophysical map into a geological map and hence the interpretation of the buried bedrock geology in greater detail across all of Minnesota.

### THE FUTURE

When Walton retired in 1986, he was replaced by Priscilla C. Grew as Director of the Minnesota Geological Survey and Professor in the Department of Geology and Geophysics. Grew, who received her Ph.D. from the University of California at Berkeley, is a former Director of the California Department of Conservation and a Commissioner of the California Public Utilities Commission. The mission of the Survey under Grew is the same as that under previous directors--"to undertake and promote the scientific study of Minnesota geology and to make the results available to the public." The high-resolution aeromagnetic survey

and scientific drilling will continue. We are experimenting with ways of manipulating the aeromagnetic data, together with other types of geophysical data to produce better interpretations of the bedrock geology. The program in engineering and environmental geology and hydrogeology also will continue. The county-atlas program begun under Walton on a cost-sharing basis is being accelerated to meet the needs for geologic information at the county and local level. As we look forward to the future, we cannot foresee all of Minnesota's needs in 1990, let alone in 1999, but we can conclude with certainty that even though they may be considerably different from those of the 1980's, they will continue to require increasingly detailed and insightful knowledge of the geology of Minnesota.



P. C. Grew, Fifth Director, Minnesota Geological Survey, 1986-present.

## MISSISSIPPI

Bureau of Geology, Mississippi Department of Natural Resources, P.O. Box 5348,  
Jackson, MS 39216. Phone 601-354-6228.

### HISTORICAL SEQUENCE OF ORGANIZATIONAL NAME:

Geological and Agricultural Survey of Mississippi, 1850-72  
Geological and Industrial Survey of Mississippi, 1903-05  
Mississippi Geological, Economic, and Topographical Survey, 1906-79  
Bureau of Geology, 1979-present

### NAMES AND TITLES OF ORGANIZATIONAL DIRECTORS AND DATES SERVED:

#### State Geologists

John N. Millington, 1850-53	Albert F. Crider, 1906-09
John C. Keeney, 1853-54	Ephraim N. Lowe, 1909-33
Lewis Harper, 1854-57	William C. Morse, 1934-58
Eugene W. Hilgard, 1858-66	Tracy W. Lusk, 1958-62
George Little, 1866-70	Frederic F. Mellen, 1962-65
Eugene W. Hilgard, 1870-72	William H. Moore, 1965-80
William N. Logan, 1903-05	

#### Directors

Alvin R. Bicker, Jr., 1980-86	Conrad A. Gazzier, 1987-present
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### HISTORY OF THE MISSISSIPPI GEOLOGICAL SURVEY

By Michael B. E. Bograd

#### INTRODUCTION

The history of the Mississippi Geological Survey may be divided into three periods that do not necessarily correspond with the dates of formal restructuring of the agency. These periods are as follows: the Early Years, 1850-72, characterized by early reconnaissance studies of Mississippi geology by B. L. C. Wailes, L. Harper, and E. W. Hilgard; the Conventional Years, 1903-70, characterized by "typical" survey work in geologic mapping and mineral resources under E. N. Lowe, W. C. Morse, and others; and the Service Years, 1970-present, characterized by continuation of "typical" work, but with an increased emphasis on activities involving service to the public and other

government agencies. The Conventional Years began with the Geological and Industrial Survey of Mississippi (1903-05), mentioned here for the first time in a history of this agency. The date 1970 given for the beginning of the Service Years is arbitrary; a gradual evolution in that direction began in the previous period.

Previous histories of the agency that provided the basic information for this report include Hilgard (1900), Hayes (1911), Merrill (1920), Lowe (1921, 1963), and Gilliland (1984).

#### THE EARLY YEARS: 1850-72

It was almost inevitable that a geological survey would be created in Mississippi in 1850. Many people were actively promoting the importance and necessity of a geological survey. The Journal of the Mississippi House of Representatives for the 1850 session contains a letter from "Doct." James B.

C. Thornton to Governor J. W. Matthews, dated January 4, 1850, that enthusiastically described the benefits to be derived from establishment of a survey. Thornton alluded to efforts of Governor Matthews along these lines. This may refer to the Governor's signature on a resolution, passed by a committee of the American Association for the Advancement of Science at the 1849 meeting, memorializing state legislatures to establish geological surveys. Among the 15 signatories to the resolution were H. D. Rogers, L. Agassiz, B. Silliman, G. Troost, W. B. Rogers, and Joseph Henry. Another person who played a role was Rob Morris, teacher, lecturer, devoted Mason, and founder of the Order of the Eastern Star. An address by Morris before the Mississippi Legislature was instrumental in the establishment of the state geological survey.

On March 5, 1850, the Mississippi State Legislature passed "An Act to further endow the University of Mississippi," which appropriated money for salaries and supplies for professors and assistant professors of agricultural and geological sciences. The principal such professor was to expend half of the funds in making a geological and agricultural survey of the state. The man chosen as Mississippi's first State Geologist was John Millington, physician, patent attorney, water works engineer, member of the Royal Astronomical Society, and Fellow of the Linnean Society of London. After a distinguished career in England, Dr. Millington had moved on to Mexico, to the faculty of the College of William and Mary in Virginia, and, at age 69, to the Professorship of Chemistry and Natural Philosophy at the University of Mississippi at its creation in 1848. In 1850, he was directed to teach geology and agricultural chemistry and take charge of the Geological and Agricultural Survey. Dr. Millington's first, and only, report, dated January 1, 1852,

explained that his teaching duties did not allow him to take to the field. The only efforts in the Geological Survey were limited reconnaissance excursions in the fall of 1851 by Millington's assistant, Oscar M. Lieber.

Oscar M. Lieber was appointed Assistant Professor of Geology on July 15, 1851, but did not arrive at the University and commence work until September. Dr. Millington had Lieber copy the 1839 map of John La Tourrette, published at Mobile, and then make excursions in northeastern Mississippi and down the alluvial plain of northwestern Mississippi toward Vicksburg. No report of Lieber's findings was published by the Survey, but he later published the first geologic map of Mississippi in an 1854 article in *Mining Magazine*. This map showed Millstone Grit and Carboniferous limestone in the northeastern corner of the state, which Lieber pointed out indicated the likelihood of coal being present. He emphasized this point "partly because it is almost the only point of interest in the State for a mining periodical," and partly because he felt his reports to Millington had been so "mutilated" that he would be denied credit for first calling attention to the probable existence of the coal measures in Mississippi. Lieber's map also delineated the Cretaceous greensand and limestone of northeastern Mississippi, Tertiary sands and clays over much of the state, and the alluvium of the Mississippi River. The map anticipated the basic pattern of our modern maps, but erred in mapping as Tertiary the outcrop of the Cretaceous Eutaw and Tuscaloosa Formations north and east of the Tombigbee River.

Lieber resigned in January 1852, days after the date of Millington's report. He was replaced as assistant the same month by Benjamin L. C. Wailes of Washington, near Natchez. Wailes was a planter, politician, naturalist, teacher at Jefferson College, and first

President of the Mississippi Historical Society. Wailes brought to the Survey his familiarity with southwestern Mississippi, and in 1852 and 1853, he traveled extensively in the eastern and southern parts of the state. His work resulted in the publication in 1854 of *Report on the Agriculture and Geology of Mississippi*, the first report by the Survey on the geology of the state. Though well received, only 90 of the report's 371 pages dealt with geology (with no geologic map); the remainder of the report included a historical outline of the state and discussions of agriculture, meteorology, flora, and fauna.



B. L. C. Wailes, "Geologist of Mississippi" but never State Geologist, published the Survey's first report on the geology of Mississippi in 1854.

In the meantime, Millington had resigned, being replaced by John C. Keeney as Professor of Chemistry, Agriculture, and Geology at the University. During Keeney's term of office (1853 to February 1854), Wailes served as the active geologist of the Survey.

Wailes expected to succeed Keeney in his position at the University and as State Geologist, and resigned when the appointment went to Lewis Harper (the anglicized name of Ludwig Hafner). Harper, originally a law student in Germany, was a teacher of natural science at an academy near Greenville, Alabama. The work of the Survey languished at first under Harper, as he devoted his attention to his teaching duties at the University. It was not until a competent assistant was hired, in the person of E. W. Hilgard, that useful reconnaissance field work was done. Furthermore, Harper had difficulties with the University administration. This, coupled with his political connections with the governor and an act of the Legislature, resulted in the Survey being made a separate agency and relocated to Jackson. Harper was given office space at the state penitentiary, at the site of the present State Capitol building, and a convict for assistant.

The University administration wanted to insure that the Survey fulfilled the requirements of law in pursuing its work. Dr. F. A. P. Barnard, Professor of Physics at the University, was requested to locate a competent assistant geologist while attending the August 1855 meeting of the American Association for the Advancement of Science. Dr. Barnard did his job well by offering the position to the young Dr. Eugene Woldemar Hilgard, then serving as chemist at the Smithsonian Institution.

E. W. Hilgard was born in Germany but raised and educated in Illinois. He returned to Germany for his higher education, obtained a doctorate, and came back to the United States for a long and distinguished career.

Dr. Hilgard accepted the position of Assistant Geologist at the Mississippi Geological Survey in August 1855. On his way south to take up his duties, he stopped at New Harmony for an





E. W. Hilgard, twice State Geologist of Mississippi, helped develop modern soil science and the field of agricultural geology.

"important and fruitful" visit with David Dale Owen and others. In mid-September he reached Oxford, where Harper had just returned from a rapid reconnaissance of eastern Mississippi. Harper and Hilgard set out soon after, in early October, on a tour of the state. They traveled to northeastern Mississippi to examine the Cretaceous deposits, then southward across the Tertiary units, westward to the Mississippi River at Fort Adams, and then by steamboat to Memphis. After spending the winter at Oxford arranging the Survey collections, Hilgard set out in April 1856 for more detailed study of the Paleozoic, Cretaceous, and Tertiary deposits of northeastern Mississippi. He also examined the troublesome clastic deposits of northern Mississippi, his "Orange Sand," later called for many years the "Lafayette Formation." Hilgard was able to visit Michael Tuomey, State Geologist of Alabama, for valuable discussions of stratigraphy

and paleontology. By this time, Hilgard had determined that deposits of such commodities as precious metals were not to be found in Mississippi, and so directed his geological investigations toward rendering service to agriculture. This included recording surface features, soils, vegetation, water supplies, and marls.

As the Assistant Geologist, Hilgard turned over his notes and information to Harper. Harper incorporated them into his own ideas and scheme of work to produce his 1857 report *Preliminary Report on the Geology and Agriculture of the State of Mississippi*. Among other unfortunate errors, Harper's report and accompanying geologic map reversed the Miocene of southern Mississippi with the Eocene of the north-central part of the state. Hilgard was very dissatisfied with what was done with his work, calling the report "a literary, linguistic and scientific curiosity" (Hilgard, 1900).

The years 1856 and 1857 were trying times for the Survey, as Harper's actions and his 1857 report brought expressions of displeasure from the University, the Legislature, and the public. The crisis brought a proposal to abolish the Survey, the resignation of Lewis Harper in late 1857, and a brief suspension of the Survey. Hilgard returned to the Smithsonian during the suspension, but was brought back to Mississippi in early 1858 as State Geologist. Hilgard's appointment reversed the trend of these early years of the Survey's assistant geologists being more important than the state geologists.

Hilgard's first act as State Geologist was to move the Survey from Jackson back to the University at Oxford, though state law demanded that an office be kept in Jackson. He also convinced the Legislature to continue the Survey, conducted additional work in the field, and prepared his very valuable *Report on the Geology and*

*Agriculture of the State of Mississippi.* This report was printed in 1860, which date it bears, but it spent the duration of the Civil War in a warehouse in St. Louis, where it had been sent for binding. Hilgard's report has two parts, a geological report and an agricultural report, with the geology portion comprising just over half the book. The geologic map, at scale 1 inch equal to 25 miles, corrected many of Harper's errors and added a considerable amount of detail. Hilgard's report served as the primary source of information about the geology of Mississippi for 50 or 60 years. An act of the Legislature in 1860 re-established the Survey along the same lines as before, allowed the move to Oxford, and increased the appropriation to cover expenses, equipment, and the printing of Hilgard's report.

Hilgard had so impressed the state's leadership that in the traumatic year of 1861 the Legislature took time to provide a salary for the State Geologist for the duration of the war for the purpose of his conducting analyses and preserving state property. The actual work of the Survey was suspended, and no Assistant Geologist was provided. Hilgard fulfilled his charge of protecting state property in 1862 when an invading Union army prepared to burn the University buildings. He convinced the commanding general to save the buildings for use as hospital facilities. Hilgard probably neglected to mention his work as an agent of the Confederate Nitre Bureau.

The work of the Survey resumed after the war. Dr. George Little, Professor of Natural Sciences at Oakland College near Rodney, Mississippi, was appointed in July 1866 as Assistant Geologist. In October, Hilgard resigned as State Geologist and became Professor of Chemistry at the University. Upon Hilgard's recommendation, Dr. Little was named State Geologist; he held the position until October 1870. Dr. Little did some field

work, but teaching duties and lack of funds for the Survey prevented publication of any results. Once again, the Survey acquired a very competent Assistant Geologist in November 1868 in Dr. Eugene A. Smith of Alabama. Smith made at least two lengthy field excursions in his 3 years as assistant, but nothing of his work was published by the Survey until 1963 when his reconnaissance of the Bluff Region and alluvial plain of the Mississippi River was included in Bulletin 100.

When Little resigned in 1870, Hilgard again took the post of State Geologist to help insure that the Survey was not abolished. Hilgard stipulated that he not be required to go to the field. Fortunately, he had the able assistance of E. A. Smith until Smith's departure in September 1871 for Alabama and a long career with the Alabama Survey. Smith was replaced as assistant by R. H. Loughridge. Loughridge later worked for the Georgia Survey and then went to California to work for Dr. Hilgard.

In the fall of 1872, the State Auditor of Public Accounts arbitrarily withheld the Survey appropriation, resulting in a suspension of activity until after the turn of the century. The enabling legislation for the Survey was not repealed. Little work was done except for occasional outside publications by the U.S. Geological Survey and other workers.

#### THE CONVENTIONAL YEARS: 1903-70

Throughout its history, the Mississippi Geological Survey has studied and mapped the geology and mineral resources of the state, with more than a little dabbling into other aspects of natural history. Progress was and is made as staff and funding allow, and as influenced by outside authority and public demands. In that respect, the "conventional years" are not unique. However, this period is distinct from the early, reconnaissance work done

previously. It is distinct also from the succeeding period in the Survey's research-oriented work in mapping geology and mineral resources. The state geologic map was brought into modern form, many county reports were published, and the educational and, in particular, the economic aspects of the work were emphasized.

A little-known chapter in the history of this agency is the short-lived Geological and Industrial Survey of Mississippi, organized in 1903 at the Mississippi Agricultural and Mechanical College (now Mississippi State University). Several faculty members, with J. C. Hardy (President of the college) called *ex officio* Director, were listed as "Members of the Survey." Actually, the Survey consisted of Dr. William N. Logan of the recently created Department of Geology. In the absence of a special appropriation for the work, the Survey began work toward its goal of "a complete investigation of the geological, agricultural, and industrial resources of each county in the State" with a report on Oktibbeha County, location of A. and M. College (Logan, 1904). Report 1 of the Geological and Industrial Survey of Mississippi, *Geology of Oktibbeha County*, covered geography, topography, physiography, archeology, water resources, surface geology, and economic geology. It had separate sections on soils, forage plants and grasses, and forestry and trucking lands. The geologic map was in color, at a scale of 1 inch equal to 2 miles, and delineated the Selma and Ripley of the Cretaceous, Lignitic Eocene, and Lafayette Pliocene. The aspect of the map is more of the 19th than the 20th century, probably due to the lack of a topographic base and the use of stratigraphic terms that have since become obsolete. This Survey published a second report in 1905 entitled *The Underground Waters of Mississippi*, by W. N. Logan and W. R. Perkins.

Just as in 1850, when many groups began working to establish a geological survey in Mississippi, the first years of the 20th century saw a resurgence in demands for a state survey. In 1903, as mentioned above, Mississippi A. and M. College took the initiative and created the Geological and Industrial Survey to try to fill the need, without the benefits of legislation or appropriation. Also in 1903, the U.S. Geological Survey was brought in to study geology and mineral resources. The man sent to Mississippi was Albert F. Crider, working under the supervision of E. C. Eckel for geology and M. L. Fuller for water resources. In 1906, Crider published a USGS Bulletin on the geology and mineral resources of Mississippi and coauthored a Water-Supply Paper on underground-water resources of the state; both contained a 1905 preliminary geologic map by Eckel and Crider at scale 1 inch equals 38 miles.

In 1906, the Legislature created a "geological, economic and topographical survey of the state of Mississippi." The Survey was to be governed by an *ex officio* board composed of the governor, the State Superintendent of Education, the Chancellor of the University of Mississippi, the President of Mississippi Agricultural and Mechanical College (later MSU), and the Director of the Department of Archives and History. From 1906 to 1960, the agency used the name Mississippi State Geological Survey, which is what appeared on the first 88 bulletins. Albert F. Crider, formerly of the U. S. Geological Survey, was chosen as Director. He enlisted as his staff the industrious Dr. W. N. Logan, of A. and M. College and the short-lived Geological and Industrial Survey, and Dr. Calvin S. Brown, a multitalented professor at the University of Mississippi. Crider was based in Biloxi, Logan at Starkville, Brown at Oxford, and the reports published at Jackson, the state capital; the Survey covered the state. During



Crider's 3 years as State Geologist, bulletins were published on cement materials, clays, lignite, and forest conditions. A *Provisional Geologic and Topographic Map of Mississippi* was bound into each of Bulletins 1 through 3, all published in 1907. This map, at a scale of 1 inch equals about 13 miles, was a refinement of the 1905 map of Eckel and Crider. Crider resigned May 31, 1909, and subsequently worked as a petroleum geologist in the Gulf Coast.

Dr. Ephraim N. Lowe, Professor of Geology at the University of Mississippi, succeeded Crider as State Geologist and Director of the Mississippi State Geological Survey. He held the position for 24 years. Dr. Lowe was among the last of a breed of men who trained as medical doctors and pursued careers in geology and other aspects of natural history. From Lowe's appointment in 1909 until 1924, the Survey was based in Jackson, first in cramped quarters in the New Capitol and later in somewhat less cramped rooms in the Old Capitol. The Survey was moved to the University of Mississippi in 1924, and Dr. Lowe was given the additional duty of teaching and heading the Geology Department.

During Lowe's term, the Survey published reports on regional stratigraphy and such natural resources as pottery clays, soils, forest resources, plants, structural and road-making materials, iron ores, bauxite, bentonite, and oil and gas prospecting. From the earliest years of the century, the Survey followed developments in oil and gas exploration and encouraged the industry by keeping cores and by publishing information and drillers logs of the early dry holes. Dr. Lowe wrote an overview of the state's geology, published in 1915 as Bulletin 12 and entitled *Mississippi, Its Geology, Geography, Soils and Mineral Resources*. This was republished in 1919 as Bulletin 14 and revised in 1925 as Bulletin 20, *Geology and Mineral*

*Resources of Mississippi*. Dr. Lowe also pursued cooperative efforts with federal agencies. Operating under the 1906 enabling act, the Survey cooperated with the U.S. Geological Survey in studies of water resources and an ambitious program of topographic mapping. The Survey also cooperated extensively with the U.S. Bureau of Soils for many years in the preparation of detailed county soil surveys. Dr. Lowe died on September 12, 1933, and the Survey had no director for a year.

The next State Geologist was Dr. William Clifford Morse, who became Director of the Survey and head of the Geology Department at the University of Mississippi on September 1, 1934. Morse was originally from Ohio and received his education there; he later obtained a Ph.D. at Massachusetts Institute of Technology. His dissertation on the Paleozoic rocks of Mississippi was published by the Survey. He was a teacher throughout his career, holding positions at several universities, and at the time of his appointment as State Geologist he had been chairman for 16 years of the Geology Department at Mississippi A. and M. College.

During Dr. Morse's long term as Director (he served 24 years, as had Lowe before him) the Survey systematically mapped and reported on the state's geology and mineral resources. These were the years of the Depression and World War II, and state appropriations were slim. Morse usually had a staff of only two or three geologists, as had Lowe. He was able to augment the appropriation and greatly advance mapping progress by a cooperative arrangement with the Works Progress Administration, by which detailed bulletins on the geology and mineral resources of 16 counties were published. Nine more county bulletins were published later in Morse's term. The staff was increased during the WPA work. Among the scientists who worked for the Survey at



various times under Morse were Dr. Louis C. Conant, Dr. Harlan R. Bergquist, Dr. Richard R. Priddy, Dr. Calvin S. Brown (as archaeologist), Franklin E. Vestal (for many years), Frederic F. Mellen, Tracy W. Lusk, William S. Parks, and Thomas E. McCutcheon (ceramic engineer). The first two county bulletins (not counting the Oktibbeha County report done in 1904) were Winston and Yazoo, mapped in the late 1930's by Frederic F. Mellen, Assistant State Geologist. Mellen discovered the surface anomaly at Tinsley in Yazoo County that led to the discovery of Mississippi's first oil production and a giant oil field. Other reports published during Morse's term included educational bulletins on several state parks and reports on stratigraphy, clays, agricultural limestone, lightweight aggregate, water resources, and iron ores. Morse anticipated the studies in environmental geology of later years with reports on the Tupelo tornado of 1936, the floods of 1948, and landslides at a proposed bridge site at Yazoo City (which saved the Highway Department an amount equal to the Survey's appropriation over 15 years). Dr. Morse ended a long career of teaching and public service with his retirement on June 30, 1958.

In 1958 the Legislature reorganized the Survey's governing board. The action abolished the *ex officio* board created in the 1906 act and established a five-member board that would meet quarterly to guide and promote the Survey. The board was to be composed of two geologists, a civil engineer, and two businessmen. The "Geological, Economic and Topographical Survey" was reestablished along similar lines as before. Among the men who served on the board between 1958 and its abolishment in 1979 were the geologists Henry N. Toler, Dr. Richard R. Priddy, Gordon W. Gulmon, and Dr. Troy J. Laswell, and the engineer O. B. Curtis.

Tracy W. Lusk, then serving as Assistant State Geologist, succeeded Dr. Morse as Director and State Geologist, effective July 1, 1958. He was the youngest State Geologist in Mississippi at the time of his appointment, and served 4 years. Three more county geologic bulletins were published during Lusk's term, as well as reports on Mississippi mineral resources, water resources in northern Mississippi, heavy minerals on the coast, and three geologic profiles along highways. In 1960 the Survey's valuable core and sample library was relocated to a new facility in Jackson. This was done to relieve a need for additional storage space and to better serve the oil industry, since many oil companies were located in the state capital. From 1960 to 1962, the agency printed the name Mississippi Geological Survey on its reports. Lusk resigned on June 30, 1962.

Frederic F. Mellen, former geologist with the Survey, became Director and State Geologist on July 1, 1962. He served 3 years, with a staff of three or four geologists. Physical facilities were an immediate concern, and in 1963 the remainder of the staff and equipment was relocated to the building housing the sample library in Jackson. The agency has been at the same location ever since, accommodating growth by adding new sample warehouses to the back as the warehouses are remodeled into offices from the front. During Mellen's term additional county geologic bulletins were published, as were three collections of research papers and reports on iron ores, lightweight aggregate, and oil prospects. From 1963 until the reorganization of 1979, the name Mississippi Geological, Economic and Topographical Survey was used on reports. As before, though, the agency was referred to informally as the Mississippi Geological Survey. Fred Mellen resigned on May 20, 1965.

William H. Moore of the Survey staff replaced Mellen as Director and State Geologist. During Moore's 15 years as Director, the Survey continued publication of county bulletins and reports on stratigraphy, mineral and water resources, and paleontology. The state geologic map was improved and published at the scale 1:500,000 in 1969. At this time the Survey expanded its staff and entered new areas of environmental geology and regulatory responsibilities. Over many years the agency gradually evolved toward increased emphasis on service to the public and other agencies. Public service and education had always been a characteristic of the Survey, certainly so under Dr. Morse, but 1970 can be selected arbitrarily as a transition to a new phase in the agency's history.

#### THE SERVICE YEARS: 1970-PRESENT

The Service Years as defined here began in 1970 during the term of William H. Moore. The professional staff was increased to about 12, augmented by a librarian, secretaries, a driller, and geologic aides. The additional staff handled additional responsibilities in areas of service to the public and other government agencies. The Survey began stocking all available topographic maps for sale to the public, thus increasing the activity of the publication sales office. Consulting and petroleum geologists were encouraged to make use of the Survey's excellent geological library. The Legislature assigned the tasks of investigating water-supply problems at Alcorn College and sources of agricultural limestone for the Mississippi Department of Agriculture; both studies were published in the Information Series, which commenced in 1971. An Environmental Geology Section was organized and began educating the public and government officials about geologic hazards and the need for

geologic investigation of waste disposal sites. This section also published atlas-type books for the Jackson metropolitan area and for Adams County. The Survey began a long-term, at times intensive, involvement in studies of possible contamination at Tatum Salt Dome, where two nuclear devices were exploded in the 1960's. The Survey was given its first regulatory responsibility in 1977 with passage of the "Mississippi Surface Mining and Reclamation Act," followed in 1979 with a surface coal mining law meeting federal standards.

In 1979 the board governing the Survey was abolished by the Legislature, and the agency became the Bureau of Geology within the Mississippi Department of Natural Resources. The Mineral Lease Division, with responsibility for leasing of state-owned lands, was added to the agency during the reorganization. Bill Moore resigned his office on January 31, 1980.

Alvin R. Bicker, Jr., a geologist with the agency since 1964, was named Acting Director on February 1, 1980, and appointed Director of the Bureau of Geology on May 1, 1980. He served 6 years. During this time the agency continued its regulatory and public service activities as well as studies in geology, paleontology, and mineral resources. The Bureau served as the state's geologic expert as the U.S. Department of Energy investigated three salt domes as possible sites for a permanent repository for high-level radioactive waste. This program did not contribute a great deal to advancing knowledge of Mississippi geology, but consumed a tremendous amount of staff time and effort during the early 1980's. The Bureau began publication of its quarterly journal *Mississippi Geology* in 1980. The journal proved to be a useful mechanism for publishing short articles by staff and outside geologists and popular with the interested lay public. By this time space in the Bureau office had run short. The geological library

overflowed its shelves and the core and sample library nearly filled the available space. Bicker retired on June 30, 1986.

Following Bicker's retirement, Edwin E. Luper of the Bureau staff was named Acting Director. He held that position from July 1, 1986, to May 31, 1987.

The current Bureau Director is Conrad A. Gazzier, who was appointed as of June 1, 1987. Gazzier is actively promoting the Bureau as the repository for geological information in the state. He has set a high priority on securing adequate warehouse facilities for the growing core and sample library. Space for staff offices and the expanding geological and electrical log libraries is a critical problem. The Bureau Director sits on the state's Permit Board, which brings responsibility for applying geology to the regulation of waste disposal facilities and water use. The Mineral Lease Division is involved in an effort to properly inventory state-owned lands, so that these resources can be managed more productively. The Bureau's activities in research and public service are continuing on all fronts, with an increased emphasis on assistance to the petroleum industry.

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## MISSOURI

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### HISTORICAL SEQUENCE OF ORGANIZATIONAL NAME:

Geological Survey of Missouri, 1853-61  
Missouri Bureau of Geology and Mines, 1870-78  
Missouri Bureau of Geology and Mines, 1889-1933  
Missouri Geological Survey and Water Resources, 1933-45  
Missouri Department of Business and Administration, Division of  
Geological Survey and Water Resources, 1945-74  
Missouri Department of Natural Resources, Division of Geology and  
Land Survey, 1974-present

### NAMES AND TITLES OF ORGANIZATIONAL DIRECTORS AND DATES SERVED:

George C. Swallow, State Geologist, 1853-61  
Albert D. Hager, State Geologist, 1870-71  
Joseph G. Norwood, Temporary State Geologist, Aug.-Nov. 1871  
Raphael Pumpelly, State Geologist, 1871-73  
Garland C. Broadhead, State Geologist, 1873-75  
Charles P. Williams, State Geologist, 1875-78  
Arthur Winslow, State Geologist and Director, 1889-93  
Charles R. Keyes, State Geologist and Director, 1893-97  
John A. Gallaher, State Geologist and Director, 1898-1900  
Leo Gallaher, Acting State Geologist and Acting Director, 1900-01  
Ernest R. Buckley, State Geologist and Director, 1901-08  
Henry A. Buehler, State Geologist and Director, 1908-44  
Edward L. Clark, State Geologist and Director, 1944-55  
Thomas R. Beveridge, State Geologist and Director, 1955-64  
William C. Hayes, State Geologist and Director, 1964-71  
Wallace B. Howe, State Geologist and Director, 1971-86  
James H. Williams, State Geologist and Director, 1986-present

### THE MISSOURI GEOLOGICAL SURVEY

#### EVENTS LEADING UP TO THE FORMATION OF THE MISSOURI GEOLOGICAL SURVEY

The first white men to enter the Missouri region came in search of precious metals, especially gold and silver. A Frenchman, Philip Renault, who left France in 1719 with 200 men, led one of the early expeditions. In 1720, Renault and a company of 700 men

entered the rough hill country of the Ozarks. Although they were disappointed in their cherished dreams of finding large gold and silver deposits, their explorations led to the discovery of lead at Mine La Motte and in the neighborhood of Potosi. Lead mining flourished for a few years in the early 1720's, but the Company of the West had financial problems; it was bankrupt in a few years. Mining was not carried on to any great extent until the late 1790's and early 1800's when many



people immigrated to the Ozark region. In 1819 there were 45 operating lead mines worked by 1,100 miners.

Shortly after the United States purchased the territory in 1803, several military expeditions crossed Missouri territory. Among them were the Lewis and Clark expedition in 1804, the Pike expedition in 1805, and the Long expedition in 1819. Several important civilian expeditions were led by men like Featherstonhaugh, Owen, and Schoolcraft. Early expeditions were not regional; most observations were made along a limited strip adjacent to the line of travel. Since the frontier was moving westward, businessmen, farmers, and immigrants often requested information about Missouri's rock and mineral resources, timber, farmlands, etc. Many influential people, particularly early governors, believed accurate surveys could determine the extent of Missouri's mineral resources. They advocated forming a state survey organization.

In 1838 Governor Lilburn W. Boggs addressed the 10th General Assembly of the Missouri Legislature and recommended that money be appropriated for a geological survey. Nothing came of Boggs' proposal, but the Board of Internal Improvement carried out some geological investigations along several major rivers. In 1846 Governor John C. Edwards urged formation of a survey, but the legislature again refused to appropriate money. In 1850 Governor Austin A. King urged the 16th General Assembly to approve a state geological survey. He believed the Federal Government should contribute most of the money, since they owned two-thirds of the state. As a result, Governor King's proposal died; however, he did succeed in persuading the people of the need for a geological survey. Newspapers carried accounts of the proposed survey, and private papers were distributed. The General Assembly passed an act, on February 24, 1853, that

provided for a state survey. Only eight other states had surveys at the time.



George Clinton Swallow, first State Geologist of Missouri, 1853-61.

On April 12, 1853, George C. Swallow was appointed first State Geologist. The Survey received a biennial appropriation of \$25,000. Swallow's annual salary was \$3,000.

Swallow's instructions were as follows:

To make a thorough geological and mineralogical survey of the state, with a view to determine the order, succession arrangement, relative position, dip or inclination and comparative magnitude of the several strata, or geological formations within the state; and to discover and examine all beds or deposits of ore, coal, marls, and such other mineral substances, and mineral waters, as may be useful or valuable; and to perform such other duties as may be necessary to make a full and complete geological and mineralogical survey of the state. . . . To make in triplicate a collection of all the significant rocks, minerals, coals, fossils, etc. in the state and also to draw accurate maps of each county showing by colors or other means, the prairie, timber, bottom lands and geological formations.

Swallow hired five assistants in St. Louis. Two held M.D. degrees, one was a civil engineer, one was a chemist, and one was a draftsman who doubled as a geologist. Each assistant received \$1,800 annually and was required, before a judge, to take an oath that he would carry out his duties faithfully.

The first headquarters of the Survey were at Columbia, Missouri, from which expeditions went out by foot, boat, wagon, and train. Swallow describes some of his early expeditions in his diary. On one expedition he and his assistants rode a paddle wheel boat up the Missouri River to Council Bluffs, Iowa, where they disembarked, floated down the river in rowboats, and studied the geological formations.

After 18 months of field work Swallow published the 1st and 2nd Annual Reports of the Missouri Geological Survey. Those documents discuss the geology of the state and include reports on five counties and on the most valuable mineral resources. By 1860, geological investigations in 80 counties had been completed. Most of the work was carried out along the principal rivers and the railroads. With the advent of the Civil War geological investigations ceased and the first geological survey was abandoned in 1861. Swallow, a Maine Yankee, joined the Union cause. We next hear of him in 1865, when he was State Geologist of Kansas.

## SECOND MISSOURI GEOLOGICAL SURVEY

Two state representatives introduced a bill, in March 1870, that established the second Geological Survey. Headquarters were at Washington University in St. Louis. A Board of Directors, which included the governor and nine members, controlled the new organization, the name of which was changed to the Missouri Bureau of Geology and Mines, a designation retained until 1933. The annual appropriation was \$10,000. The second

survey continued work abandoned because of the Civil War.

Swallow wanted the job again but failed because, as he wrote:

Through political prejudice and the slander of those who wanted the place and a few whom I displeased by refusing to report mines to . . . or to find valuable mines on their land.

A. D. Hager was chosen State Geologist in August 1870, but he resigned the post in August 1871. J. G. Norwood, one of Swallow's assistants in 1858, became temporary State Geologist. Raphael Pumpelly, who succeeded Norwood in November 1871, published two reports during his tenure. The work for one of them, a report on the geology of 20 counties, was mostly done during Swallow's time. Pumpelly also issued a volume on iron ores and the coal resources of nine counties. These and other early reports were of great importance in developing Missouri's mineral economy.

In 1873, the Survey staff comprised seven geologists and a chemist. There was an economic panic that year, and the Survey was having money problems. (In 1873, 11 of 18 state surveys survived the panic.) The Survey's economic problems were exemplified in a letter, dated January 22, 1873, from a Pilot Knob shopkeeper to Pumpelly:

I have a little bill against the Survey for cabbage sold to your man amounting to \$5. He put me off with the excuse that you had not paid him yet. He also owes me \$10 for a coat I let him have on Christmas day; as he had no coat to wear, I let him have it. If you can pay me the amount due me of \$15, you will greatly oblige.

Pumpelly resigned in July 1873, and was replaced by Garland C. Broadhead, under whom the Survey continued doing county reports. *The Field Work of 1873-74*, which contains reports on iron, lead, and coal resources of various counties, was published. An outstanding report, it is still an important reference work. Broadhead also published a geologic map of

northern Missouri. His excellent development of the geologic column in Missouri, including classically detailed information on the Pennsylvanian deposits, were contributions of major significance.

Broadhead resigned in 1875, when the legislature moved the Survey to the Missouri School of Mines at Rolla, an economy move. The legislature hoped to appoint the Director of the School of Mines, Charles Williams, State Geologist. The Survey's appropriation was cut to \$5,000. Williams received an annual salary of \$2,000, which was \$1,000 less than that of the former state geologists. Shortly, Williams' pay was cut to \$1,500. About that time, a strange twist of events occurred. The Phelps County representative brought a lawsuit against Williams for taking money under false pretenses. It appears that the legislative act that moved the Survey to Rolla also stipulated that the State Geologist must be a Professor of Geology. Since the University of Missouri Board of Curators refused to appoint a Professor of Geology, Williams was charged with taking money under false pretenses. Williams beat the charge, but he resigned his position and left Rolla in 1878.

### THIRD MISSOURI GEOLOGICAL SURVEY

The Survey was dormant until May 1889, because the legislature refused to appropriate money for it. In May 1889, however, the legislature revised the law that had created the Second Survey in 1870. The organization was put under the directorship of a Board of Managers comprising the governor and four prominent citizens, most of whom had worked for reestablishment of the Survey. Arthur Winslow, formerly of the Arkansas Survey, was appointed State Geologist at an annual salary of \$3,000. The Survey received an appropriation of \$20,000 annually. There was prolonged discussion concerning loca-

tion of Survey headquarters. Broadhead wanted them in Columbia. A Mr. Blair of Sedalia wanted them in Sedalia--he even offered free rooms. The Board of Managers finally decided on Jefferson City, because it was near the legislature.

During the first 2 years of Winslow's term, reports were published on coal, iron ores, and mineral waters. Topographic mapping with the U.S. Geological Survey was begun about 1890.

On December 1, 1893, the Board of Managers decided that Winslow was not turning out enough publications; they even charged him with delaying important publications in order to receive more appropriations. The Board ordered him to finish a report on the lead and zinc deposits by June 1, 1894, or he would be fired. Winslow replied that he would not be intimidated by threats. On April 2, 1894, he was fired, and Charles R. Keyes, a paleontologist under Winslow, became State Geologist. Winslow, in order to show he had not been loafing, published two volumes on lead and zinc, on his own time. He accepted reimbursement only after the Board accepted his work for publication.

Keyes remained State Geologist until January 1, 1898, when the Board decided that he was unsatisfactory and voted him out of office. During Keyes term, seven volumes were published, most of them on paleontology, clays, and areal geology. Some noteworthy geologists working under Keyes were Haworth, Marbut, Shepard, and H. A. Wheeler. Keyes also revised the State Geologic Map in 1896.

On July 1, 1898, John Gallaher, an M.D. who studied geology under Shumard, was appointed State Geologist. Gallaher was strictly a geologist and did not believe in mixing geology with engineering, as a paragraph from his biennial report of 1898 clearly testifies:

On entering the office, the geologist found that a considerable amount of money had been expended on engineering instruments, photographic apparatus, laboratory equipment, engravings for printing topographic maps and many things pertaining more to a School of Engineering or Physical Geography than to a Geological Survey. Seeing that the energies of the Survey had been thus largely expended on the ornamental without having duly emphasized the economic features of the work, the present management determined at once to eliminate all such ornamental or irrelevant facies and go directly after the fundamental facts, which make the only logical foundation for a Geological Survey.

Gallaher contracted drillers to drill for oil and gas in northwest Missouri and for iron in the Ozarks; \$10,000 was appropriated. Some holes reached 3,000 feet in northwest Missouri.

After 2 years of hard work Gallaher published a report; the first part is strictly philosophy, but the second part is regarded by some as outstanding. Gallaher placed the Cambrian-

Ordovician boundary at the top of the Eminence Formation, still the currently recognized boundary. Gallaher died in office in 1900.

After Gallaher's death his son Leo became Acting State Geologist. Leo, who spent much of his time eulogizing his father, wrote as follows:

This is a volume of 250 pages by John A. Gallaher, September 1900. In this report, the author in a style almost unsurpassed for clearness and force differentiates and classifies the geological formation of the state so vividly that anyone of very ordinary intelligence can readily grasp the great fundamental facts of Missouri Geology. It forms a basis for all the reports to follow. Such a report is as essential to a clear and comprehensive exposition of the Geology of the state as is a knowledge of the alphabet to the language. It is a real pity that the necessity for such a work was not foreseen at the very establishment of the Survey for then a vast amount of useless and irrelevant work of past years would have been avoided.

Although Leo Gallaher was Acting State Geologist for only a few months he



Formerly the headquarters of the Missouri Bureau of Geology and Mines from 1901 to 1904, this building is now the Chancellor's residence of the University of Missouri-Rolla.





The Rolla Building, home of the "Missouri Bureau of Geology and Mines" and the "Missouri Geological Survey and Water Resources" from 1904 to 1946.

did initiate one important program. He sent letters to drillers throughout the State asking for their drill records. This might be called the first attempt at organizing a subsurface program.

In 1897, a significant development occurred. Dr. Ladd, Director of the School of Mines and formerly a geologist under Winslow, began working to have the Survey moved back to Rolla, from its location at Jefferson City. Thirty newspapers joined Ladd in this fight, and in 1901 the Survey was returned to Rolla. The Board refused to pay the cost of moving, however, so the people of Rolla donated money and the railroads provided free transportation. In Rolla the Survey was housed in a dormitory, which is now the Chancellor's Residence. In 1904, it was moved to the Rolla Building, where it remained until 1946. This was the second period of association of the Survey with the Missouri School of Mines, an association that is one of long

duration and of value to both institutions.

When the Survey was returned to Rolla in 1901, a new State Geologist, E. R. Buckley, from the University of Wisconsin, was appointed. He brought with him a young assistant, H. A. Buehler, who was later to become one of Missouri's most outstanding State Geologists.

Under Buckley (1901-08) the Survey was productive. Eight volumes were published, most of them dealing with quarrying, cement resources, and the geology of various counties. The State Geologic Map was revised and several topographic maps were completed in cooperation with the USGS. Buckley wrote a major study of the lead deposits of St. Francois and Washington Counties, a report of great value in Missouri's developing lead mining industry; it also advanced theories about the origin of the lead ores.



By the early 1920's, the Survey had replaced horses with automobiles. With one of the early staff cars are (left to right) E. O. Ulrich, Josiah Bridge, H. S. McQueen, C. L. Dake, and H. A. Buehler.

Buckley resigned in April 1908, and his former assistant, H. A. Buehler, became State Geologist, a post he held for 36 years. Many changes occurred during Buehler's tenure. Until his time, field work was done by boat, horse, foot, or railroad. F. C. Greene, one of the Survey's most productive geologists, tells of getting off a train several miles from the town where he was to spend the night and walking down the tracks studying the rocks as he walked. In 1910, three of Buehler's assistants barely escaped with their lives when their horses and rig were swept downstream as they tried to ford a flooded stream. The horses drowned and the rig was damaged to the extent of \$350. By the early 1920's however, the Survey was using automobiles, but not without difficulty, as is indicated in this letter, dated May 24, 1924, from Josiah Bridge to Assistant State Geologist, W. F. Pond:

The engine runs beautifully, but how I ever got here is a mystery. The car had dried out so thoroughly last winter that all the spokes in the rear wheels came loose, and I could rattle each one of them. So yesterday afternoon I pulled off the wheels and tightened up the bolts and put them to soak in the creek. A few days of running through creeks will probably fix them okay. Might be a good idea to warn Dake about his wheels before he starts out.

In 1919 the Survey was losing many trained personnel to oil companies, who were willing to pay a trained geologist over \$4,000 annually, compared to \$1,800 annually at the Survey. In 1919 Buehler asked the Board of Managers to raise salaries or abolish the Survey. Governor Gardner replied as follows:

The salary of the Secretary of State is \$3,000 per year. The salaries of the State Treasurer and the Attorney General are also \$3,000 a year. The members of the legislature are paid \$5 per day. In other words, if a change in salary was made it would have to, in all fairness, apply to all employees of the State. Also, the prohibition amendment will make it necessary to raise \$3,000,000 additional revenue for this biennial period. Sorry.

Somehow, Buehler managed to get salaries raised in 1921. His salary was increased from \$3,000 to \$5,000, the first raise in the 68 years since the Survey was founded in 1853.



H. A. "Chief" Buehler, State Geologist of Missouri, 1908-44, from a painting by John W. Koenig.

From 1908 to 1930 the Survey published 16 volumes, including reports on coal, oil and gas, and water resources. In 1908, the Survey began sending sample sacks and drill record books to drillers, a significant step in accumulating the subsurface data that led to the Survey's extensive log files. The State Geologic map was revised during the period 1912-22. Some of the better known geologists connected with the Survey at this time were Wallace Lee, F. C. Greene, Henry Hinds, and C. L. Dake.

In 1933, the Board of Managers was abolished and the Survey was made a separate department in state government. The name was also changed from the Bureau of Geology and Mines to the Missouri Geological Survey and Water Resources. It remained as a department of state government until 1945, when Senate Bill No. 348 created the Department of Business and Administration, which included the Division of Geological Survey and Water Resources.

During the 1930's and early 1940's the Survey published several volumes on fireclay, oil and gas, surface water, springs, and pyrite. It also began publishing shorter reports as appendices in the Biennial Reports. The State Geologic Map was again revised in 1939. The subsurface geology section did extensive research on insoluble residues principally as a means of zoning Cambrian-Ordovician dolomites.

In 1944 Buehler died suddenly while attending a Board Meeting of the Highway Department at Jefferson City, and Ed Clark became the State Geologist. Under Buehler the Survey had been gradually built up until it gained national recognition. Most of its trained personnel, however, left to work for oil companies during World War II. One of Clark's main jobs was that of building up a staff depleted during the war years. In 1944 the Survey had only two trained geologists.

In September 1946, the Survey moved from the Missouri School of Mines campus to a former USO building. The Rolla Building was needed for classrooms when enrollments increased after World War II.

Under Clark the Survey addressed a wide range of problems and issues following World War II. Much emphasis was placed on acquiring and developing additional staff, providing support to Missouri's mineral industry, developing water resources, and on other activities.

During Clark's term (1944-55) shorter reports, Information Circulars and Reports of Investigations began to be published. Reports on springs, surface waters, and several aeromagnetic maps were also published.

In 1955 Clark resigned to take a position with the Four Corners Uranium Company. T. R. "Tom" Beveridge then assumed leadership as the 14th State Geologist. Under Beveridge's guidance, volumes on caves, subsurface geology, and on the stratigraphic succession in Missouri were published, along with several guidebooks covering the northeastern, western, and the Ozark regions of Missouri. The State Geologic Map was revised in 1961. From 1955 to 1960, 1,209 test holes were drilled in 19 counties in northwestern Missouri, a program intended to gain more knowledge of the ground-water possibilities of Pleistocene deposits. A total of 16 ground-water reports were published. Beveridge also established the ground-work for expanding engineering geology in the Survey, the statutes of which for years cited such studies as a responsibility of the State Geologist. Site investigations of waste-disposal facilities, dam sites, landslides, mine collapses, and the like became Survey routine. Tom was noted for his ability to work with the legislature and the public, partly because of his infectious good humor. He often told the story of a farm lady, who when he asked

permission to look at some bedrock exposures on her land, asked him, "Do you get paid to do that?" In 1964, Tom left the Survey to accept a position as Professor of Geology at the University of Missouri-Rolla. Just before his resignation, the staff of the geological survey moved into a new building with excellent office and laboratory facilities, the present home of the Missouri Division of Geology and Land Survey. A new headquarters building had been one of Beveridge's goals while serving as State Geologist.

When Beveridge resigned, Assistant State Geologist William C. Hayes replaced him. Hayes developed an organizational structure of the Geological Survey that generally remains in effect today. He organized the work of the Survey by sections, in line with major statutory responsibilities, which include economic, water resources, engineering geology, geologic and subsurface studies, and information services. Bill had a background in the economic geology of midwestern mineral deposits. During his tenure, exploration of the Viburnum Trend was becoming a profitable venture for a number of companies. The Survey's major role in that development included consultation with the geological staff of each of the major mining companies that participated in the exploration and development activity, and assistance in logging and stratigraphic interpretation of exploration drilling. The availability of drilling data at the Survey was an essential supporting factor in each company's exploration program. Bill also had an engineering background and continued to develop engineering geology in the Survey, which was far ahead of most institutions in such studies. Bill resigned his position as State Geologist in 1971 and returned to Springfield, his home town, where he continued his work in engineering geology until his retirement.

Following Hayes' resignation in 1971, Wallace B. (Wally) Howe was appointed State Geologist, and with the passage of the Omnibus State Governmental Reorganization act of 1974, Howe became Director of the Division of Geology and Land Survey, Missouri Department of Natural Resources. His duties also included general supervision of the State Land Survey Program, administration of State Oil and Gas Council activities, service on Land Reclamation Commission, and development of a State Dam and Reservoir Safety Program. Interactive relationships with other divisions of the department, particularly the Division of Environmental Quality, were developed in order to help insure the greatest benefits of reorganization. Engineering geology, ground-water geology, and water resources activities, along with coal and oil and gas investigations became increasingly important during the period of Howe's administration of the survey (1971-86). Broader and more comprehensive cooperative programs with U.S. Geological Survey and U.S. Bureau of Mines were established, and increasing emphasis was placed on program enhancement through grants and contracts with federal and other entities. Efforts begun in 1971 and 1972 to develop automated data systems for the Survey were unsuccessful but continued interest and receptivity by the geological staff helped insure the success of a departmental thrust in that critical area, beginning in the early 1980's.

Robert E. Myers was appointed State Land Surveyor in 1971 and is responsible for assuring that all surveys in Missouri meet minimum standards, and for maintaining all land survey records and making them available to the general public. The State Land Surveyor also directs surveys for resolving political boundary problems.

During the initial period of Howe's administration, Larry D. Fellows was





The Missouri Geological Survey Building, built in 1964, is the present headquarters of the Missouri Division of Geology and Land Survey. Built in Buehler Park on a 3.5-acre site, three buildings with over 42,000 square feet now house the laboratories and offices of approximately 100 division employees.

appointed Assistant State Geologist and had major responsibility for assistance in program development. Fellows resigned in 1979 to become the State Geologist at the Arizona Geological Survey, and Jerry D. Vineyard, a long-time member of the Survey staff, was appointed Assistant State Geologist.

In January 1986, James Hadley Williams succeeded Wally as State Geologist and Division Director. The current period is marked by major state government reduction in support funding. In an effort to meet statutory responsibilities, a much greater emphasis has been placed on seeking outside funding. The outcome of this trend is yet unknown, but many excellent projects have been completed. They include the USGS Conterminous

United States Mineral Assessment Program (CUSMAP), engineering geology studies, and geologic reports on watersheds and counties, all of them supported to some extent by federal funds. Another trend has been fee-supported work. The Land Survey Program has responsibility for all land survey records in Missouri and the recovery of surveyed corners. These records, 1.3 million, are available to the general public and the entire program is supported by fees.

The Dam and Reservoir Safety Program, established in 1981, is not fee supported but is exempt from withholding of funds. This program, vital to public safety, is an example of the Survey's mission to respond to the safety and welfare of Missouri citizens.

## MONTANA

Montana Bureau of Mines and Geology, Montana College of Mineral Science and Technology, West Park Street, Butte, MT 59701. Phone 406-496-4181.

### HISTORICAL SEQUENCE OF ORGANIZATIONAL NAME:

Established as Montana State Bureau of Mines and Metallurgy in 1919 by Legislative Assembly; changed to Montana Bureau of Mines and Geology in 1929.

### NAMES AND TITLES OF ORGANIZATIONAL DIRECTORS AND DATES SERVED:

Charles H. Clapp, President and Director, 1919-21  
 George W. Craven, President and Director, 1921-28  
 Francis A. Thomson, President and Director, 1928-50  
 Arthur E. Adami, Acting President and Director, 1950-51  
 J. Robert Van Pelt, President and Director, 1951-56  
 Arthur E. Adami, acting President and Director, 1956-57  
 Edwin G. Koch, President and Director, 1957-69  
 Uuno M. Sahinen, Director and State Geologist, 1969-71  
 Sidney L. Groff, Director and State Geologist, 1971-82  
 Edward C. Bingler, Director and State Geologist, 1982-84  
 Henry G. McClernan, Acting Director and State Geologist, 1984-86  
 Edward T. Ruppel, Director and State Geologist, 1986-present

Note: From 1919-69 the President of the College also served as Director.

### MONTANA BUREAU OF MINES AND GEOLOGY\*

Recognizing the need to promote the development of mineral resources, increase mine safety and efficiency, collect and disseminate geologic information, and address elements of conservation of resources, the Montana Legislative Assembly in 1919 established the Montana State Bureau of Mines and Metallurgy. The Bureau was established as a research and service agency of the State, with no regulatory duties or authority, and it remains as such today. Its purposes were to aid in the development of the mineral resources of the State and to increase the safety and efficiency of mining. The Bureau was located on the campus of

the Montana School of Mines in Butte, now the Montana College of Mineral Science and Technology, and was designated a Department in the School. Although some of its functions have changed as new needs for earth science information became apparent, the Bureau is still a Department in Montana Tech and a part of the Montana University System, but its budget is separate from that of the College.

The appropriation for the funding of the new Bureau during its first biennium was \$20,000. The Bureau was organized into four departments: Administrative, Geology, Mining, and Metallurgy and Safety. The staff included a Director, who was a geologist

\*Modified from Herndon, E. S., 1981, Oro y Plata y Cobre: A History of the Montana Bureau of Mines and Geology; Montana Bureau of Mines and Geology Annual Report, 1981, p. 62-76.

and President of the School, and two part-time staff members--one a mining engineer and the other trained in metallurgy and safety--who were professors at the School.

The staff lost no time in fulfilling the charge to "prepare and publish bulletins and reports." The first year saw the issuance of Bulletin 1, *The Montana State Bureau of Mines and Metallurgy*, which was simply a small booklet stating the duties, aims and structure of the new Bureau, and inviting citizens to avail themselves of the services offered. Bulletin 2, *Directory of Montana Metal and Coal Mines*, was also issued in 1919 and was a 30-page booklet giving much information on the operating mines of the State. Bulletin 3, *Mechanical Ore Sampling in Montana*, was issued in 1920, and Bulletin 4, *Geology and Oil and Gas Prospects of Central and Eastern Montana*, was published in 1921. Bulletin 5, *The Location, Representation, and Patenting of Mineral Lands in Montana*, was published in 1923.

During the 1920's, the Bureau expanded its research in geology, mineral resources, metallurgy and ground water. A new series of publications started in 1928 with the issuance of Memoir 1, *The Kevin-Sunburst and Other Oil and Gas Fields of the Sweetgrass Arch*.

The next year, 1929, the Legislature changed the name of the agency to the Montana Bureau of Mines and Geology, to make the title more descriptive of the Bureau's functions as a state geological survey.

For more than a decade, the Bureau was staffed only by part-time members of the faculty of the School and by graduate students. The President of the School was the Director of the Bureau. A program of geological field work and mining and metallurgical investigations was carried out by the part-time

staff, and results produced a small but steady stream of publications.

Uuno M. Sahinen, a 1929 graduate in geological engineering of the School, became the first full-time employee of the Bureau in 1931, as statistician, geologist and draftsman, while he completed work for his Master's degree. Sahinen left in 1938 to spend 2 years as a soils engineer on the construction of the Fort Peck dam, worked briefly in industry, and spent the years from 1942 to 1945 with the Navy seabees in the Pacific. He returned to the Bureau in 1945 as Geologist, became Chief Geologist in 1959, Associate Director in 1962, and Director and State Geologist in 1969 when the Legislature created that position.

Although the Bureau continued to be staffed principally by College faculty members and graduate students in the late forties and early fifties, a second full-time employee was added to the Bureau staff in that period when an analyst, Clem Bartzen, was hired for the Bureau laboratory. The staff remained the same until the mid-fifties, when another geologist, V. C. DeMunck, and a laboratory technician, Don C. Lawson, were employed, as well as one or two secretarial support people. The years 1957 and 1958 saw another modest increase in full-time staff: S. L. Groff (1957), F. A. Crowley (1958), and W. M. Johns (1958), as well as a part-time draftsman. Groff was employed as a geologist and head of the Ground-Water and Fuels Division; Crowley was a geologist; and Johns served as a geologist and head of the Kalispell branch office.

A Kalispell branch office was established to handle the first large outside-funded geologic study--Mineral Resources of Northwestern Montana--sponsored by Pacific Power and Light Company and the Great Northern Railway Company. The purpose of the cooperative project was to map the geology and evaluate the mineral

deposits of Lincoln, Flathead, and parts of Sanders and Lake Counties; out of the studies came a series of six bulletins by Johns and others, describing various sections of the 6,870-square-mile area, issued between 1959 and 1964. Further study under an extension of the cooperative agreement resulted in two additional bulletins concerning geochemical sampling of stream sediments in selected areas, by Sahinen, Johns and Lawson, which were published in 1965 and 1967. Many student assistants were employed in those studies. The Bureau's geochemical soil-sampling program grew out of that first effort.

When Johns completed work in the Lincoln-Flathead area, he returned to the Butte office to become Chief of the Geology Division. The thrust of that Division through the years has been in several directions: (1) economic geology studies (metallic and nonmetallic) of areas and commodities; (2) basic geology studies; and (3) programs designed to assist the prospector or small-mine operator, such as the directory of mines now published annually, the mineral identification service, and the aid to small mines programs. The Division received its first real impetus for growth in 1967, when the U.S. Bureau of Mines funded the small-mines assistance program.

Numerous publications have been produced with the prospector or small-mine operator in mind. Such books include *Gold Placers of Montana* (Lyden, 1948), which has been reprinted several times; *The Location, Representation and Patenting of Mineral Lands in Montana* (Adami, 1923); *Practical Guide for Prospectors and Small-Mine Operators in Montana*, and *Operating Ideas for Small Mines* (Stout, 1955, 1956), both of which were translated into Spanish by the government of Mexico and adapted for publication in that country; and *Handbook for Small Mining Enterprises in Montana* (Sahinen and others, 1964;

revised 1976). In addition, for many years members of this Division have managed the Mineral Museum of the College.

Bureau Information Circular 16, *Progress Report on the Geology and Ground-Water Resources of the Eastern Part of the Bitterroot Valley, Montana* (McMurtrey and Konizeski, 1956) stated:

The largest undeveloped water resource in Montana is the water that occurs beneath the land surface (ground water). It is one of Montana's most valuable, yet least known and appreciated, natural resources. Like many other natural resources, ground water is readily available in some places but difficult to obtain in other places. Unlike the exhaustible mineral resources, ground water is a renewable resource similar to the forests and grasses.

The study of Montana's ground water has long been one of the most significant efforts of the Bureau. Beginning in 1930, E. S. Perry, Bureau geologist, conducted a number of ground-water reconnaissance studies; some of those studies were regional in nature, while others were undertaken for specific towns or projects.

Recognizing that the economic well-being of the state was becoming increasingly dependent on the availability, utilization and conservation of its ground water, the 1955 State Legislature authorized the Bureau to establish a cooperative agreement with the U.S. Geological Survey for the purpose of investigating the availability and quality of the ground waters of the State. The Bureau and the Survey share equally the costs of the cooperative investigations, which are continuing. The collection of ground-water data through this cooperative arrangement has resulted in many publications; in addition, pertinent data are presently being stored in the Montana Groundwater Information Center.

In 1957 the Legislature requested that the Bureau prepare a report summarizing the extent of knowledge



regarding the ground-water resources of Montana to that time. The report (Information Circular 26) stated:

The greatest public benefit can best be achieved by maximum development of the ground-water resources as long as this can be accomplished without depleting the supply or impairing the quality. For proper development and conservation of ground water, investigations must be made to determine the amount of ground water present, its location, and the best means of development.

The Montana University Joint Water Resources Research Center (WRRRC) was established by the Board of Regents in 1964 as a cooperative effort among three colleges of the State--the University of Montana, Montana State University, and Montana Tech, of which the Bureau is a department. The center is administered by MSU at Bozeman. The Bureau has worked with the WRRRC from its inception, principally in the areas of hydrogeologic aspects of strip coal mining, and in the problems of saline seep, which occurs in areas of dryland farming and has taken several million acres of farmland out of production.

Increasing governmental regulations and public concern over the environment of southeastern Montana brought about still another aspect of the Bureau's work in the field of hydrology. Because some of the coal mining companies in that area were finding it difficult to deal with those problems owing to lack of complete data, the Bureau sought support to study the effects of strip mining on ground water, by investigating hydrogeologic conditions before, during and after such mining. Funding for these studies was provided by the U.S. Geological Survey, the Bureau of Land Management, the WRRRC and also by private companies. The resulting data were made available to the public through Bureau publications and to the other governmental agencies. The primary objectives of these studies were to

determine pre-mining hydrologic conditions, to establish a ground-water observation program and to monitor and understand mining-related hydrologic changes in order to make reasonable predictions concerning long-term effects of future mining developments in the Fort Union coal region. These projects began in 1970 and are continuing.

A branch office in Billings has been operating for over a decade, supervised by the Hydrology Division, to provide a base from which to conduct that Division's investigations in southeastern Montana.

For almost 60 years, the main investigations into Montana's coal resources were conducted by the U.S. Geological Survey. Use of coal had diminished with the increased use of oil and gas throughout the United States. Renewed interest in Montana's coal began in 1961 at a meeting of the Governor's Economic Advisory Council. The Bureau responded to that renewed interest and subsequently sponsored the First Montana Coal Resources Symposium, held in October 1964. Immediately following that event, there was increased support in the State Legislature for research in coal, and the result was the creation of the Coal Resources Council, through which funding for coal research was channeled. Not only did the Council support expanded research in coal, but in 1966 it drafted a strip coal-mined land reclamation bill, which was passed by the 1967 Legislature. The Bureau's work through the Coal Council consisted of field evaluation of strippable coal resources, and a number of publications appeared in the following years on various coal fields.

Four conferences--the 1964 Coal Symposium; the 1966 Industrial Seminar, Western Phosphate Region (sponsored by the Bureau and the Montana State Planning Board); the 1969 Governor's Conference on Mined-Land Reclamation and its 1970 follow-

up conference that presented recommendations--served to focus attention on the Bureau work and started the era of the Bureau's first real expansion.

One of the first highly visible results of the 1964 Coal Symposium was the establishment in 1966 of a cooperative field program between the Bureau and the Northern Pacific Railway Company to map coal beds and delineate coal reserves of the Foster Creek coal deposit in southeastern Montana. That was an especially significant project because it was the first Bureau investigation to evaluate a coal deposit.

The growing public concern over air quality and pollution served to intensify national interest in Montana's low-sulfur coal. In 1969, the Bureau sought Federal funding for expanded work in the field of coal-resource evaluation. As a result, a \$300,000 contract was awarded by the Public Health Service to fund that work; the program was later extended by the Department of Health, Education and Welfare. When that program ended, the project's Federal funding was taken over by the U.S. Geological Survey, and the investigations continue to be largely funded by that agency to the present time. The drilling under this long-term project was for the purpose of gathering data on the thickness, quality, extent and recoverability of strippable coal beds, and the lithologic characteristics of the associated rocks in the Powder River basin.

Laboratory support through the years was supplied by a small staff. Funding from the Coal Council in the mid-sixties provided the impetus for expansion of laboratory facilities for the first time. Additional Bureau work in water analyses in the late sixties added

another dimension to the Lab's work. These two roles laid the foundation for the type of work carried on by the Lab at the present time.

One of the most significant outgrowths of the Bureau's development in the last several years is the increasing utilization of automatic data processing equipment. The Hydrology Division has an ongoing ground-water data management program, the purpose of which is to develop and make accessible ground-water information for the entire State. The Bureau participates in a cooperative arrangement with the U.S. Geological Survey, through which the Bureau enters geologic and coal-resource data into the nationwide National Coal Resource Data System, the purpose being to make such data accessible to those interested in Montana's vast coal resources. The Information Services Division uses a computerized phototypesetter for in-house composition and typesetting of its publications, resulting in much closer control over the finished products. The Analytical Division uses an ARL spectrometer to analyze water, coal and rocks, and to computerize the resulting data. A terminal in the Earthquake Studies office accesses other seismic-studies agencies to determine quickly and accurately the hypocenter/epicenter of any earthquake activity noted on its recorders.

Much work remains to be done. Coal, uranium, thorium, oil and gas, and metallic resources still need evaluation, research and data collection. The State will continue to require ground-water data so that it can efficiently manage that resource. The focus of the nation is on the so-called "strategic minerals," of which Montana has a vast supply.

## NEBRASKA

Conservation and Survey Division, Institute of Agriculture & Natural Resources,  
University of Nebraska-Lincoln, 113 Nebraska Hall, Lincoln, NE 68588-0517.  
Phone 402-472-3471.

### HISTORICAL SEQUENCE OF ORGANIZATIONAL NAME AND NAMES AND TITLES OF ORGANIZATIONAL DIRECTORS AND DATES SERVED:

Samuel H. Aughey, Honorary State Geologist, 1871-83  
Lewis E. Hicks, Honorary State Geologist, 1884-90  
Erwin H. Barbour, State Geologist, 1891-1918  
George E. Condra, State Geologist, 1919-21

#### Conservation and Soil Survey

George E. Condra, Director, 1909-21

#### Conservation and Survey Division

George E. Condra, Director, 1921-54  
Eugene C. Reed, Director, 1954-67  
Vincent H. Dreeszen, Director, 1967-87  
Perry B. Wigley, Director, 1987-present

## NEBRASKA CONSERVATION AND SURVEY DIVISION

### INTRODUCTION

The earliest explorers in Nebraska, although contributing chiefly to geographical knowledge of the state, did record geological observations. Expeditions and travelers included James Mackay, John T. Evans, Meriwether Lewis, William Clark, G. K. Warren and Prince Maximillian and his artist Karl Bodmer. Discoveries leading to economic resource development were minimal, but a number of the explorers noted the occurrence of fossil mammalian remains in Pleistocene and Tertiary sediments. These discoveries generated considerable scientific interest leading to many expeditions to collect fossils in the late 1800's and early 1900's.

State leadership, however, was more interested in economic geology, and David Butler, Nebraska's first governor, firmly believed that Nebraska needed to develop its

"inexhaustible" coal resources to solve the problem of fuel on the "treeless plains." Congress responded to Nebraska's plea, and in 1867 appropriated \$5,000 for a geological survey. Professor Ferdinand H. Hayden was commissioned to conduct the survey. Dr. Hayden, who was then teaching geology at the University of Pennsylvania, infuriated newspapers, promoters and prominent leaders by concluding that workable deposits of coal did not exist in Nebraska and that for fuel, "the farmers must plant trees, and in a few years the demand for fuel will be supplied." J. Sterling Morton, one of Dr. Hayden's bitter antagonists, eventually led Nebraska toward tree planting and established Arbor Day to help renew this commitment yearly.

Institutionally though, the Conservation and Survey Division has its roots in the Nebraska Geological Survey, one of four present programs of the Division, which is part of the Institute of Agriculture and Natural Resources, University of Nebraska-Lincoln. The division Director is *ex officio* State Geologist.

This modern survey evolved from two sources, the earliest dating back to 1871, 4 years after statehood and the year the University of Nebraska opened its doors.

#### EARLY HISTORY: 1871-1921

That year Samuel H. Aughey, a Lutheran minister and natural scientist operating independently in Nebraska since 1864, was appointed by the regents to the chair of natural history at the new university. The only scientist on a faculty of five, Aughey somehow acquired the title "Honorary State Geologist" at the same time. The title carried no stipend but presumably provided the practical-minded people of Nebraska a focal point for public and private questions about geological resources while at the same time saving the state a considerable amount of money. Possibly the most noted member of the University faculty during the 1870's, Aughey probably toiled harder for the people of the state than for his students and became a well-known Nebraska booster. He promoted the richness of the state's soils, the idea of increasing precipitation by cultivating more acres, and the prospects of coal for fuel in this state of few trees.

Aughey resigned in August 1883, apparently because the regents were dissatisfied with the amount of time he spent in Wyoming Territory investigating coal deposits. The regents asked Aughey to withdraw his resignation, but he refused and migrated to Wyoming Territory.

Lewis E. Hicks joined the faculty the following year as Professor of Geology and apparently was given the honorary geological title that Aughey had held. A student of Louis Agassiz, Hicks was more than a teacher and academic. Like Aughey, he was a practical scientist concerned about the development of the natural resources of the state; his special interest was ground-water resources. Critical of the



*Samuel Aughey*

Samuel H. Aughey, Honorary State Geologist, 1871-83.

federal policy of spending money to investigate only surface-water resources, Hicks became an early advocate of the need for surveying ground-water resources and for using ground water to irrigate crops.

During Hicks' tenure the Nebraska State Legislature enacted legislation and appropriated funds for geologic investigations, not to the University of Nebraska, but to the Board of Public Lands and Buildings. Under provisions of the act, the Board contracted for the drilling of a well to explore and develop salt under saline lands owned by the state west of Lincoln. The legislature appropriated \$16,125 for this purpose and appointed Byron P. Russell geologist in charge. The well was cored from 205 to 2,643 feet and was completed in 1887. Although relatively strong brines were found, neither salt nor coal, which had also been anticipated by the legislature, was judged to be worth developing. The Capitol beach core was not made available to the Nebraska Geological

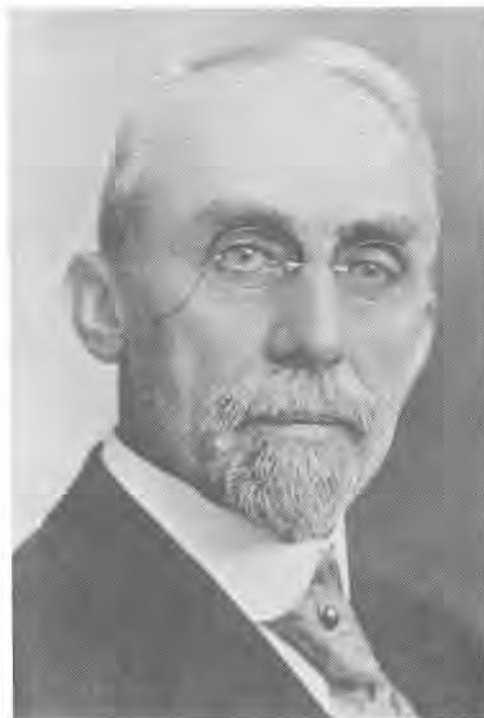


Survey for study or archiving until 1939. However, the core into the Precambrian was the nucleus for the Nebraska Geological Survey's extensive core and sample library and suggested the later commitment toward sub-surface investigation by the survey.

A wave of resignations hit the University in 1892, according to historical accounts, presumably because other institutions were offering Nebraska professors more pay and better teaching conditions, and Hicks departed that year. Hastening his departure may have been the arrival in 1891 of another geologist, Erwin H. Barbour, who became Head Professor of Geology and Acting State Geologist the year he arrived.

Barbour came to Nebraska with credentials--a Ph.D. from Yale, where O. C. Marsh and J. D. Dana were two of his teachers, field experience with the U.S. Geological Survey, and 2 years teaching at Grinnell College. Although his principal interest was vertebrate paleontology, Barbour recognized the commercial importance of geology, and the rudiments of a State Geological Survey slowly assumed shape. Governor Thayer had appointed Barbour Acting State Geologist the year he arrived, and in 1893, legislation was enacted that made the Head Professor of Geology at the University the geologist for the state. Formal appointment to what amounted to the position of Director of the State Museum also came to Barbour in 1893, so leadership in public geology was officially concentrated in the Head of the Geology Department of the University.

The state was free with titles but free with little else. No money was designated for the Geological Survey by either the regents or the legislature, but Barbour did conduct some field work at his own expense in 1891 and 1892. In 1893, Regent Charles H. Morrill, who also was interested in paleontology,



Edwin H. Barbour, State Geologist, 1891-1918.

began financing expeditions to collect fossils and other geologic samples and continued to do so until 1902. Information was at last being obtained on a systematic basis with private money.

Public funds for the State Geological Survey became available in 1899 when the regents provided \$500 for this purpose from the University budget. These funds were decreased to \$250 for the years 1900, 1901, and 1902. The first direct state aid to the Survey came in 1901 when \$1,200 was appropriated by the legislature for the 1901-02 biennium and probably provided funds for the first publications of the Geological Survey in 1903. Slightly larger biennial sums were voted until 1911, when legislation was passed that enabled the state survey to cooperate with the U.S. Geological Survey. That year, the part of the general appropriation bill referring to the state survey was worded as follows:

For publishing reports of the Geological Survey of Nebraska and for cooperation with

the United States Geological Survey, ten thousand dollars, said money to be expended under the direction of the Board of Regents and the State University.

After 20 years of labor, Barbour appeared to have established a stable Geological Survey with a financial base. Appearances are deceptive; however, the same legislature passed two bills that must have shaken Barbour's confidence in the future of the State Geological Survey as it was then organized. One was an act that empowered "the regents to appoint a member of the teaching staff to be state geologist," a significant departure from the 1893 act which automatically made the Head of the Department the State Geologist. The other was an appropriation of \$6,000 for another *ad hoc* University unit with the unwieldy name of Nebraska Conservation and Soil Survey.

One cannot decide at this date whether or not the 1911 Legislature was signaling coming changes for the State Geological Survey, but changes there were in ensuing decades. Most of them centered on the Conservation and Soil Survey and its dynamic Director, George E. Condra, the second source of the modern Nebraska Geological Survey. Condra came to Lincoln, Nebraska, in 1892 to teach science and coach athletics in the city's high schools while continuing his education at the University of Nebraska. He completed his doctorate in 1902, and his Ph.D. dissertation, done in consultation with E. O. Ulrich, then at Kentucky, and R. S. Bassler of the National Museum, constituted part one of the second volume of reports published by Barbour's Geological Survey in 1903.

The big, bull-voiced athlete joined the University faculty in 1902 and began espousing resource conservation, a popular national movement of the early 20th century. On this issue, Condra became to Nebraska what Theodore Roosevelt was to America—a



Geology student from the University of Nebraska doing field work, probably on University Hill at Agate Fossil Beds in Sioux County, western Nebraska, August 27, 1906.

highly visible public figure leading the conservation cause. Invited to a 1907 governors' conference on conservation called by Roosevelt, Condra returned from Washington and set to work. In 1908, the biennial legislature was in recess, but Governor Sheldon, on his own initiative, created a Nebraska Conservation Commission. The following year the legislature appropriated \$1,000 for the Commission and required that it be spent by Condra as Director of the Conservation and Soil Survey under the control of the regents. In 1911, the indirect appropriation for the fledging survey was 60 percent of the appropriation for the State Geological Survey. Finally, in 1913, the legislature created the Conservation and Public Welfare Commission, consisting of the Governor,

the Chancellor of the University, the Director of the Conservation and Soil Survey, and two additional state officials.

One of the principal duties of the Commission was to "serve as an advisory board for the various state surveys." This meant that Condra was one of five advising himself and Barbour. During the same session, legislation was enacted to formalize the existence of the Conservation and Soil Survey within the University and to define its work. One of the duties was to survey the natural resources of the state with the following resources being outlined by statute: soil, water, water power, potash, forests, and road materials. The appropriation for Condra's survey doubled to \$12,000 while Barbour's survey received \$10,000, the same amount that was voted in 1911.

A clear but probably covert rivalry had developed between the two men and their Surveys. Barbour, long a prominent figure at the University, had other duties to attend to in the Geology Department and the Museum. Condra could cultivate his single crop. If biennial appropriations are a guide, then Condra clearly gained the upper hand in 1915 when his appropriation remained constant at \$12,000 while the Geological Survey's dropped to \$7,500. Two years later, the Conservation and Soil Survey appropriation grew to \$25,000 while the Geological Survey received nothing. Barbour continued to be State Geologist, but by now there was no longer an effectual State Geological Survey. The legislature in 1919 ended the rivalry, for all practical purposes, by enlarging the duties of the Conservation and Soil Survey to include some geological activities while not calling these activities geological, by again appropriating \$25,000 to this Survey, by ignoring the State Geological Survey, and by discon-

tinuing the Conservation and Public Welfare Commission.



George E. Condra, Director, 1921-54.

### BIRTH OF THE CONSERVATION AND SURVEY DIVISION

In 1921, legislation was passed that did away with the Conservation and Soil Survey but created a new, broad-based organization within the University: the Conservation and Survey Division. Among a wide range of other things, the law specified that the Division would include a Geological Survey, that the Director of the Division would be appointed by the regents, that expenses incurred in carrying out the act would be subject to the approval of the regents and paid out of appropriations made by the legislature, that the Division could enter into agreements with federal departments with the approval of the regents, and that the 1913 law which provided for the appointment of a State Geologist be repealed. An official State Geologist thus no longer existed. In place of a person, an official State Geological Survey was firmly established by law,



and Condra was the head of that Survey.

Erwin H. Barbour and George E. Condra loom as the two greatest figures in the history of Nebraska geology, and they cast long shadows. Both were of statewide renown by 1921, and both would linger at the University for years, pacing known territory but never venturing too far into new fields. Barbour continued as Head of the Geology Department until 1934 and Director of the State Museum until 1941. From 1919 to 1929, he also served as Chairman of the Geography Department. Acquiring the additional title of Dean in 1929, Condra continued as Director of his Survey until mid-1954.

The early Condra years involved an era of ever-escalating field research, for the most part under primitive conditions--sleeping under the stars, eating sandwiches by the side of the road, and always with insufficient money and insufficient staff. Condra cultivated the art of "courting" the legislature for funds to carry on the mandated research of the Survey.

Few scientists trained today have had the opportunities to absorb knowledge in so many natural-resource fields as did Condra. He was well informed in the fields of botany, zoology, chemistry, forestry, mineralogy, paleontology, and hydrology. He was one of the first to recognize the tremendous opportunity for the use of ground water and water from streams to supplement agricultural production. He helped organize the Nebraska Well Drillers Association in 1929 to encourage professionalism, the sharing of ideas, and, most importantly, sanitary well construction.

Ground-water data collection and research were accelerated in 1930 through a cooperative program of water-resource investigation with the U.S. Geological Survey initiated by Condra. He was also instrumental in

establishing one of the first statewide programs of test drilling and water-level measuring in the nation.

### THE MODERN SURVEY

In 1954, Condra reluctantly stepped down as Director. His pioneering days of innovative research were over, and it was time for a man of new vision and new goals to assume command. This lot fell to Eugene C. Reed, the first native Nebraskan to be recognized, even if *ex officio*, as State Geologist. Resembling Barbour more than Condra, the spare, angular, quiet-spoken Reed acquired his Bachelor's degree at the University in 1923, then spent the next 8 years as a petroleum geologist in Mexico and Venezuela. Returning to Nebraska, Reed completed his graduate studies in 1933 and went to work for the Conservation and Survey Division as a geologist. Becoming Associate Director in 1944, he toiled at the Survey during Condra's declining years before being named Director in 1954.



Eugene C. Reed, Director, 1954-67.

Reed is the principal figure in the transition from the old surveys to the modern organization and, of course, knew both Barbour and Condra. A first-hand observer of the debilitating effects of the Great Depression and World War



II on state institutions in general and state geological surveys in particular, Reed, along with Condra, stressed the importance of cooperative work with the U.S. Geological Survey in order to get something done in Nebraska. This cooperation was particularly critical for ground-water surveys and the monitoring of ground-water resources. After World War II, Reed, with the help of a young Vincent H. Dreeszen--who would eventually succeed him as Director--devised a systematic, long-term drilling program for investigating these ground-water resources and the significant post-Cretaceous deposits of the state in cooperation with the federal survey. This program, which at an early date applied some oil-field technologies to ground-water investigations, continues today and is a large source of information for one of Nebraska's most important resources.

Reed's experience as a petroleum geologist served the Division and State well because oil strikes were made near Falls City in southeast Nebraska in 1939, north of Sidney in the panhandle in 1949, and near McCook in southwest Nebraska in 1959. As he was for many years the only public geologist with significant experience in this field, Reed became the focal point for both industry and public interests. The State Geologist was given the assignment of overseeing some of the activities of the petroleum industry in the state in 1941, and his powers were broadened in 1951. Reed felt the leading institution of higher learning and public research in the state should not be simultaneously a regulatory agency so he helped create the Nebraska Oil and Gas Conservation Commission in 1959. He had by this time, however, added more geologists to the Division staff in order to make use of the information that was accumulating from both the petroleum industry and the cooperative test-drilling program.

When Reed became Director in 1954, the Division had a very small professional staff working primarily with ground-water resources and stratigraphy and a loosely associated group of individuals from other parts of the University and federal agencies. Reed increased the geological staff, especially those mapping the deeper subsurface features, and, during his tenure from 1954 to 1967, the Conservation and Survey Division probably acquired an identity more nearly akin to a Geological Survey than to a broadly-arrayed natural resources survey. Applied geology, utilizing subsurface information and techniques, set the general tone of the Division. In 1963, a detailed geologic mapping program was initiated with the U.S. Geological Survey, and this program continues today.

Vince Dreeszen became Acting Director upon the retirement of Reed in 1967 and was appointed Director by the regents 2 years later. Like Reed, a native of Nebraska, Dreeszen received his Bachelor's degree at Peru State Teachers College in 1942 before entering the navy. Returning to Nebraska after the war, he worked part time for the Division and completed his graduate studies at the University in 1949, the same year he joined the Division staff as a geologist-hydrologist. Named Assistant Director in 1959, Dreeszen continued shepherding the test-drilling program and studying his principal interests, the Cenozoic rocks of Nebraska and their critical importance to the water supplies of the state. On becoming Director, he gradually expanded the scope and scale of the Conservation and Survey Division to more nearly coincide with the provisions of the 1921 act, especially with regard to the survey of water and land resources. The Geological Survey, while still emphasizing applied geology and relying strongly on subsurface

techniques, was enlarged and broadened.



Vincent H. Dreeszen, Director, 1967-87.

The basic statutes pertaining to the Division have been changed little since 1921, but an increase in the size and complexity of the University, coincident with the expansion of the Division, has altered the ruling bureaucracy. Until 1968, the Conservation and Survey Division legislative appropriation was an individual item in the University budget and the Director of the Division reported to the Chancellor of the University. A three-fold university system with a president over three chancellors emerged in 1968 after the State acquired the University of Omaha. At this time, the Conservation and Survey Division became part of the University of Nebraska-Lincoln, and the Director of the Division reported to the Chancellor of that University. An individual legislative appropriation to the Division within the University appropriation continued until 1973. In that year, reorganization of the University of Nebraska-Lincoln placed the Division within the Institute of Agriculture and Natural Resources,

headed by a Vice-Chancellor, and the Division's appropriation became a part of the Institute's budget.

Dreeszen's 20-year tenure saw a tremendous increase in the budget, programs, and staff of the Division. When he became Director in 1967, the Division staff numbered 22; by the time he retired in 1987, the staff had increased to 60. In 1969 the budget of the Division was \$290,000; in 1987 it was \$2.3 million.

With these increases in budget and staff also came increases in Division programs and activities. Basic stratigraphic studies were continued in both the surface and subsurface with major emphasis on the Cretaceous, Tertiary, and Pleistocene. Emphasis shifted to the Paleozoic and the Precambrian rocks with the discovery of oil in southeastern Nebraska in the 1940's and in south-central Nebraska in the 1960's. Basic geologic framework investigations contributed to the expansion of the mineral industry in Nebraska. Between 1950 and 1980, the value of mineral production in Nebraska (oil and gas, limestone and sandstone, and new developments in uranium and rare earths) increased ten-fold.

Many new and innovative programs were added to the Division's responsibilities under Dreeszen's leadership. These included a remote sensing program, a program in water resources management, cooperative work with the State's natural resources districts, and a major role in the state water planning and review process, among others. A major expansion of the Division's role in providing technical support to state regulatory and management agencies of the state also occurred during this period.

Also emerging as a program of some visibility was the Nebraska Remote Sensing Center and, later, the Center for Advanced Land Management Information Technologies (CALMIT). In late

1971, a group of University of Nebraska researchers planned to submit a grant proposal to the National Aeronautics and Space Administration (NASA) to acquire remotely sensed images of the state. At the time, they had virtually no idea what kinds of imagery these satellite-borne scanners might produce. They proposed to apply remote sensing to a land-use inventory, an irrigation inventory, geological interpretations, evapotranspiration studies, water-quality studies, and soils and range management in the Sand Hills, as well as to develop a remote sensing center for Nebraska users.

After getting the NASA research grant, the next step was to persuade the University administration of the importance of a professional-level, full-time remote sensing coordinator located within the Conservation and Survey Division. The drive to establish a Remote Sensing Center (RSC) within the division was spearheaded by Marvin P. Carlson, Assistant Director of the Division from 1971 to 1986. The full-time position of Coordinator was provided and the focus of the RSC moved into the Division in 1973.

As NASA began to see the results of this applied research, they put an emphasis on trying to develop an audience beyond the University research community. The Division was again well-positioned to seek consumers of this data because of its close working relationship with the State's natural resources districts, Natural Resources Commission (NRC), and the State Office of Planning and Programming, now the Policy Research Office. One of the concerns of the planning office, and eventually the NRC, was land use. This interest prompted the first pilot projects carried out by the new center. Out of those projects came some of the first products generated by the center: land-use maps for the state and for a few NRD's and counties. Eventually, land-

use data were collected for several of Nebraska's NRD's.

Some of the more successful projects included the land-use inventories, the inventories of wetlands and Sand Hills lakes, and the irrigation inventory, which became the annual center-pivot inventory, one of the most successful continuing projects in the nation using remote sensing. By the 1980's, Nebraska was the only state in the nation with a center-pivot database and an annual statewide inventory, one that now covers more than a decade. Also, in the mid-1970's, an annual remotely sensed inventory of Nebraska's pits, mines and quarries and their reclamation was begun and continues to the present.

By the mid-1980's, lack of financial support from NASA, the increased cost of the data (initially provided as part of the grant), problems with the continuity of the data, and the need for supplemental "ground truth" data made remote sensing more of a tool and less of an end in itself. It was combined with other tools, such as digitized information from existing maps and computerized manipulation of remote sensing imagery. The automation of these images, that is, programming computers to interpret the direct signal from the satellite, as opposed to converting it to a picture, became a parallel activity. These changes in image interpretation and manipulation ultimately gave rise to the concept of a new center that would use a network of information technologies and multidisciplinary expertise to shed light on land-management problems.

In October 1986, the University of Nebraska Board of Regents approved the creation of CALMIT as a program of the Conservation and Survey Division. The idea is to build a University-wide and, eventually, nationally known center of excellence in geographic information technologies at the University of Nebraska-Lincoln. Such an enterprise



would collaborate with regional universities, help the public or private sector process computerized earth-science information and enhance educational opportunities by stimulating interdisciplinary research.

As both a multidisciplinary and a regional concept, CALMIT has developed an affiliate program to provide links with UNL faculty, with other universities, with public agencies, and with the private sector. Because of this design, CALMIT faculty represent such diverse specialties as agricultural meteorology and climatology, agronomy, computer science, ecology, electrical engineering, geography, geology, and industrial and mechanical engineering. In addition, the center maintains a memorandum of agreement with its primary affiliate, the University of Kansas, and with Kansas State University and the University of Nebraska-Omaha. State agency affiliates include the Natural Resources Commission and the Departments of Environmental Control and Health. Agreements have also been negotiated with the Earth Resources Observation Systems Data Center in Sioux Falls, South Dakota, and Earth Resources Data Analysis Systems of Atlanta.

However, CALMIT is more of a process than an organization, and while the process is the evolution of uses for land-management research systems, the tools are the specific applications of space-age technology, including remote sensing techniques, digital image processing, geographic information systems, and automated cartography.

Another major expansion of the scope of the Conservation and Survey Division (CSD) occurred in 1984 when the Water Resources Center was merged with the Division. This move was made to better enhance coordination of water research and education at the University of Nebraska. Actually, the Water Center was merely returning home because it was originally located

in the Division, and Eugene C. Reed, then CSD Director, also served the water center as its first part-time Director.

The Water Center was established as the Nebraska Water Resources Research Institute (NWRRI) in November 1964 after the Federal Water Resources Research Act created a network of state water-research centers and institutes in July of that year. Over its 23-year-history, the Center has promoted and coordinated water-related research, education and dissemination of information on statewide, regional and national water-related issues.

Since merging with the Division, the Water Center has continued to administer and coordinate water-research projects and help researchers obtain financial support for their investigations. The Center integrates University water-research and training programs according to the requirements of federal, state and local agencies. As a result of research grants and projects sponsored by the Water Center, significant advances have been made in research on irrigation scheduling, agricultural meteorology, and eutrophication, among other studies.

Another main intent of the federal authorization is to prepare scientists for water-related research, and through an interdisciplinary, master's degree program in water-resources planning and management, the Center sees that a major part of its federal money trains water scientists.

The Water Center publishes reports, transcripts of staff presentations at scientific meetings, popular articles, press releases, and a bimonthly newsletter, *Water Current*. It also cosponsors seminars, conferences, and workshops that are effective means of bringing students, researchers, and users together for training and interaction. Examples include: the annual Nebraska Water Conference, a 2-day exploration of a current water-



related topic; the annual Water Resources Seminar, a series of weekly seminars given for credit each semester in conjunction with the University; the Water Policy Forum, an annual examination of a water-policy issue; and the Kremer Lecture Series, a day-long set of on-campus presentations held once or twice a year.

These are only a few examples of the expanding focus of the Conservation and Survey Division under Dreeszen's leadership. On March 1, 1987, Dreeszen resigned as Director. He had served the Division under Condra and Reed and knew Barbour and his work. Each of these leaders over a 95-year span established for the Survey a statewide and national reputation for scientific credibility and achievement. The record of public service to the state established during their tenure is one of strong influence on public decisions in matters related to natural resource utilization and management.

### **CURRENT PROGRAMS**

The current Director of the Conservation and Survey Division is Perry B. Wigley, experienced in basic and applied geology in both the public and private sectors. Born in Alabama, Wigley received his M.S. and Ph.D. degrees in geology from Virginia Polytechnic Institute. His background includes stints as Professor of Geology, Assistant Director of a Geologic Survey, and Exploration Manager for an oil company.

Under Wigley's leadership the internal structure of the Division was reorganized in 1987 into four major program areas: (1) Water Survey Branch, (2) Geological Survey Branch, (3) Geographic Information Systems, and (4) the Nebraska Water Resources Center, already discussed above.

#### **Water Survey Branch**

Each branch has its unique history and contributions, and the Water

Survey is no exception. Recognition that Nebraska is uniquely endowed with huge ground-water supplies led in 1930 to the establishment of one of the first statewide programs of ground-water investigation and monitoring in the nation. That program of cooperation between the Conservation and Survey Division and the U.S. Geological Survey is now in its 58th year.

The water survey program has drilled more than 4,500 test holes representing approximately 900,000 feet of carefully collected, logged, and permanently preserved samples. Tests have been drilled in every county in the state. Test drilling, which has contributed significantly to the Geological Survey, has established a base of knowledge about the occurrence and availability of ground water, which, in total volume of good quality water, is practically unmatched by any state. CSD staff provide water-availability information to citizens, consultants, public entities, and others.

Information from almost 3,500 observation wells--an increase from about 120 in 1930--is now obtained through a multi-agency cooperative effort. Data storage and retrieval have been automated. Last year, the 33rd annual report was published summarizing water-level data and evaluating water-level changes. The historic water-level records and the hydrogeologic framework and hydrologic data based on test drilling have permitted the Division and other public and private natural-resource organizations to prepare predictive and management models of the hydrologic system in specific areas of the state.

#### **Geological Survey Branch**

Current emphasis of the Geological Survey includes: (1) geologic mapping on 7.5-minute quadrangles published at a scale of 1:250,000; (2) stratigraphic studies and correlation of the outcropping and subsurface rocks of

Nebraska into surrounding geographic areas; (3) mineral resource inventories and investigations resulting in the mineral resource development of the state; (4) subsurface oil, gas, and structural studies; (5) geophysical studies; (6) landslide studies; and (7) paleontologic studies.

### **Geographic Information Systems**

This program area includes the Center for Advanced Land Management Information Technologies (CALMIT) already discussed. Another major activity under the GIS program is the Division's cooperative soil survey program, now in its 85th year. Yet its diamond anniversary was noted in 1978 with as little fanfare as was its beginning in 1903.

The Nebraska State Legislature first provided funds for soil surveying in 1912, and each year since, state funds have been invested in the soil survey program. Each year, the variety of uses of the land inventory has grown. Early soil surveys were also widely used as the first accurate road, drainage and county maps. Today, architects, bankers, engineers, farmers, homeowners, ranchers, and others use information from the surveys for planning, developing and managing the state's land resources to meet an ever-increasing variety of cultural needs.

The Conservation and Survey Division has been the state agency participating in the state-federal soil

survey program since 1921. The federal soil-survey program has been under the direction of the U.S. Department of Agriculture Soil Conservation Service since its beginning in the late 1890's.

By 1950, soil surveys had been published for all Nebraska counties except six Sand Hills counties. A new generation of soil surveys was initiated in 1955, resulting in a larger map scale, more interpretive soil information and a more precise background produced by means of aerial photography. These modern soil surveys have been completed for 85 of Nebraska's 93 counties. In addition, 8 surveys are in progress, and the entire state is scheduled to be completed by the end of 1990.

In 1986, a program of updating older soil surveys began. The updating of soil surveys more than 25 years old, along with basic soils research, will keep the soil survey program working well into the future. This updating is needed because the usefulness of a soil survey declines over time due to changes in land use, tax structure and land management, and advances in soil science.

Barbour, Condra, Reed, and Dreeszen each bequeathed a legacy of ideas and innovations, programs and public service to the Conservation and Survey Division. Inevitably, the current Director, Perry Wigley, also will leave his mark as the Division prepares for its future in the 21st century.

## NEVADA

Nevada Bureau of Mines and Geology, University of Nevada-Reno,  
Reno, NV 89557-0088. Phone 702-784-6691.

### HISTORICAL SEQUENCE, NAMES AND TITLES OF ORGANIZATIONAL DIRECTORS AND DATES SERVED:

**State Geologist, 1865**

Position not filled

**State Mineralogist, 1866-78**

Richard H. Stretch, 1866

A. F. White, 1867-70

H. R. Whitehill, 1871-78

**State Analytical Laboratory, 1895-1985**

Directors:

Robert D. Jackson, 1895-1899

Charles P. Brown, 1899

George J. Young, 1900-14

Francis Church Lincoln, 1914-24

Walter S. Palmer, 1924-51

Vernon E. Scheid, 1951-72

John H. Schilling, 1973-85

**Nevada Bureau of Mines, 1929-71**

Directors:

John A. Fulton, 1929-39

Jay A. Carpenter, 1939-51

Vernon E. Scheid, 1951-71

**Nevada Bureau of Mines and Geology, 1971- present**

Directors:

Vernon E. Scheid, 1971-72

John H. Schilling, 1972-87

### THE NEVADA BUREAU OF MINES AND GEOLOGY

By Joseph V. Tingley

#### THE BACKGROUND YEARS: 1865-1929

On March 20, 1865, during its first session, the Nevada Legislature created the position of state geologist; an act was passed that provided for appointment by the Board of Regents of a State Geologist of Nevada who,

... shall proceed to make a preliminary and superficial geological survey of the mineral regions of the state, ... and to prepare a map, marked and colored in such a manner as to indicate the general geological

divisions, as developed in the country examined.

Not more than 8 months were to be occupied in this task, and the grand sum of \$6,000 was appropriated to defray expenses. Even with these formidable conditions there were applicants for the job, but the regents deemed it "inexpedient" to make the appointment and the position was not filled.

The following year, during the second session of the legislature, an act was passed which created the office of State Mineralogist. The State Mineralogist was to serve under the Board of Regents and was, among other things, to be superintendent of a state mining school; to visit and examine

mineral properties within the state; to collect, mark, and catalog mineral specimens; to devise the course of studies at the mining school; to teach at the school; and to collect information concerning the different modes of working mines and reducing ores. In addition, he was to establish and supervise an assaying facility at the mining school which would, at a fee which covered only costs, analyze ores delivered thereto. Professor Richard H. Stretch was appointed State Mineralogist in the spring of 1866 and immediately set forth to accomplish the tasks requested by the Legislature. As State Mineralogist serving under the Board of Regents, Stretch also became the first employee of the University of Nevada. By the time he filed his first report to the Regents in December 1866, he had compiled the first comprehensive accounting of activity in the nearly 150 mining districts in the state. In addition to comments on mines and mining operations, Stretch's report also noted that the Legislature had failed to appropriate funds with which to pay him. Stretch did not serve another term and was succeeded by A. F. White in 1867. White, a Presbyterian minister, was State Superintendent of Public Instruction and a member of the Board of Regents. In his first annual report, White also remarked that no provision had been made for payment of his salary or expenses and,

To discharge the duties legally required of me as State Mineralogist, I have therefore economized as best I could; have advanced my own funds at a heavy personal sacrifice; and have labored under many disadvantages.

In the spring of 1868 White joined with the party of Clarence King of the U.S. Geological Survey who was then engaged in work on the Nevada portion of his survey of the Fortieth Parallel. King provided White with field support; White gave his services as a mineralogist to the party and was

thereby able to continue his coverage of mining activity in the state.

In 1869, the position of State Mineralogist was removed from the control of the Board of Regents and was made an elective office; White was appointed to continue in the position until the general elections of 1870. H. R. Whitehill was elected to the position and took office in January 1871. Whitehill held the job until 1878 when the office was abolished by the Legislature. The reports of the State Mineralogist, issued biennially during the 12-year life of the office, are in some cases the only surviving records of many mining operations in remote parts of the state.



Robert D. Jackson, first Director of the State Analytical Laboratory, 1895-99. Source: Mackay School of Mines archives.

In 1888, a School of Mining was formally organized at the new Reno campus of the University of Nevada with Robert D. Jackson as its first Director. In 1895 the Nevada legislature charged the University with the responsibility of providing an assay service for citizens of the state and the



Mining Analytical Laboratory was established. As the first public service division of the University, the laboratory was the organizational predecessor of the Nevada Bureau of Mines and Geology.

Jackson, in his capacity as head of the School of Mines, also became Director of the Mining Analytical Laboratory. Jackson, a respected mining engineer and educator, occupies a somewhat unique place in the history of the university. Like many mining professors, both past and present, he carried on a flourishing consulting practice in addition to his teaching duties. His outside commitments, however, took more of his time than the regents felt was proper. In 1899, when Jackson offered his resignation because of a perceived affront from the regents, it was quickly and eagerly accepted. Jackson was very popular among the

students and, when news of his departure spread, a demonstration was held on campus and the students marched through Reno in protest; Jackson inadvertently was the cause of the first student "riot" on the University of Nevada campus.

It was the duty of the Mining Analytical Laboratory to analyze, free of charge, all samples of minerals and ores submitted to it; all that was required was that the submitters be United States citizens and that the samples be from locations within Nevada. The laboratory was, however, expressly forbidden to make assays for gold or silver--the fire-assayer's lobby was apparently quite strong in the Nevada Legislature in 1895! The State Analytical Laboratory shared space with the School of Mines, and in 1895, both organizations were housed in the Hatch Building on the Reno campus.



Hatch Building, first school of mines building on the University of Nevada-Reno campus. The State Analytical Laboratory was located in this building from 1895 until shortly after 1900. Source: UNR archives.

This building, also known as the School of Mines Building, was located on the west side of the central campus area approximately on the site of the present Clark Administration Building. Shortly after the turn of the century, the school of mines expanded into a second building, the former Agricultural Experiment Station, on the southeast side of the campus. This building, later known as the Physics Building, was in the area now occupied by the Mackay Science Building. In 1905 an annex was constructed on the east side of this building to house the mining laboratories. This annex became the second home of the State Analytical Laboratory until 1908 when it, along with the rest of the school of mines, moved into the new Mackay School of Mines building.

Following Jackson's resignation in 1899, Charles P. Brown became the

second Director of both the School of Mines and of the Mining Analytical Laboratory. Brown, formerly a professor of mathematics and metallurgy at the University, died of typhoid fever a few months after his appointment. George J. Young was appointed Director of the mining school and of the state laboratory in 1900. Young had graduated from the University of California in 1899 and, in contrast to Jackson, was almost totally lacking in mining industry experience. He, again in contrast to Jackson, devoted his entire time and efforts to the school and soon earned the respect of the faculty and of the state's mining fraternity. In 1904, the School of Mines offered its first publication; Vol. 1, No. 1, *Bulletin of the Department of Geology and Mining*, by John A. Reid, described building stones in Nevada. Director Young authored the next three



The Agricultural Extension Building, located on the present site of the Mackay Science Building, was the second home of the State Analytical Laboratory. The laboratory facilities were moved into this building shortly after the turn of the century and were located in the low wing extending from the east side of the older two-story structure. Source: Nevada Historical Society.

bulletins. These works, issued in 1909, 1911, and 1912, described the ventilating systems in the Comstock mines, fires in metaliferous mines, and slime filtration.



George J. Young, Director of the State Analytical Laboratory, 1900-14. Source: Mackay School of Mines archives.

### THE MACKAY SCHOOL OF MINES

In 1906, an event that was to be a major turning-point for Nevada's mining school came about; Clarence H. Mackay and his mother, Marie Louise Mackay, widow of the late Comstock mining magnate, John W. Mackay, donated funds to build a school of mines building on the University of Nevada campus. This building, along with other financial gifts from the Mackay family, established the school--renamed the Mackay School of Mines--as one of the major mining schools in the United States. The new mines building was erected at the north end of what later became the central quadrangle of the Reno campus. The Mackay family retained the noted architect Stanford White to design the structure and a

statue of John W. Mackay was set in front. The statue, created by Gutzon Borglum, still serves as the focal point of the University of Nevada's Reno campus.

George Young continued as head of the school and thereby became the first Director of the Mackay School of Mines under its new name. In 1914 Young was replaced by Francis Church Lincoln who served as Director of the Mackay School of Mines and of the State Mining Analytical Laboratory until 1923. Lincoln was keenly interested in Nevada mining history and, during his tenure, amassed a great deal of information on the geology, past production, and mining history of Nevada's mining districts. Published privately in 1923 as *Mining Districts and Mineral Resources of Nevada*, his work became the standard reference on mining districts of the state. It has been republished twice, the last time in 1982, and remains a prime historical reference on Nevada mining districts.

### JOHN A. FULTON AND THE NEVADA BUREAU OF MINES: 1929

In 1924, Lincoln was succeeded as Director by John A. Fulton, setting the stage for another turning point in the history of the school and for the official formation of the State Bureau of Mines. Fulton, an 1898 graduate of the Nevada mining school, returned to Reno early in 1924 after some 25 years engaged in the practice of mining engineering at gold camps around the western United States. At the insistence of Emmet Boyle, former Nevada governor and also a mining engineering graduate of the Nevada School of Mines, Fulton was asked to accept the directorship of the school. He accepted the position on December 1, 1924, and embarked upon a program to strengthen both the student enrollment and the reputation of the school. Walter S. Palmer was given the position of Director of the State



The Mackay School of Mines Building as it appeared shortly after its completion in 1908. The State Analytical Laboratory was housed in this building from 1908 until 1962; the Nevada Bureau of Mines was located in the building from 1929 until 1955. Source: Mackay School of Mines archives.

Analytical Laboratory; the first person to hold that position who was not also the Director of the School of Mines. A 1905 graduate of the University of Nevada, Palmer received a mining engineering degree from Columbia University and returned to Nevada in 1910 as professor of metallurgy. In his years of service with the state laboratory he gained a reputation for his uncanny ability to call the location of samples submitted for assay, almost to the exact outcrop, just by looking at a hand specimen.

In 1929, under Fulton's directorship, the Nevada Bureau of Mines was formed as the second public service division of the University of Nevada. Fulton took personal credit for initiating legislation which led to the formation of the Bureau. In a letter to the President of the University in 1939, Fulton stated:

The mining states of the West all have a Bureau of Mines... The services performed by these Bureaus are of great value to the mining industry and inasmuch as mining is the paramount industry in Nevada, it seemed to me important to have such an agency here... I therefore, after discussing the matter with the President [of the university], had a bill introduced in the 34th legislature in 1929 establishing a Bureau of Mines...

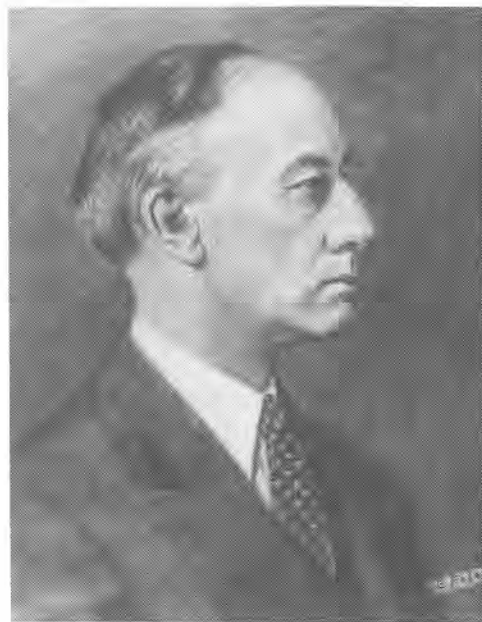
Assembly Bill No. 83, approved March 29, 1929, brought the Nevada Bureau of Mines into existence. It was to be under the direction of the Board of Regents of the University and "a competent mining engineer" was to be appointed director. Clearly spelled out in the bill were objectives that Director Fulton must have had in mind. The first listed was:

To, by questionnaire or otherwise, conduct a thorough mineral survey of the state and to catalog each and every mineral deposit and occurrence, both metallic and nonmetallic of whatsoever nature..., and to serve as a bureau of information and exchange on Nevada mining.





Francis Church Lincoln, Director of the Analytical Laboratory, 1914-24. Source: Mackay School of Mines archives.



John A. Fulton, first Director, Nevada Bureau of Mines, 1929-39. Source: Mackay School of Mines archives.

This still remains as one of the prime functions of the organization. Another section, although much further down the page, stated that:

It shall be illegal for the director or any attaché of the bureau of mines to receive a commission or to act as agent or broker of, or for any purchaser, owner, or his or their agents of a mining property, or to act in any other than a wholly impartial way while so employed.

The Nevada Bureau of Mines was now set in a form that would carry it through the depression, a world war, and up to its next major transition. The Bureau and the Mining Analytical Laboratory, both public service organizations, along with the teaching departments, made up the Mackay School of Mines. The Bureau and the School were headed by Director Fulton; the Analytical Laboratory continued with Walter Palmer as its Director. Lines between the three segments of the school were not clearly drawn. All faculty of the school were considered to be staff of the bureau and of the lab; neither the bureau nor the laboratory had staff members solely their own.

Nevada's fight for an allocation of Boulder Dam power was started by Governor Balzar's administration about the time that the Nevada Bureau of Mines was established. The Colorado River Commission had no reliable data on the mineral resources of southern Nevada. At their request Fulton detailed Jay Carpenter, professor of mining engineering, to make a mineral survey of southern Nevada. Carpenter's work, published as the first official Bulletin of the Nevada State Bureau of Mines, Vol. 1, No. 1, Nov. 1929, formed the basis of a report subsequently given to the Secretary of the Interior by G. W. Malone. Malone, then Secretary of the Colorado River Commission and later U. S. Senator from Nevada, credited the Bureau report with results that touch us today:

... without the help of the Mackay School of Mines staff, whether it was called the

Bureau of Mines or the Mackay School of Mines, it would have been very doubtful whether I could have made the proper showing on such short notice before the Secretary of Interior, which in my opinion was absolutely necessary to secure a proper allocation of power to the state of Nevada.

Nevada received a firm power allocation and, in Director Fulton's words:

... the results we aided in obtaining justified the creation of the Bureau of Mines even if nothing else had been accomplished.

It was also during Fulton's term that the Bureau began its ventures into the publishing of timely information on the geology and mineral resources of the state. In the 10-year period between 1928 and 1938 the Bureau published 26 bulletins. The authors included Bureau personnel but many bulletins were written by geologists with the U.S. Geological Survey or with universities (such as Stanford) who were working on projects within Nevada. Each bulletin usually contained a short but complete coverage of a specific mine, mining district, or perhaps a commodity in a small portion of the state. The first two of the Fulton-era publications were issued as University of Nevada Bulletins; the third, Carpenter's mineral resource study of southern Nevada, was Vol. 1, No. 1, Bulletin of Nevada State Bureau of Mines and Mackay School of Mines; the next group of 23 bulletins combined the two organizational titles and came out as University of Nevada Bulletins, Bulletins of Nevada State Bureau of Mines and Mackay School of Mines.

### THE CARPENTER YEARS

John Fulton died in 1939 and Jay A. Carpenter was appointed Director of both the School of Mines and the Nevada Bureau of Mines. Carpenter was a 1907 graduate of the School of Mines. He remained to teach at the school between 1908 and 1910, then left to work in the mines in Tonopah, Belmont, and other Nevada camps

before returning to the University as professor of mining in 1926. Under Carpenter, the Bureau of Mines and the Analytical Laboratory continued to operate much as they had during the Fulton years; Carpenter was Director of the Nevada Bureau of Mines, Walter Palmer continued as Director of the Analytical Laboratory, and the staffs of all three divisions of the School of Mines remained largely indistinguishable.



Jay A. Carpenter, Director, Nevada Bureau of Mines, 1939-51. Source: Mackay School of Mines archives.

In 1948, the Nevada Bureau of Mines acquired its first two staff members, who were not also teaching faculty of the School of Mines, when Victor Kral and Fred L. Humphrey joined the Bureau as field engineers. Earlier, Director Carpenter had made a practice of hiring short-term, or even part-time, staff members to accomplish specific projects.

With the acquisition of its own staff, office space became a problem. The Mining Analytical Laboratory shared quarters on the second floor of the mines building with the school faculty. Space

for the new Bureau staff was found in a corner of the unfinished basement along with "overflow" publications from the Mines Library.

The Bureau of Mines continued to publish on Nevada geology and, on May 1, 1939, its publications series suffered yet another name change; bulletins were thereafter issued as University of Nevada Bulletins with the designation: "Geology and Mining Series No. --". The series numbers were consecutive, starting with the first publication in 1904, and cut across all of the various bulletin names. Bureau publications continued to stress mining district descriptions and local geology, and in 1947, the first county-scale bulletin was produced. When Carpenter directed that work be started on county studies in 1945, he intended them to be supplements to Lincoln's 1923 publication and, in line with Lincoln's work, the first few stressed mineral resources rather than general geology. The first counties chosen for study were those that had not been covered in an earlier county-study program carried out in Nevada by the U.S. Bureau of Mines (USBM). The USBM work by W. O. Vanderberg in the 1930's resulted in published reconnaissance studies of mining districts in seven of Nevada's counties. The first Nevada Bureau of Mines publication in Carpenter's new county series, Geology and Mining Series No. 46, described the mineral resources of Douglas, Ormsby, and Washoe Counties; the second, Geology and Mining Series No. 49 covered Storey and Lyon Counties; and the third, Geology and Mining Series No. 50, was Nye County alone. These counties, eventually restudied in greater detail and described in later publications, were the first of a series of bulletins which described geology and mineral resources of each of the state's seventeen counties. The last, Bulletin 101, *Geology of Elko County*, was released in 1987.

## VERNON E. SCHEID, "THE DEAN"

Following the end of World War II, Director Carpenter found himself at the head of a venerable but definitely aging institution. Most of his faculty had been at the school since at least the early 1920's. Walter Palmer, Director of the Analytical Laboratory, began his service in 1910 and Carpenter himself began teaching at the school in 1926. Faced with an increasing student enrollment brought on largely by returning servicemen, a limited budget, and a faculty that essentially had not been enlarged since the Depression, Carpenter and the school's alumni set in motion measures which led to the elevation of the Mackay School of Mines to college status. The timing of this move was rather good since, at this time, two of the University regents were mining engineering graduates of the School of Mines.



Vernon E. Scheid, first dean, Mackay School of Mines and director of the Nevada Bureau of Mines and State Analytical Laboratory, 1951-72. Source: Mrs. Vernon Scheid.

In 1951 the mining school, while retaining the name Mackay School of

Mines, became a full-fledged college within the University. Jay Carpenter retired as Director of both the School of Mines and the Bureau of Mines and was replaced by Vernon E. Scheid, the first Dean of the College of Mines. Walter Palmer also retired this same year as Director of the State Analytical Laboratory. Scheid, in addition to being Dean of the College of Mines, was appointed Director of the Nevada Bureau of Mines and Director of the State Analytical Laboratory thereby becoming the first person to hold the position as the head of all three divisions of the school. Dr. Scheid was also the first "academic" geologist to head the mining school. He held a Ph.D. from Johns Hopkins University and, prior to arriving at the Mackay School of Mines, had taught geology at the University of Idaho. Scheid first concentrated his efforts on the school and the task of accomplishing the transformation from an undergraduate-oriented hard-rock mining school to a modern college of mines with a strong graduate program. He also, however, began to build up the Bureau of Mines staff and, by 1959, had increased the staff from 2 to 8 members.

With the larger staff the need for separate Bureau quarters became apparent. In 1921, the U.S. Bureau of Mines had established a research station on the University campus housed in a small building immediately to the rear of the Mackay School of Mines building. By the early 1950's the U.S. Bureau of Mines found that they had outgrown the 1921 accommodations and moved to new quarters to the north of the campus. As the U.S. Bureau staff moved out of the old building, the Nevada Bureau staff moved in, and in 1955, the Nevada Bureau of Mines had its first official headquarters.

The building was in sad repair, the roof leaked, paint hung in curling strips from the ceilings, and later, it was found that some of the old chemical

laboratories were contaminated with radon. They were stripped of furnishings and made "safe" for occupancy. It was, however, home for the bureau for 8 years. During this time, the Analytical Laboratory continued to occupy quarters on the second floor of the School of Mines Building.

In 1953 the last of the University of Nevada Bulletins, Geology and Mining Series, was issued; No. 51, *The History of Fifty Years Mining at Tonopah*, authored by Jay Carpenter and completed 2 years after his retirement, became the last of this series. Beginning in 1957 publications of the Nevada Bureau of Mines were issued under the Bureau's name—not as publications of the University of Nevada. Bulletins were issued in numerical sequence with the old Geology and Mining Series; the first issued therefore became Nevada Bureau of Mines Bulletin 52. Rising printing costs brought about a new publication series in 1961. Issued as "reports," the new series was designed to present information on more limited topics, to be more timely in releasing information, and to be less formal in presentation than were the bulletins. In 1962 a "map" series was added to the Bureau's publications. The map series was at first dominated by commodity location maps--15 separate commodity maps were issued during the first year of the series--but other maps showing power and transportation facilities, metal mining districts, land status, status of geologic mapping, and earthquake epicenters were also issued, and in 1967, the first of a series of 2°-sheet-scale gravity maps was released.

#### THE MODERN BUREAU

By 1960, the activities of the Nevada Bureau of Mines had expanded to the point that a full-time administrator was needed and Dr. S. E. Jerome was brought in as Associate Director. Dean Scheid, retaining the title of Director, continued to guide the





The old U.S. Bureau of Mines Experiment Station, now the Physical Plant Building, was occupied by the Nevada Bureau of Mines between 1955 and 1962. Source: UNR archives.

major policies of the Bureau. The new Associate Director, however, handled all other administration. Scheid also continued as Director of the State Analytical Laboratory. Dr. Jerome received his Ph.D. from the University of Utah and had worked in mineral exploration throughout most of the western United States before joining the Nevada Bureau of Mines.

In 1963, the Bureau moved into offices in the new Scrugham Engineering-Mines Building constructed directly east of the old Mackay School of Mines Building. Dean Scheid, through persistent negotiations with Nevada legislators, had managed to have an entire wing of the new building earmarked for the use of the Nevada Bureau of Mines and the State Analytical Laboratory. The Bureau in 1987 occupies most of the four floors of the mines wing of this building.



Scrugham Engineering-Mines Building. The Nevada Bureau of Mines and the State Analytical Laboratory moved into the western wing of this building in 1962. At the present time, the combined Nevada Bureau of Mines and Geology and the mining laboratory occupy the first, third, fourth, and most of the second floors of the mines wing of this building; the remainder of the building houses the College of Engineering. Source: Larry Jacox.

Jerome left the Bureau of Mines in 1965, returning to industry where he became head of mineral exploration for

the Kerr-McGee Corp. Robert C. Horton followed Jerome and became the second Associate Director of the Bureau; Horton, a 1949 graduate of the Mackay School of Mines, had joined the Bureau as a mining engineer in 1956. Horton was born in Tonopah and came from a Nevada mining family. His father had mined in Diamondfield and Goldfield and, in 1927, his older brother had made discoveries on the father's claims southwest of Tonopah that resulted in one of Nevada's last boom gold camps--Weepah. Horton served as Associate Director for only 2 years, leaving in 1967 to pursue private interests. In 1981, he was appointed Director of the U.S. Bureau of Mines by President Reagan and served in that capacity until 1987.

Arthur Baker, III, replaced Horton as Associate Director of the Nevada Bureau of Mines and held the position until 1972. Baker, with a Ph.D. in geology from Stanford University, had worked in mineral exploration for many years and, prior to joining the Bureau, had operated his own consulting practice out of Bishop, California.

In 1971, during Baker's tenure as Associate Director, the state legislature modified the objectives of the Bureau, making changes which signified the changing image of the organization. The name was expanded from Nevada Bureau of Mines to Nevada Bureau of Mines and Geology, and the qualifications for director were changed from "competent mining engineer" to "competent scientist or engineer." Two other sections of the assembly bill outlining these changes carried more importance than did the name changes. The Director of the Bureau, with only the Governor's approval, was authorized to enter directly into agreements with the U.S. Geological Survey for cooperative work; funds for the state portion of this venture would be through direct legislative apportionment. The resulting

cooperative program with the U.S. Geological Survey has assisted topographic mapping in Nevada, contributed to water resources studies, and furthered the research efforts of both agencies in the fields of general geology and mineral resources. Authorization was also given to the bureau, subject to regents approval, to allow publication sales money to be retained as a printing and distribution fund. This latter point has allowed the Bureau great flexibility in its publication efforts.

Vernon Scheid retired as Dean of the Mackay School of Mines in 1972, vacating as well the positions of Director of the Nevada Bureau of Mines and Director of the State Analytical Laboratory. Arthur Baker moved into the position of Acting Dean in 1972, and in 1973, became the second dean of the Mackay School of Mines.

John H. Schilling replaced Baker as Associate Director of the Nevada Bureau of Mines in 1972. When Baker assumed the Dean's position in 1973, Schilling was appointed Director of both of the school's public service divisions, the first Director to hold both of these positions who was not also the head of the School of Mines. John Schilling reported to the Dean, but he operated the Bureau and Laboratory as units quite separate from the school's teaching division. John Schilling joined the Nevada Bureau of Mines in 1960. He was previously with the New Mexico Bureau of Mines and had done extensive work on the mineral deposits, especially molybdenum, of that state. During Schilling's time of service, the Nevada Bureau evolved into its present form. The staff expanded to over 20 professional and support personnel. Public information services increased to a point where information files now occupy a good portion of one entire floor of the building, and the Bureau has computer ties with geologic data bases of the U.S. Geological Survey, the U.S.



John H. Schilling, Director of the Nevada Bureau of Mines and Geology, 1972-87, and of the State Analytical Laboratory, 1972-85. Source: John Schilling.

Bureau of Mines, and others. One of John Schilling's special interests was a strong publications program, and during his time as Director, the Nevada Bureau of Mines and Geology maintained a high profile among other state bureaus with the quality and quantity of its publications. In 1973 a new "urban map" series was issued. Maps in this series cover such things as geologic hazards, land use, vegetation, and hydrology and are of special use to land-use planners in urban areas. A "special report" series was started in 1975. Publications in this series include general interest subjects such as a rockhound's map of the state, a treatise on Nevada's weather and climate, mining claim procedures in the state, and a bibliography on geology and mineral resources of Nevada. In 1979, the Bureau began a system of releasing

information as open-file documents, a procedure that allows research results to be quickly made available for public use. With these additions the Bureau now publishes information in six formats; bulletins, reports, special publications, maps, urban series maps, and open-file reports. Several of each category are now issued each year and selected publications are reprinted as they are sold out.

In 1985 another major organizational change came about within the School of Mines. The State Analytical Laboratory, after 90 years of service, was abolished by the state legislature and its functions, personnel, and equipment were transferred to the Bureau of Mines and Geology. Although always used to some extent by the prospectors of the state to assay their ore samples, the Laboratory's public service function had been declining for many years. In 1981, the practice of providing free sample analysis had been stopped and fees thereafter charged, although minimal, had caused a further decline in use. With its functions transferred to the Bureau, the laboratory still provides mineral identification and ore sample analysis for prospectors, but its main service is now research and support for the Bureau of Mines and Geology.

In May 1987, after 27 years with the Nevada Bureau of Mines and Geology--the last 14 of these as its Director--John Schilling left the service of the Bureau. Upon Schilling's departure James V. Taranik, then Dean of the Mackay School of Mines, assumed the position of Acting Director of the Bureau. Larry J. Garside was appointed Acting Associate Director. Garside received his graduate degree in geology from the Mackay School of Mines in 1968 and joined the bureau staff that same year. He had held positions with the Bureau as geologist, energy resources geologist, deputy to the director for research, and, at the time he was appointed Acting

Associate Director, was serving as Chief Geologist.

In July 1987 Taranik, who had replaced Arthur Baker as Dean of the Mackay School of Mines some 3 years earlier, resigned to assume the presidency of Desert Research Institute, another branch of the University of Nevada. James L. Hendrix, head of the Department of Chemical and Metallurgical Engineering within the Mackay School of Mines, will serve as Acting Dean of the school until a permanent dean can be selected in 1988. Hendrix also assumed the Acting Director's position while Garside continued to serve as Acting Associate Director and will hold the position until a permanent director is selected in 1988.

#### FINALLY, A STATE GEOLOGIST

The title "State Geologist" returned to use in Nevada in 1981 when it was assumed by John Schilling. Schilling was active in the Association of State Geologists and, since the Director of the Nevada Bureau of Mines and Geology essentially functioned as a State Geologist, he began to use "State Geologist" as part of his title in June 1981. The University regents, perhaps drawing upon authority granted to them by the legislature in 1865\*, recognize the use of this title and when a new head of the Nevada Bureau of Mines and Geology is selected in 1988 the position will be described as Director/State Geologist, Nevada Bureau of Mines and Geology.

\*The act providing for the appointment of a state geologist by the board of regents, passed by the legislature in 1865, was apparently never repealed--the office was never filled until assumed by John Schilling in 1981. In reality, however, the 1865 statute is interpreted to have created the position of state geologist only to do a certain task which was to last no longer than 8 months--at the end of the 8-month job the position would have passed out of existence. Even though the job was never filled, it must have expired since the first compilation of Nevada statutes in 1873 makes no reference to the position of state geologist.

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- Stretch, R. H., 1867, Annual report of the State Mineralogist of the state of Nevada for 1866: State Printing Office, Carson City.
- White, A. F., 1869, Report of the State Mineralogist of Nevada for the years 1867-1868: State Printing Office, Carson City.



## NEW HAMPSHIRE

Office of the State Geologist, University of New Hampshire, 117 James Hall,  
Durham, NH 03824. Phone 603-862-3160.

### HISTORICAL SEQUENCE OF ORGANIZATIONAL NAME:

Geological and Mineralogical Survey of the State, 1839-78  
New Hampshire Department of Resources and Economic Development, 1942-87  
Department of Environmental Services, 1987-present

### NAMES AND TITLES OF ORGANIZATIONAL DIRECTORS AND DATES SERVED:

Charles T. Jackson, State Geologist, 1839-44  
C. H. Hitchcock, State Geologist, 1868-78  
T. R. Meyers, Geologist, 1942-63  
Glenn W. Stewart, Geologist, 1963-67; State Geologist, 1967-79  
Robert I. Davis, State Geologist, 1979-84  
Lincoln R. Page, State Geologist, 1984-86  
Eugene L. Boudette, State Geologist, 1986-present

### THE HISTORY OF THE NEW HAMPSHIRE GEOLOGICAL SURVEY

The New Hampshire State Geologist has always served as a one-man operation. In fact, until 1987, the position was funded as a half-time position, with the other half assigned to duties with the University of New Hampshire Geology Department. Despite such limited manpower, the Office of the State Geologist has issued a number of highly regarded area and quadrangle geologic reports and maps, as well as a widely acclaimed state geologic bedrock map and a state

surficial geology map. Much of the geologic mapping in New Hampshire has been achieved through the engagement of summer services provided by professors and students, as well as the U.S. Geological Survey. Thus, the publications record of the New Hampshire Office of the State Geologist far exceeds what one might expect from a one-man State Survey.

Now that New Hampshire has become environmentally conscious and has doubled its regular staff size (from a half-time to a full-time position), it is projected and hoped that this phenomenal rate of growth will continue.

## NEW JERSEY

New Jersey Geological Survey Element, Water Resources Division of Department of Environmental Protection, Box CN-029, Trenton, NJ 08625. Phone 609-292-1185.

### HISTORICAL SEQUENCE OF ORGANIZATIONAL NAME:

Rogers Survey, 1835-40  
 Kitchell Survey, 1854-56  
 Geological Survey of New Jersey, 1864-1915  
 Division of Geology and Waters, Department of Conservation and Development, 1915-25  
 Division of Geology and Topography, Department of Conservation and Development, 1925-47  
 Bureau of Geology and Topography, Division of Planning and Development, Department of Conservation and Economic Development, 1947-61  
 Bureau of Geology and Topography, Division of Resource Development, Department of Conservation and Economic Development, 1961-71  
 Bureau of Geology and Topography, Division of Water Resources, Department of Environmental Protection, 1971-74  
 Bureau of Geology and Topography, Commissioner's Office, Department of Environmental Protection, 1974-79  
 Bureau of Geology and Topography, Division of Water Resources, Department of Environmental Protection, 1979-81  
 Geological Survey Element, Division of Water Resources, Department of Environmental Protection, 1983-present  
 New Jersey Geological Survey is still used informally.

### NAMES AND TITLES OF ORGANIZATIONAL DIRECTORS AND DATES SERVED:

Henry D. Rogers, State Geologist, 1835-40  
 William Kitchell, State Geologist, 1854-56  
 George H. Cook, State Geologist, 1864-89  
 John C. Smock, State Geologist, 1889-1901  
 Henry B. Kummel, State Geologist, 1901-37  
 Meredith E. Johnson,<sup>1,2</sup> State Geologist, 1937-58  
 Kemble Widmer,<sup>2</sup> State Geologist, 1958-80  
 Frank Markewicz,<sup>2</sup> Acting State Geologist, 1981-83  
 Haig F. Kasabach,<sup>2</sup> Acting State Geologist, 1984-86; State Geologist, 1986-present

<sup>1</sup>and Chief, of Division of Geology and Topography, 1937-47.

<sup>2</sup>and Chief, Bureau of Geology and Topography.

### HISTORY OF THE NEW JERSEY GEOLOGICAL SURVEY

By I. G. Grossman

New Jersey, one of the first states to join the Union, was also one of the first to have a Geological Survey. It is

believed to be the second oldest state survey in terms of continuous operation. In 1835, following enabling State legislation, the Governor appointed Henry Darwin Rogers State Geologist. His office was, like most of the early state and federal Surveys, a temporary

one; his task was "to provide a geological and mineralogical survey of the State of New Jersey." Professor Rogers was one of four brothers who distinguished themselves in science, two of them in geology.



Henry D. Rogers  
1835-40

Rogers laid out five traverses covering the State in an east-west direction, although the pioneering map of the eastern United States by Maclure, published in 1809, had shown that the regional strike was northeast. Rogers' first annual report appeared in 1836. His field work extended several miles on both sides of his five traverses and was completed in 1839. He drew geologic sections to illustrate the distribution of formations. His final report, published in 1840, had 300 pages and included a colored geologic map. The report divided the State into northern and southern regions along a line extending northeastward from the Delaware River, near Trenton, to the Raritan River, near New Brunswick. This line, which he was among the first to recognize, roughly coincides with much of what came to be called the "Fall Line." Northwest of this line he

identified three formations he called the "Middle Secondary Strata" in what is now called the Piedmont Province. Northwest of these lay the "Primary Rocks" in what is now dubbed the New Jersey Highlands. Northwest of these lay "Older Secondary or Appalachian Rocks" in what is now known as the Valley and Ridge. In the "Appalachian" rocks, he identified six strata. Most of the strata in the southern half of the State he assigned to the latest period of the Secondary formations. These, with the exception of a few shallow local deposits of "later Tertiary date" were subdivided into five strata. He recognized that these dipped southeastward toward the Atlantic Ocean. Despite subsequent changes in stratigraphic nomenclature, Rogers' studies built a secure foundation for all later work in the State.

Rogers' report dealt with the economic geology of each region. For example, he mapped the greensand marl extending northeastward from the Delaware River near Salem to Raritan Bay and stressed its use as a fertilizer. Most of his report dealt with the identification and location of the minerals and rocks that had been found in the State. He also included some theoretical speculations on the origin of some of the formations and deposits. In some instances, his catastrophism led him astray; it led him to believe, for example, that the trap dikes had burst through the sandstone and shale. His ad hoc survey ended with his final report.

In 1854, a special committee of the New Jersey legislature authorized a new survey and William Kitchell, a teacher at Newark Institute was appointed Director. He was a nonpracticing medical doctor who had studied natural science in Germany. Kitchell opted to do his work in the northern half of the State and appointed George H. Cook, the newly hired Professor of Chemistry and Natural Science at Rutgers College, to be his

## Summary of the Nine State Geologists of New Jersey

Name	Life Span	Remarks
Henry D. Rogers	1808-66	Appointed State Geologist of Pennsylvania in 1836.
William Kitchell	1827-61	Worked without salary when appropriations were suspended by legislature in 1860. Died of pneumonia in 1861.
George H. Cook	1818-89	Also worked without salary from 1863 to 1864, after which legislature restored funding.
John C. Smock	1842-1926	Worked for the Survey for 33 years; the last 12 as State Geologist.
Henry B. Kummel	1867-1945	First President of the Association of American State Geologists. Served the longest as State Geologist; 36 years.
Meredith E. Johnson	1898-1975	Worked for the Pennsylvania Geological Survey for 6 years before coming to New Jersey.
Kemble Widmer	1913 - living	Has lectured extensively on American Revolutionary history following his retirement.
Frank Markewicz	1921 - living	Actively engaged in consulting and volunteer work following his retirement.
Haig F. Kasabach	1935 - living	Present incumbent; started work with the New Jersey Geological Survey in 1960.



William Kitchell  
1854-56

assistant and to survey the southern half. Kitchell also hired Lieutenant Egbert L. Viele, a topographical engineer who was a recent graduate of West Point, and Dr. Henry Wurtz a chemist-mineralogist. It is noteworthy that Kitchell organized the first state-sponsored topographic survey in the

United States. The topography **and** the geology of the State were to be mapped on a county basis, starting with Cape May County in the extreme southern part of Cook's area. Meanwhile, Kitchell pursued his field work in the northern part of the State. He substituted the terms "Azoic" for Rogers' "Primary Rocks" and "Paleozoic" for his predecessor's "Older Secondary Strata." He took advantage of the careful work done by the New York Survey and traced their contacts and formations southwestward into New Jersey. However, economic considerations clearly needed emphasis, so Kitchell updated Rogers' descriptions of the iron, copper and zinc deposits, and described numerous active iron mines. Despite the pressures of field work, Kitchell managed to complete three annual reports. His contributions to pure science were meager, probably because of his short tenure, though he was the first to point out the importance of the alga, *Chara*, in precipitating calcium carbonate and forming fresh-water marls. Most of the Survey's stratigraphic work was done by Cook, who, among other things, updated



Rogers' marl studies. He also investigated the apparent gradual encroachment of the sea in Cape May County and estimated that the coast was subsiding at the rate of about 2 feet a century. His complete report on Cape May County was published in 1857, accompanied by Viele's topographic map. Kitchell's plan to map the geology and topography of the State on a county-by-county basis was far too ambitious, given the resources available at the time. In 1856, appropriations were abruptly suspended by the legislature so that the office of State Geologist was abolished. However, in 1860 Kitchell obtained approval from the legislature to continue work on the survey, at his own expense, under the auspices of the State Agricultural Society. He was allowed the use of the apparatus and materials belonging to the State survey. Kitchell died suddenly in 1861.



George H. Cook  
1864-89

In 1863, the legislature authorized George H. Cook to continue Kitchell's project. Cook also worked without a salary and at his own expense, until 1864. In that year, he presented his

report "Upon the Geological Survey of New Jersey and its progress during the year 1863." This so impressed the legislature that it restored funding for the Survey, reimbursed Cook for his 1863 expenses, and appointed him State Geologist. Cook submitted annual reports each year from 1864 to 1867 and followed up with a final report "The Geology of New Jersey" in 1868. This major work, which was published the same year, was divided into three parts: (1) a geologic description of the State, (2) economic geology, and (3) "historic" geology. The economic geology part included many pages on the flourishing iron and zinc mines and also included information on water supply. The report was accompanied by a portfolio of eight maps. Cook had studied the marl formations and the economic geology section contained chemical analyses of marls from about 100 sites together with 9 illustrated sections of marls. He rejected the previously assigned Cretaceous age for the upper marls and reassigned them to the Eocene or earliest Tertiary series, based on their fossil content. He recognized the fine quality of Cretaceous clay extending across the state and pointed out that it was just as good as the expensive foreign clays that were being imported by manufacturers of crucibles and glass pots. Cook's strong emphasis on economic geology so impressed the legislature that a much more extensive work was authorized. However, Cook by no means confined himself to practical economic work. His "Geology of New Jersey" contained detailed descriptions of the Precambrian, Paleozoic and Triassic Formations. He rejected Lyell's attribution of the drift to marine deposition and agreed with Louis Agassiz that it had been deposited by a continental ice sheet. Cook, assisted by John Smock, began mapping the terminal moraine in New Jersey in 1877. Cook also mapped the moraine westward into eastern Pennsylvania

and eastward across Staten Island and Long Island, New York. In the 1880 report of the Geological Survey, he also described glacial Lake Pequest and glacial Lake Passaic.

In the 1870's Cook made a water-supply study of the Passaic River basin upstream from Little Falls and showed that enough lakes and reservoir sites were available to provide ample supplies of potable water. Water supplies were also needed by communities near the coast and this required a knowledge of ground water. Cook knew that the marl beds at Kirkwood were 70 feet above sea level and dipped gently seaward at a rate of 25 feet per mile. Based on a southeastward projection of 45 miles to Atlantic City, he estimated that the marl should occur at a depth of about 1,055 feet below tide level and fresh groundwater should be found at a depth of 1,055 to 1,125 feet. Subsequent drilling successfully encountered fresh water and made possible the development of seaside communities. Cook was able to continue his important contributions because the legislature renewed his mandate several times. In effect, the survey became a permanent part of the state government after 1864.

Cook, like his predecessor, recognized the importance of topographic mapping in the state, both as an aid in geologic mapping, and as a spur to economic development. By 1875, he was ready to abandon piecemeal mapping of small areas and initiate topographic mapping of the entire state. He placed the mapping under the direction of Cornelius C. Vermeule, topographic engineer. He also took advantage of a federal law passed in 1871 providing triangulations by the U.S. Coast Survey for states that were conducting their own surveys. Thereupon, the Coast and Geodetic survey proceeded to work in New Jersey at Cook's direction and utilizing his staff. Under this fiscal arrangement, the federal government

paid for the triangulations and the state financed the topographic survey. In 1884, the U.S. Geological Survey began a program of topographic mapping of the entire country. The federal survey agreed to fund all of the remaining work in the state in return for copies of the maps that New Jersey had already completed, covering about half the state. Finally, in 1887, the state was completely covered by 17 overlapping topographic maps on the scale of 1 inch to the mile. New Jersey thus has the distinction of being the first state to have had a topographic map of a quadrangle and also the first to have had complete topographic map coverage of the entire State.

Cook continued to pursue a vigorous program for the more extensive publication authorized by the state although he was busy in his dual position as State Geologist and Vice President and Professor of Chemistry, Natural History and Agriculture at Rutgers College. A first volume, *Topography, Magnetism and Climate* appeared in 1889. That same year, Cook, laden with honors, died. He had served as State Geologist for 25 years. The last volume of the eight-volume *Final Report of the State Geologist* series entitled *Surface Deposits* did not appear until 1916.

John Conover Smock, a graduate of Rutgers College, succeeded Cook as State Geologist and Director of the Geological Survey in 1889. Smock had been Cook's assistant for 21 years, from 1864 to 1885, and had helped him map the terminal moraine in New Jersey. During this period, Smock was also on the staff of Rutgers College. He and Cook were the first to recognize that the glacial deposits in New Jersey represented the effects of more than one ice sheet. They also collaborated in tracing the extent of Glacial Lake Pequest and Glacial Lake Passaic. Smock was especially interested in the thickness of the ice and studied its

effects elsewhere, in the Catskills of New York State. He concluded that the great ice sheet that had occupied the Hudson River valley had had a thickness of 3,000 feet and that it had thinned to the south, to a maximum thickness in northern New Jersey of about 1,200 to 1,300 feet.



John C. Smock  
1889-1901

In 1885, Smock resigned to accept an appointment as Assistant State Geologist of New York under James Hall. As such, he was in charge of the New York State Museum. He returned to New Jersey in 1889, when Cook died, to become State Geologist. Smock moved the Survey and the "State Mineral Cabinet" or museum of the Geological Survey to Trenton; thus, for the first time separating the Survey from Rutgers. The Geologic Museum became the State Museum in 1895. He arranged a division of labor with the U.S. Geological Survey; the federal survey mapped the bedrock formations of New Jersey and the state survey mapped the surficial deposits. He collaborated with Professor R. D. Salisbury in completing his glacial mapping. Smock hired Lewis Woolman

to study the burgeoning number of wells on the New Jersey Coastal Plain. Woolman identified most of the aquifers of the Coastal Plain and mapped their extent in New Jersey during the 1890's. Smock also hired Dr. Henry B. Kummel as Assistant State Geologist. Under Smock's administration, C. C. Vermeule completed and published a major work on the Water Supply and Water Power of New Jersey. In 1892 Smock was sent to Holland to study the reclamation of drowned land as a prelude to improving New Jersey's Hackensack Meadows. In 1890 he hired Gifford Pinchot to study the forest resources of the State. Indeed, from 1894 to 1906, the Survey assumed most of the responsibilities of a forestry service.

Only about 10 scientific articles or reports on the geology of New Jersey bear Smock's name. This underrepresentation of his major contributions is due, in large part, to the subsumption of his earlier work in the "Annual Reports" under Cook's authorship. This obscured the fact that the early geologic maps were based on much of his work. Whether he smarted under this arrangement is not known. However, when he later became State Geologist, he was scrupulous in granting credit, in print, to work done by others.

Smock retired in 1901. After retirement, he grew interested in classical studies, especially the influence of Greek on the English language. He completed a work on the Greek roots of scientific words just before he died in 1926.

Henry B. Kummel, the fifth State Geologist, was from Wisconsin but he received early training in the geology of New Jersey when he mapped some of the state's glacial deposits in 1893 under the direction of Professor Rollin D. Salisbury, of the University of Chicago. In 1896 Kummel received his Ph.D. from that newly-built university, following acceptance of his dissertation



Henry B. Kummel  
1901-37

titled *Lake Passaic - an extinct glacial lake [in New Jersey]*. From 1896 to 1899 he was Assistant Professor of Physiography at Lewis Institute in Chicago, but he returned to New Jersey each summer for the field season. Kummel's mapping of the Triassic rocks of central and northern New Jersey at this time became his best-known professional work. In 1889, he became Assistant State Geologist and moved permanently to his adopted state.

When Smock retired in 1901, Kummel became State Geologist. Little more than a year later he had a premature brush with death. In 1903, he and his party were caught in a late autumn snowstorm in the Uinta Mountains of southern Wyoming. The party turned back and managed to reach civilization, thereby enabling Kummel, who had fallen ill with a



Henry Kummel doing field work on horseback in August 1902.  
Photo probably by Rollin D. Salisbury.



serious case of typhoid, to survive because he was able to get medical help quickly.

In 1922, Kummel received a second title and also added responsibility as Director of the New Jersey Department of Conservation and Development. His administrative duties as director of a large state agency were heavy, but he maintained his interest in geology and in the Survey. The Annual Reports had been discontinued in 1910 in favor of a program of publishing bulletins on specific subjects, a program he continued and one maintained to this day. Also, under Kummel, the Atlas Sheet series was finally completed. A Geodetic Monument System had been established for New Jersey in 1854 but it had deteriorated to near uselessness by 1900. The current geodetic system was established under the Works Progress Administration in 1935. The system was turned over to the New Jersey Geological Survey in 1935.

Kummel was a veteran photographer who took hundreds of photographs to illustrate the geology and physiography of his adopted state. Many of his older negatives, on 8- by 10-inch glass plates, are still on file at the Geological Survey. He retired in June 1937, having served in the lead position for 35 years, longer than anyone before or since. His bibliography lists 47 titles. Many of these were necessarily administrative or data reports, but at least 15, including his revision of "The Geology of New Jersey" were basically interpretive. He was a member of numerous civic and scientific organizations and served as officer or member in many local, state, and federal organizations. He died, greatly honored and esteemed, in 1945.

Meredith Johnson, the sixth State Geologist, was born in the mountains of eastern Tennessee where his father was manager of an iron company at Embreeville. He received an E.M. degree from Lehigh University and also



Meredith E. Johnson  
1937-58

studied at Harvard. He worked for the Pennsylvania Survey from 1921 to 1927 and became Assistant State Geologist of New Jersey in 1928. When Kummel retired in 1937 Johnson succeeded him. The Great Depression and resulting cutbacks in state expenditures soon reduced the entire State Geologic Survey to two people--Johnson and his secretary! He later rebuilt the staff to 11.

He continued the Survey's emphasis on economic geology and considered one of the major achievements of his administration the discovery of some workable ilmenite deposits in the state. Under Johnson's direction, the Survey also studied projected reservoir sites, such as those at Round Valley and Spruce Run. He also secured passage of a well-drilling law which provided invaluable data on subsurface conditions and ground water.

Despite administrative duties, he made it a point to get out into the field one day a week, if at all possible. This caused a narrow escape from death in July 1952 when he and an assistant, Henry Herpers, were inspecting an old

quarry north of the Delaware Water Gap. They inadvertently touched a low-dangling high-tension line concealed by brush. Johnson was knocked unconscious for about an hour and Herpers was killed. Johnson suffered third degree burns but recovered and continued to serve as State Geologist until he retired in 1958. His bibliography includes about 30 reports, of which about a dozen are data compilations of mineral and rock production in the state. He died in Greene, Rhode Island, in July 1975 at the age of 77.



Kemble Widmer  
1958-80

Kemble Widmer became State Geologist when Johnson retired. Widmer was born in New Rochelle, New York, in 1913. He graduated from Lehigh University (A.B. in Geology) in 1937 and did postgraduate work at Stanford University (1937-39). He entered the U.S. Army as a Second Lieutenant in 1941 and came out as a Lieutenant Colonel in 1945 at the end of World War II. He continued his geologic studies at Princeton and received an M.A. (1947) and Ph.D. (1950).

During his early professional years, his summers were spent working for the Newfoundland Geological Survey (1937-41, 1946, and 1947). He was Assistant Professor of Geology at Rutgers University (1949-51) and Associate Professor of Geology at Champlain College, State University of New York (1951-53). He became Principal Geologist with the New Jersey Geological Survey in 1953 and State Geologist in 1958.

Under his leadership, revision of all the mile-to-the-inch topographic maps of New Jersey was completed. Widmer believed in enforcing State laws requiring licenses for drillers and permits for drilling. He went out into the field, accompanied by State Troopers, to remedy lax enforcement. After a few summonses were handed out, word got around and compliance improved. Widmer also started a program of study on erosion of New Jersey's shoreline. A crew of four spent summers taking samples along the coast. Another innovation was the distribution of small sets of New Jersey rocks to schools in the State; these were sold at \$5.00 per set.

On a more technical level, he introduced the "Land Oriented Reference Data System" (LORDS) in 1974. This is a data bank of environmental information, which includes six semitransparent overlays for each state atlas map. The six overlays are (1) land use, (2) geology, (3) water service areas and public-water-supply wells, (4) sewer service areas, sewage treatment plants and sanitary landfills, (5) surface-water drainage, drainage-basin boundaries and flood-prone areas, and (6) population density and market roads.

Widmer retired on the last day of 1980. He had maintained his reserve officer status as a Colonel in the U.S. Army through the years and had become Adjunct Professor in the Department of Earth, Space, and Graphic Science at the U.S. Military Academy at West Point. In addition to

his numerous professional geologic and geographic affiliations, he is a Fellow of the Company of Military Historians. He did a little consulting work after retiring but his interest in American Revolutionary history won out. He has given over 50 speeches on the subject in his first six retirement years. His bibliography includes about a dozen papers on the geology of New Jersey. He has also authored a popular book *The Geology and Geography of New Jersey*.



Frank J. Markewicz  
1981-83

Frank Markewicz became Acting State Geologist in 1981 following the retirement of Kemble Widmer. Markewicz was born in Newark, New Jersey, in 1921. During World War II, he served for 4 years in the U.S. Navy aboard aircraft carriers in the southwest Pacific. He graduated from Upsala College in 1950 with majors in geology and economics. While still a sophomore in college, he worked for the U.S. Geological Survey during the field season. He spent four summers with the USGS, chiefly mapping the geology of coal deposits on the Kenai Peninsula in Alaska.

His field work for the Survey resulted in several significant contributions. From 1957 to 1965, he discovered and, with the help of an assistant, mapped three major ilmenite deposits in the state, of which two were commercially exploited. During the late 1950's and early 1960's, he supervised engineering geology studies at reservoir sites on Spruce Run and Round Valley. After the State Division of Fish and Game had vainly searched for a large supply of water for a new fish hatchery, Markewicz discovered a major aquifer, supplying the requisite quantity, 6 to 7 million gallons per day, near the Pequest River. The subsurface supply proved to meet all the water quality requirements for this major hatchery. He also subdivided a complex sequence of dolomitic limestone, 4,000 feet thick, into formations and members. It is now known as the Kittatinny Supergroup. The subdivision made possible the drilling of high-capacity wells in targeted units. "Mark," as he was popularly known, was promoted to Acting State Geologist in 1981. He retired in 1983 and has since done consulting and volunteer work. He is the author of 12 publications.

After serving as Deputy State Geologist in 1983 and Acting State Geologist during 1984-86, Haig F. Kasabach was appointed State Geologist in 1986. He had completed Bachelor's and Master's degrees from the University of Michigan before he joined the New Jersey Geological Survey in 1960. He completed several ground-water reports and subsurface maps for the Survey before joining the Division of Water Policy and Supply in 1966 as the State's first hydrogeologist. He worked on several ground-water recharge and dam projects and provided hydrogeologic expertise to the State for allocation of ground water. In 1974 he organized a new ground-water investigation unit in the Division's Enforcement Element, which for the



Haig F. Kasabach  
1984-present

first time began prosecuting ground-water polluters and remediating ground-water contamination.

In 1977 he became Chief of the State Bureau of Water Quality Planning and Management which investigated ground-water contamination and pioneered the use of bioassays for regulatory purposes. In 1980 he organized the Bureau of Ground Water Management which issued the State's first permits to discharge to ground water and which provided support to the enforcement units. When the Governor declared a building moratorium to save New Jersey's 1.1-million-acre Pinelands in 1979, the Bureau controlled growth in the area by utilizing ground-water models and information on ambient water quality to effectively control development until the Pinelands Commission could implement a plan in 1981. In 1983 Kasabach rejoined the Geological Survey when it merged with his Bureau and all regulatory functions were transferred to other agencies. This merger tripled the size of the Geological Survey to about 50 and made it an

integral part of the Division of Water Resources.

Increased funding from a State Water Bond Act in 1984-85 enabled the Survey to expand its ground-water program and embark on several ground-water studies under a cooperative program with the U.S. Geological Survey. Concurrently, the Survey concluded a cooperative agreement with the USGS to revise the State Geologic map which had not had a major revision since 1906. Seven new geologists were recruited to work with USGS staff to complete the field work on the map in 5 years. Fledgling geophysics and drilling programs also were expanded at this time through the acquisition of new equipment and by recruitment of geophysicists and well drillers.

Major new Federal and State water-pollution laws caused a tremendous demand for hydrogeologists to assist in ground-water pollution investigations. To avoid duplicating the Survey's tremendous investment in equipment and specialized services, the Department of Environmental Protection decided to concentrate all groundwater pollution investigatory work within the Geological Survey. This centralization expanded the staff to 65 professionals and 20 support staff and has provided the Survey with new quarters, which include laboratories as well as maintenance facilities for three drill rigs.

In March 1988, all ground-water pollution work formerly performed for the Division of Water Resources and other DEP agencies was transferred to the regulatory arm of the Division along with the staff from the Bureau of Ground-Water Pollution Analysis. All ground-water and surface-water monitoring programs, including the Division's biological and shellfish laboratories, were transferred to the Geological Survey.



## NEW MEXICO

New Mexico Bureau of Mines & Mineral Resources, Division of New Mexico  
Institute of Mining & Technology, Campus Station, Socorro, NM 87801.  
Phone 505-835-5420.

### HISTORICAL SEQUENCE OF ORGANIZATIONAL NAME:

Established by Laws of New Mexico 1927, Chapter 115, March 14, 1927

### NAMES AND TITLES OF ORGANIZATIONAL DIRECTORS AND DATES SERVED:

Edgar H. Wells, Director, President New Mexico School of Mines, 1927-39  
Claude E. Needham, Director, President New Mexico School of Mines, 1939-42  
John M. Kelly, Director, April-August 1942  
Richard H. Reece, Director, President New Mexico School of Mines August  
1942-March 1944  
John M. Kelly, Director, March 1944-January 1945  
Abner D. Haun, Acting Director, January 1945-July 1945  
E. Carter Anderson, Director, July 1945-September 1949  
Eugene Callaghan, Director, September 1949-January 1957  
Alvin J. Thompson, Director, February 1957-July 1968  
Frank E. Kottlowski, Acting Director, July 1968-June 1969  
Don H. Baker, Jr., Director, July 1969-July 1973  
Frank E. Kottlowski, Acting Director, July 1973-February 1974;  
Director, February 1974-present

### NEW MEXICO BUREAU OF MINES AND MINERAL RESOURCES

Originally designated a department of the New Mexico School of Mines, the New Mexico Bureau of Mines and Mineral Resources (NMBM&MR) was established by the New Mexico Legislature March 14, 1927 (Section 3, Chapter 115, Laws of New Mexico 1927). During the first 17 years, the Bureau's Director was the President of the New Mexico School of Mines. In 1927 the first Director, Edgar H. Wells, and four other part-time employees comprised the entire Bureau staff; all were also employees of the School of Mines. The positions they filled in the Bureau were a Director, two geologists, a librarian-statistician, and a stenographer. Projects that first year included beginning a bibliography of New Mexico geologic literature;

starting field investigations in Taos, Rio Arriba, and Santa Fe Counties, and the Magdalena district of Socorro County; and doing field investigations on deposits of mica, lithium, and fluorspar.

In July 1928 most of the Bureau's records and library were destroyed by fire, including the almost-completed report on mica and lithium. All notes and maps for that report also were lost. While insurance covered some of the property damage, information on the accomplishments for the Bureau's first year was forever lost. Second-year projects included expansion of the Magdalena district field investigation, resuming work on the New Mexico bibliography (published in 1930 as Bulletin 5), and working with the New Mexico State Tax Commission in its appraisal of state mining properties. Bulletin 4 *Fluorspar in New Mexico* was published in 1928--the first of the

Bureau's technical reports. (Bulletins 1-3 were published by the School of Mines as part of the New Mexico Mineral Resources Survey, prior to the establishment of the Bureau.)

During the Bureau's third year, the first full-time staff member, Samuel G. Lasky, was employed. Projects of the first 2 years were continued and more new ones were initiated. A report of these first 3 years was made to the Legislature in the Bureau's Circular 3, published in 1931.

For the 1931-46 period, annual reports were not issued. Consequently, our knowledge of these years is limited. In 1939, after the death of President Wells, Claude E. Needham became President of the School of Mines and Director of the Bureau. Dr. Needham resigned in 1942 and was replaced as Director by John M. Kelly, then State Geologist (when the Oil Conservation Commission was formed, the title of State Geologist was given to its director, although that person has only a few times been a geologist, and the duties are mainly regulatory petroleum engineering). Mr. Kelly's appointment was on a temporary basis. Later that year Richard H. Reece became President and Director. In 1943 the first group of permanent full-time staff members was hired. In 1944 President Reece resigned as Director of the Bureau, and Mr. Kelly (a petroleum engineer) was reappointed Director. Because he was also State Geologist, Mr. Kelly maintained an office in Santa Fe, while the rest of the Bureau remained in Socorro--the only time the director has lived outside of Socorro. Prior to this time the directorship of the Bureau had always been a part-time duty of the President of the New Mexico School of Mines.

In January 1945 the Bureau was placed under a part-time Acting Director, Abner D. Haun; in July of that year a full-time director, E. Carter Anderson, a mining engineer, was

appointed. During the fiscal year 1945-46, the staff consisted of eleven full-time employees, and the Bureau was organized into an oil and gas division and a mining division. A field office was established in Artesia on April 16, 1946, with Raymond Lamb, petroleum engineer, in charge. The office aided oil and gas operators with petroleum engineering problems, particularly equipment corrosion and secondary recovery of oil. The Artesia office represented the Bureau in such groups as the New Mexico Nomenclature Committee, the Interstate Oil Compact Commission and the Lea County Operators Committee. The Artesia office was closed in 1953.

During the 1940's Bureau projects expanded progressively, and the already-large collection of oil well samples increased. Circulars and bulletins were published from time to time; circulars were free of charge. By fiscal year 1947-48, a ground-water survey and basic geological survey were begun in cooperation with the U.S. Geological Survey. The ground-water survey was supervised by Charles V. Theis, regional geologist, Ground-Water Resources Division of the U.S. Geological Survey. The basic geological survey was supervised by Charles F. Park, Jr., Professor of Geology at Stanford and former Chief of the Metals Section, U. S. Geological Survey.

In 1948 Raymond Lamb resigned as supervisor of the Bureau's Artesia office and was replaced by Edward Kinney, petroleum engineer. Also in 1948, work continued on the ground-water survey and the basic geological survey. The first ground-water report was published, in addition to a major revision of the Oil and Gas Map of New Mexico (originally published in 1942). For the first time, charges were placed on circulars.

After the resignation of Mr. Anderson in September 1949, Dr. Eugene Callaghan, economic geologist,

was appointed Director of the Bureau. Dr. Callaghan had previously worked for the U.S. Geological Survey and taught economic geology at Indiana University. During October 1949, the Bureau having long since outgrown its cramped quarters in the basement of Brown Hall (the current administration building of the New Mexico Institute of Mining and Technology), moved to the building that housed the Research and Development Division (this building was later named the E. J. Workman Center). In 1950 the Bureau participated in the Arkansas-White-Red River Basins Inter-Agency Committee, set up by directive of the 81st Congress to examine and report upon those drainage basins. This 4-year project contributed significantly to knowledge of the area.

During 1950-52, under Eugene Callaghan's leadership, the Bureau staff increased substantially, adding 7 economic geologists, a hydrologic engineer, a paleontologist, a mineralogist, 4 geological technologists, a draftsman, and the temporary service of 2 other geologists.

The Bureau's paleontological collections were initiated by Rousseau H. Flower during the years 1952-54; by 1954 large Permian and Ordovician collections had been established. During these years much work was continued on the ground-water surveys. A severe water shortage in Santa Fe in 1951 made exploration particularly important in that area. This led to a cooperative report with U.S. Geological Survey, USGS Water-Supply Paper 1525.

The Bureau established research contracts with the U.S. Bureau of Indian Affairs in 1954. These contracts included geologic mapping of 484 sq. mi., a mineral survey, assessing ground-water resources, preparing detailed maps of mineral deposits, mineral testing, and an economic analysis. The area covered included

McKinley County, New Mexico, and Apache County, Arizona.

With the intensified interest in uranium resources during the early 1950's, many people wrote or visited the Bureau to find out more about this interesting source of energy. In cooperation with such organizations as the Atomic Energy Commission and the U.S. Bureau of Land Management, Bureau staff members assisted prospectors whenever possible.

During the period of 1954-56, the Bureau moved into a new wing on the south side of Workman Center that provided much-needed space and laboratory facilities; by this time, additional space was also needed for the oil well sample library. In 1955 the Bureau used the new quarters to host the annual meeting of the Association of American State Geologists.

Projects during this period placed emphasis on the ground-water surveys, paleontologic and stratigraphic projects, detailed studies of volcanic rocks, gas and petroleum research, and a new state geologic map. The first book in the series *Scenic Trips to the Geologic Past*, covering the Santa Fe area, was published in 1955. This series was the brain child of Dr. Brewster Baldwin, economic geologist, 1951-58. The first of the *Memoir* series was published in 1956, (stratigraphic studies of the San Andres Mountains) as was the first of the *Geologic Map Series* (Hillsboro Peak).

Dr. Callaghan resigned in January 1957. In February, Alvin J. Thompson, a metallurgist, was appointed Director of the Bureau. He also continued to serve as head of the Department of Mining and Metallurgy at New Mexico Tech, a position he had held for the previous 10 years.

Research in metallurgy was begun in 1957 on a limited basis. In 1959 the first full-time metallurgist, Roshan B. Bhappu, was hired and a metallurgy section was established within the

Bureau. About \$22,000 of metallurgical equipment and laboratory supplies was acquired at this time, some through donations. From 1960-62 another \$20,000 of additional equipment and supplies was purchased. Projects were initiated on systematic froth flotation methods, recovery of minerals from pegmatites, copper recovery, and molybdenum leaching. During the mid-1960's the Bureau's metallurgy section increased in size and activities. Students were hired to assist with the projects. Professional metallurgists were also hired on a temporary basis for specific projects.

In 1964-65 Bureau projects initiated included geothermal studies and a clay resources survey. A clay-testing laboratory was also begun at this time.

Following the retirement of Mr. Thompson in July 1968, Frank E. Kottlowski served as Acting Director. After a 16-month search that began when Mr. Thompson first announced his plans to retire, Don H. Baker, Jr., a metallurgist previously at the University of Waterloo in Ontario, was appointed Director in July 1969.

By 1969 the metallurgy section of the Bureau comprised about a third of the Bureau's work. Coal research also began to play an important role in the Bureau's activities at this time, as energy sources other than oil and gas began to be intensively explored.

In 1971 the Hydrologic Report series was initiated. In 1972 the first Progress Report and first Resource Map were published.

In 1972 the new building for housing the New Mexico Library of Subsurface Data was occupied. This collection includes well logs, subsurface maps, and nearly 3½ million individual well samples, all valued at millions. This same year the Bureau also participated with the National Aeronautics and Space Administration in the ERTS-A (Earth Resources Technology Satellite) program.

The Director of the Bureau also became the director of the New Mexico Coal Surface Mining Commission from its inception in 1972 to 1977. He served as the official liaison with coal company officials, the public, and the Commission. The Reorganization Act of 1977 gave most of the duties of the Commission to the Bureau of Surface Mining. The director of the Bureau of Mines and Mineral Resources, or an alternate, continues to be a member of the Commission, and has served as its chairman.

Mr. Baker resigned as Director in July 1973, to rejoin the U.S. Bureau of Mines, and Dr. Kottlowski again served as Acting Director until February 1974, when the Regents appointed him Director. He had joined the staff in 1951 as an economic geologist, hired by Dr. Eugene Callaghan.

The expanding mineral industry and additional functions for the state government, led to substantial staff and budget increases in the 1970's. This also was the beginning period for increased cooperative projects with federal and with other state agencies, so that grant-and-contract monies became a significant part of the Bureau's expenditures. To accommodate the expanded functions and staff, a new southwest wing was added to Workman Center in 1975. In 1977 a second floor over the north part of this southwest addition was completed and in 1983, a second addition was added to the south side of the previous building. This latter construction is used mainly to house expanded offices and files for the petroleum section, offices for energy geologists, and the Geotechnical Information Center, which is a library-repository for geologic and mineral resource reports, maps, and similar data.

In 1979 and 1983, two butler buildings were constructed on the west edge of the New Mexico Tech campus, about half-a-mile west of the Bureau



offices, to house cores, rock samples, garage, shops, and drilling equipment.

In recognition of the expanded staff and additional administrative duties, the Legislature authorized a Deputy Director in 1976. Dr. George S. Austin, industrial minerals geologist, served in that capacity until March 1988, when he returned to research as senior industrial minerals geologist, and James M. Robertson, senior mining geologist, became Deputy Director.

NMBM&MR began to function as a full-fledged bureau of mines and mineral resources under E. Carter Anderson in 1945. It expanded in 1949 when Eugene Callaghan became director, to also completely cover duties of a state geological survey. From a staff of 6 salaried (geologists, engineers, chemists, metallurgists, etc.) and 4 hourly (secretaries, technicians, etc.) personnel under Carter Anderson, this expanded to 19 salaried and 5 hourly staff directed by Eugene Callaghan, and to our present (June 1988) 34 salaried and 20 hourly staff. A few part-time student employees were utilized in the 1940's; beginning in the 1960's and increasing in numbers until 1988, an average of about 50 New Mexico Tech undergraduate and 10 graduate students worked part-time on Bureau projects. An addition, since the 1970's, numerous projects by "outside" geologists and graduate students have received financial and other cooperative support. These research associates have been from New Mexico State University, University of New Mexico, University of Texas at El Paso, Wisconsin University, Stanford University, U.S. Geological Survey, U.S. Bureau of Mines, Western New Mexico University, Eastern New Mexico University, New Mexico Highlands, Kansas University, Louisiana State University, Rice University, Colorado School of Mines, Carnegie Museum, Pittsburgh University, West Texas State University, Michigan State University,

Southern Methodist University, Indiana University, Texas Tech University, University of Texas at Austin, Missouri University at Rolla, American Museum of Natural History, Petroleos Mexicanos, Arizona University, Colorado University, University of California at Berkeley, and other universities and agencies.

Scientific staff was chiefly made up of economic, petroleum and mining geologists and petroleum and mining engineers until metallurgists and chemists were added in 1959 and a geophysicist in 1975. Environmental geologists were authorized in 1977 and 1980, and an engineering geologist in 1982. Thus, the scope of the Bureau's activities have expanded into the geologic hazards aspects of New Mexico, with increasing attention to landslides, expanding and collapsing soils, earthquakes as evidenced from faults, and possible sites for disposal of various types of man-made wastes.

Duties given to the Bureau by the 1927 Law have been increased in recent years. The 1927 duties, generalized, require: collection and publication of geologic and mineral statistics; collection of geologic and mineral specimens, photographs and models of mines, mills, and other mineral activities; collection of a library and bibliography of geology and minerals; studying of the geologic formations of the State with special reference to the economic mineral resources; examine the topography and physical features of the state; study the mining, milling, smelting operations and oil and natural gas production; prepare and publish reports, with necessary illustrations and maps, of the mineral resources and geology; make qualitative examination of rocks and mineral specimens; assist in education of miners and prospectors; and communicate special information on New Mexico geology, mining and oil and natural gas, and to serve as a Bureau of Exchange and Information on minerals,

oil and natural gas resource of New Mexico.

Additional duties include aiding the Commissioner of Public Lands in classification of "known geothermal resources fields;" serving on the New Mexico Coal Surface Mining Commission; Bureau's Director serves as chairman of Mine Safety Advisory Board; serves on Water Quality Control Commission; and assists the Secretary of the Energy, Minerals and Natural Resources Department with those projects which come within the expertise and jurisdiction of the Bureau.

The increased staff, budget and duties beginning in the 1950's are documented by number of publications as shown in the following table, for memoirs, bulletins, circulars, geologic maps, ground-water reports, resource maps, and open-file reports:

	M	B	C	GM	GWR	RM	OF
1927-49	0	29	21	0	1	0	0
1950-70	14	64	90	22	9	1	28
1971-88	28	28	89	39	10	15	294

The explosion in the number of open-file reports is related to increased costs of publications and the need to make geologic and mineral resource data available as quickly as possible.

Major projects in the 1970's and 1980's are also an indication of the increased scope of NMBM&MR's activities and duties. In 1970, the Bureau sponsored a symposium on mill-tailings waste disposal, did a determination of the San Juan Basin's low-sulphur strippable coal deposits, in cooperation with the National Air Pollution Control Administration, evaluated minerals and fuels potential of state lands in east-central New Mexico, and made many evaluations of clay, perlite, and limestone deposits.

In 1971 an advisory committee was initiated by Don Baker, consisting of representatives from the mining industry, petroleum industry, coal

industry, water resources, geologic societies and New Mexico Tech Board of Regents. This advisory committee was discontinued in 1974 because the governing body of NMBM&MR, the New Mexico Tech Board of Regents, deemed its expertise (that of the Board) sufficient to direct and advise NMBM&MR on its operations. For several years, a "mineralmobile" was utilized which exhibited rock and mineral specimens, maps, photographs, and brochures in trips to high schools throughout the state. About this time, the NMBM&MR mineral museum was expanded to include all of the mineral and fossil collections at New Mexico Tech, and since then has continued to be a visible and attractive part of the Bureau's educational program, with hundreds of visits every year from school children, rockhounds, and interested citizens, including, in recent years, many senior citizen groups. The mineral museum contains minerals, rock specimens, and fossils from throughout the world with concentration on New Mexico and adjoining areas (New Mexico, Arizona, Utah and Colorado).

In 1972, there was heavy participation in the National Aeronautics and Space Administration ERTS-A, Earth Resources Technology Satellite Program. NMBM&MR began its service on the New Mexico Coal Surface Mining Commission and began a cooperative project with the Tuscaloosa, Alabama laboratory of the U. S. Bureau of Mines to test clays from throughout the state. In 1973, the year of the energy crisis, NMBM&MR increased its programs to help determine reserves of energy resources, oil and gas, coal, uranium, and geothermal, as well as other key deposits such as fluor spar, gold and silver, base metals, various industrial rocks and minerals, along with cooperative programs with U.S. Geological Survey and U.S. Bureau of Land Management in geophysical

mapping, utilizing airborne magnetometer, as well as gravity and seismic studies. The metallurgists engaged in investigations of leaching of metals by micro-organisms, heap leaching, and hydrometallurgical applications to New Mexico ores and concentrates. The chemical analytic capabilities were expanded so that analyses of rocks, minerals, and water samples could be done by atomic absorption, x-ray electron microprobe spectrometry, and the normal wet chemical methods as well as fire assaying.

In 1974, a highlight was a symposium on base-metal districts in New Mexico and adjoining areas, publication of geologic maps in south-central New Mexico, a mapping series done by geologists from the Earth Science Department of New Mexico State University and continuing to the present, a report on the coal resources of the Southern Ute and Ute Mountain Indian Reservations, a symposium on the energy crisis, geologic map of the Grants Uranium Region, and a study of the seismicity of the proposed radioactive waste disposal site in southeastern New Mexico.

1974 also saw the revision of our Scenic Trips to the Geologic Past No. 9 of the Albuquerque area. These popular guides explain the geology of areas and point out the scenic and geologic wonders. They serve many New Mexicans and most of the tourists visiting the state, who may not be directly concerned with technical geologic investigations, but do have a lively interest in the state's enchanting landscapes. It helps them to understand how the canyons and mountains, arroyos and mesas, volcanoes and desert playas were formed. Tens of thousands of copies of these scenic trips have been distributed and the demand continues.

The first four scenic trips were done during the 1950's, Santa Fe area, Taos-

Red River-Eagle Nest circle drive, Roswell-Ruidoso-Valley of Fires, and southern Zuni Mountains. Five were prepared in the 1970's beginning with the Silver City-Santa Rita-Hurley scenic trip, then the trail guide to the Upper Pecos, the High Plains of Northeastern New Mexico, Mosaic of New Mexico's Scenery, Rocks and History, and ST9 of Albuquerque--its mountains, valleys, water and volcanoes. During the 1980's, the scenic trips have been of southwest New Mexico, Cumbres and Toltec scenic railroad, history of mining in New Mexico, and the Espanola-Chama-Taos--a climb through time. These publications are in demand along with the Highway Geologic Map of New Mexico which is published by the New Mexico Geological Society in cooperation with NMBM&MR.

Some of the more notable projects in 1975 were the geology of the Sandia Mountains and vicinity (bordering Albuquerque), geologic quadrangle maps in the southern and northern parts of the state, and our Memoir 15, *The Geology and Technology of the Grants Uranium Region*, prepared in cooperation with the Society of Economic Geologists. In 1976, NMBM&MR published the Water Law Atlas; reports on Ordovician cephalopods, Pennsylvanian fishes, and Cenozoic mollusks; numerous geologic maps; resource maps related to the ground-water in southeastern New Mexico; a reissue of the strippable low-sulphur coal resources of the San Juan Basin, and a cooperative report on New Mexico's energy resources with the Energy and Minerals Department.

1977 was NMBM&MR's golden anniversary year. During those 50 years, New Mexico's mineral production rose from \$26.4 million in 1927 to \$2.37 billion in 1976. In 1927, metals and coal were about 80 percent of the mineral production, while in 1977, oil and gas was 71 percent of the mineral produced,



almost complete reversal in the percentages. With the New Mexico Geological Society and the Permian Basin Section of SEPM, the Bureau sponsored a symposium on the Ochoan and Guadalupian rocks of southeastern New Mexico and west Texas, with heavy emphasis on the potash and petroleum resources; geologic maps of north-central and south-central New Mexico; began our reports and open-file articles on petroleum source rocks and thermal metamorphism; prepared a guidebook to coal geology in northwestern New Mexico for the Geological Society of America field trip, and did geologic reports and maps on Cerro de Cristo Rey, Doña Ana Mountains, and the Potrillo basalt field.

1978 saw an upsurge in the activities related to increasing federal regulation such as reviews and commentary on environmental impact statements, land withdraw proposals of federal agencies, RARE II proposals, and coal surface-mining reclamation plans. Projects completed included Geology of the Albuquerque Basin, fluorspar in New Mexico, appraisal of deep coals in the San Juan Basin, paleontology of the Ogallala Formation, estimates of New Mexico's future oil production, washability test and heat-content predictions for New Mexico coals, surficial geologic maps of the quadrants of the state, and a resource map on the coal fields and mines of New Mexico.

In 1979, NMBM&MR cosponsored an international symposium on the Rio Grande Rift, and with the newly formed Energy Minerals Division of the American Association of Petroleum Geologists, a symposium on the Grants Uranium Region. The Bureau began cooperation with the U.S. Geological Survey on the Silver City (New Mexico and Arizona) quadrangle CUSMAP project. Early in the year the Bureau began a quarterly journal of science and service entitled *New Mexico Geology*,

featuring short, mostly technical articles providing insight to state geology and mineral resources as well as information on new publications, conferences, projects, and mineral production. The Rio Grande Rift symposium was emphasized by a detailed guidebook, covering the region from El Paso to Denver. Also a report on the symposium of the Ochoan rocks of southeastern New Mexico and west Texas was prepared.

In 1980, Charles Chapin, Senior Geologist was awarded the van Diest Gold Medal from the Colorado School of Mines and we cohosted a Minerals Waste Stabilization conference with Molycorp. Reports issued emphasized geochemistry of Precambrian rocks, Cretaceous ammonite faunas, resources of coal fields, and geologic maps in the central part of the state. In 1981, NMBM&MR was host for the 17th Annual Forum of the Geology of Industrial Minerals, a conference workshop on the availability of coal resources as related to paleontology and the second New Mexico Mineral Symposium, sponsored by NMBM&MR and gem and mineral clubs throughout the state.

A classic geologic and mineral research report on the Organ Mountains was published, as well as the Grants Uranium Symposium papers entitled, "Geology and mineral technology of the Grants Uranium District," studies of earthquakes in New Mexico, Pennsylvanian stratigraphy of Big Hatchet Peak, reports on Cretaceous paleontology and stratigraphy, groundwater in the Sandia and northern Monzano Mountains, and a full-color satellite map of New Mexico (which was prepared in cooperation with the U.S. Agricultural Stabilization and Conservation Service). During 1981 and 1982, the New Mexico Institute of Mining and Technology purchased a modern x-ray fluorescence spectrometer, and an x-ray



defractometer and dedicated computer equipment. These instruments are managed by NMBM&MR and used for analytical services as well as by the various departments of New Mexico Tech. A landmark publication on the soil and geomorphology in the Basin and Range area of southern New Mexico--Guidebook to the desert project--was published along with reports of Quaternary geology of Lake Animas, the western extent of the Ogallala Formation, porosity trends in the San Andres Formation, industrial rocks and minerals in the southwest, adobe bricks in New Mexico, and geologic maps of quadrangles and mountain ranges in north-central, southwestern and south-central New Mexico.

In 1983, in cooperation with the New Mexico Geological Society, an expanded updated New Mexico highway geologic map was published. The core library was expanded to occupy most of two metal butler buildings, a perlite evaluation laboratory was set up as well as a soils testing laboratory. Work was continued on the NCRDS, National Coal Resources Data System, in cooperation with the U.S. Geological Survey. A report was prepared on possible sites for New Mexico for low-level radioactive waste disposal, the Bureau began participation in the Western States Seismic Policy Council, and continued active participation in the Water Quality Control Commission and the New Mexico Coal Surface Mining Commission. This year the Commission was heavily involved in a dispute on the use of badland areas and coal stripping operations. Open file reports and maps and a memoir on Cretaceous ammonites were derived from a cooperative study with the U.S. Geological Survey of the coal deposits in west-central New Mexico, reports on geology and geothermal waters of the Lightning Dock Region, a report on the

hydrogeology of water resources of the San Juan Basin, resource map on active mines and processing plants in the state, and a guidebook to the Abo redbeds in central New Mexico, were the main projects completed in 1983.

John W. Hawley, Sernior Environmental Geologist, with co-authors Leland H. Gile and Robert B. Grossman, received the 1983 Kirk Bryan Award from the GSA Quaternary Geology and Geomorphology Division for Memoir 39 on soils and geomorphology of the Las Cruces area Desert Project.

In the 1984-86 period, the mineral industry suffered a decline in almost all aspects, particularly in uranium and molybdenum, but in addition to the Bureau's continuing aid to encourage more exploration and development of mineral resources, much effort was devoted in helping solve problems of environmental and engineering geology such as collapsing and expanding soils, waste disposal sites, geologic hazards, related landslides and earthquakes, and special use facilities such as the superconducting super collider. The analytical laboratory was particularly involved in studies of acid rain and trace-metal contaminants and sediments in water. The work of the perlite testing lab expanded greatly as it is one of the very few, and perhaps the most accessible perlite testing facility in the nation. Geotechnical Information Center received important donations of maps, books and reports from the estates of Richard H. Jahns and Tom S. Lovering as well as much material from mining companies and federal agencies such as U.S. Bureau of Mines, U.S. Geological Survey and U.S. Bureau of Land Management. This material is computerized.

The annual New Mexico Mineral Symposium continued to expand and to have representation of significant mineral papers with publication of abstracts in *New Mexico Geology*.

Extensive damage to homes and larger buildings near Espanola lead to a certification of a state disaster area by the Governor and a detailed study by NMBM&MR concerning the affects of collapsing soils, which occur not only in that area, but in other cities such as Albuquerque and Alamogordo. The National Uranium Resource Evaluation (NURE) data was made available to our Geotechnical Information Center, thus a pamphlet was published describing the NURE data, their potential uses, and the availability of specific information. To aid the U.S. Bureau of Land Management, the Bureau engaged in extensive mineral-resource potential evaluation of much of the northwestern and north-central part of the state. Projects completed and reported include several on Cretaceous fossils and stratigraphy, the Abo redbed gas production, regional geology of Ochoan evaporites, Devonian stratigraphy of the San Andres Mountains, various reports on Permian vertebrates, Eocene tectonics and depositional setting in west-central New Mexico, the subsurface petroleum geology of the Triassic Santa Rosa sandstone, oil and gas potential of the Tularosa Basin-Otero Platform-Salt Basin Graben area, a symposium volume on epithermal deposits in New Mexico, several hydrogeologic sheets, geologic maps mainly in the west-central and south-central part of New Mexico, a resource map on gold and silver occurrences, and another one on the geothermal resources of the state. Publication of Isochron/West was continued; this is done jointly with the Nevada Bureau of Mines and Geology, and is a catalog of isotopic geochronology, inviting a quick publication media for this valuable data.

In 1987-88 the major cooperative projects included a 4-year study of the quality of the strippable coals in the state, done in cooperation with six coal

mining companies and the New Mexico Research and Development Institute. NMBM&MR continued the NCRDS cooperative project with the U.S. Geological Survey, as well as being in the third year of a COGEOMAP project in cooperation with the U.S. Geological Survey, revising the 1965 geologic map of New Mexico. This revision is necessary because of the extensive, more detailed studies of Cenozoic rocks, particularly volcanic rocks, Cenozoic sediments in general, and more detailed mapping of Quaternary units. Major reports were of Sierra Nacimiento, a guidebook for the GSA coal field trip in west-central New Mexico, a popular report on the geology of Carlsbad Caverns, a report on fresh water mollusks in the state, a multi-colored relief map of New Mexico, geology of the Las Cruces 1:250,000 quadrangle, geology and coal resources of the Atarque Lake 1:50,000 quadrangle, and the history of 100 years of coal mining in the San Juan Basin.

As noted previously, during the past two decades, a considerable number of geologic and mineral resource investigations have been carried out by support of, and in cooperation with, geologists from New Mexico State University, the University of New Mexico, University of Texas at El Paso, and numerous other universities near and far from New Mexico. These projects included numerous masters theses and doctoral dissertations. The research associates have been listed in our annual and biannual reports and have included or include such outstanding geologists as Richard Jahns, John Frye, Charles B. Hunt, Vincent C. Kelley, Lloyd C. Pray, James Lee Wilson, Aureal T. Cross, and Richard A. Tedford, among many.

NMBM&MR, like all geological surveys and bureaus of mines, owes its accomplishments to its staff, whether internationally known geologists or part-time freshman students. A few of

our most notable past members include Dr. Robert Balk, internationally known structural geologist. He joined NMBM&MR in the early 1950's, worked on the Navajo Reservation and in southwestern New Mexico and met an untimely end during an airplane crash on the western face of the Sandia Mountains near Albuquerque. At the time, he was on a trip to Washington, D.C. to deliver a geologic map to William and Heintz for printing and publication. Dr. Eugene Callaghan, NMBM&MR Director 1949-57, came out of Columbia University to work with the U.S. Geological Survey doing significant studies during World War II, then joined the staff of Indiana University as an economic geologist before coming to New Mexico. He left NMBM&MR to work for various mining companies worldwide and then joined the geology department and aided the Utah Geological Survey in Salt Lake City until his retirement. He was statistician for AASG and hosted the AASG annual meeting in Socorro in 1955. Dr. Rousseau H. Flower, internationally known paleontologist, joined the staff in 1951, coming from New York, and remained active even after retiring in 1978. His primary work was on Ordovician cephalopods, not only in New Mexico but in almost all parts of the world. Dr. Robert L. Bates, recently retired as Professor of Geology at Ohio State University, moved from Midland to join NMBM&MR in 1941 essentially as a petroleum geologist. His major contribution in New Mexico was Bulletin 18, the second edition of *The oil and gas resources of New Mexico*.

It is not only the scientists whose names are on the published reports, but the help of the support staff that is indispensable in most of our investigations and service. Marion Burks, Socorro native and wife of Judge Garnett Burks, served as staff secretary in the late 1940's and early 1950's when

the expansion of NMBM&MR by Eugene Callaghan was taking place. Mrs. Mertie Edgar took over the position of executive secretary in 1953 continuing for 15 years through 1968; she was involved in the steady growth of NMBM&MR under the directorship of Pat Callaghan and Lefty Thompson. Alvin J. Thompson, metallurgist and Professor of Mining and Metallurgy at New Mexico Tech, directed NMBM&MR from 1957 to 1968. He was responsible for initiating much of our analytical laboratories and the metallurgical laboratories research and service as well as being an outstanding cooperater with the New Mexico Mining Association. His keen interest in minerals led to the development and expansion of our mineral and fossil museum.

The director of NMBM&MR has always represented New Mexico in the Association of American State Geologists, although the title of State Geologist had been given to the Director of the Oil Conservation Commission/Division. The three-person governing board of the Commission had been, the director of the Oil Conservation Commission/State Geologist, the Governor, and the Commissioner of State Lands. When the New Mexico Energy and Minerals Department was formed in 1977 during a general reorganization of state government, the Commission was changed to OCC Director/State Geologist, State Land Commissioner, and Director of the Mining and Minerals Division of the Energy and Minerals Department. When the Energy and Minerals Department was combined into the Energy, Minerals, and Natural Resources Department in February 1988, the Oil Conservation Commission was set up as a designee of the Commissioner of Public (State) Lands, a designee of the Secretary of Energy, Minerals, and Natural Resources Department, and the Director of

the Oil Conservation Division. This vacated the title of State Geologist. Hopefully, in the near future that title will be legally applied to the director of NMBM&MR.

New Mexico's record mineral production was in 1984 when the total was \$6.5 billion. Oil and gas values were \$5.7 billion or 83 percent. Production dropped to \$6.3 billion in 1985, with oil and gas \$5.1 billion, 81 percent; then to \$4.1 billion in 1986, with oil and gas declining to \$2.7 billion, 66 percent. In recent years, uranium and molybdenum production decreased drastically, with potash production declining, copper output down until the recent upswing in 1987, and with relatively steady coal production. Production of crude oil had been downward since the middle 1960's, but owing to intensive exploration efforts in the early 1980's, both production and reserves increased. However, the drastic drop in the price of

oil has dropped exploration, reserves, and production since 1983.

Looking to the future, NMBM&MR has continued to develop geologic data to aid exploration for, development of, and production of all mineral resources, even if expansion in parts of the mining and petroleum industry may be a decade hence. Geologic maps and other basic geologic data are the main tools in aiding the exploration industry.

Sixty-one years is less than half of tenure of many of the geological surveys in the eastern United States. With the outstanding geology and mineral resources of New Mexico, however, we have just begun to scratch the surface of work that can be done for the state of New Mexico and for the nation.

This report was built on Candace H. Merillat's *Sketch of the First Fifty Years of the New Mexico Bureau of Mines and Mineral Resources*, published in 1977, and was compiled by George Austin and Frank Kottowski.



Alvin J. (Lefty) Thompson and Eugene Callaghan resting on their laurels, 1986. Eugene was director of NMBM&MR 1949-57, and Lefty 1957-68. Photograph by Robert Eveleth.



## NEW YORK

New York State Geological Survey, New York State Museum - State Education  
Department, 3136, Cultural Education Center, Albany, NY 12230.  
Phone 518-474-5816.

### HISTORICAL SEQUENCE OF ORGANIZATIONAL NAME:

New York State Geological and National History Survey, 1836-43  
Office of the State Geologist - State Cabinet, 1843-70  
Office of the State Geologist - State Museum, 1870-1945  
Office of the State Paleontologist - State Museum, 1926-45  
Office of the State Geologist - Museum & Science Service, 1945-55  
Office of the State Paleontologist - Museum & Science Service, 1945-54  
New York State Geological Survey - Museum & Science Service, 1955-86  
New York State Geological Survey - State Museum, 1986-present

### NAMES AND TITLES OF ORGANIZATIONAL DIRECTORS AND DATES SERVED:

#### State Geologists of New York

William W. Mather, 1836-41	John M. Clarke, 1904-25
Ebenezer Emmons, 1836-41	David H. Newland, 1927-40
Lardner Vanuxem, 1836-41	Chris A. Hartnagel, 1940-44
Timothy A. Conrad, 1836-43	John G. Broughton, 1949-68
James Hall (First Director), 1837-98	James F. Davis, 1970-78
Frederick J. H. Merrill, 1898-1904	Robert H. Fakundiny, 1978-present

#### State Paleontologists of New York

Timothy A. Conrad, 1837-42	Winifred Goldring, 1938-54
James Hall, 1843-98	Donald W. Fisher, 1955-82
John M. Clarke, 1898-1925	Ed Landing, 1986-present
Rudolf Ruedemann, 1926-37	

### THE NEW YORK STATE GEOLOGICAL SURVEY

By Robert H. Fakundiny and  
James R. Albanese

#### INTRODUCTION

The New York State Geological Survey (NYSGS) has operated without halt since its founding in 1836, which makes it the oldest continuously functioning geological survey in the New World. Unlike many other state geological surveys that terminated when yearly budget appropriations ceased, the NYSGS continued to func-

tion whenever the State Legislature failed to provide funds by the force of personality, enthusiasm, and energy of its first Director, James Hall.

#### GEOLOGICAL AND NATURAL HISTORY SURVEY

Governor DeWitt Clinton was one of the first influential 19th century New Yorkers to become concerned over the lack of information about the State's natural resources. In 1822 he published, under the penname "Hibernicus," a series of articles in the Albany *Zodiac* that called attention to the dearth of knowledge about the natural history of the State. A few years before that, a

young lawyer named Amos Eaton was languishing in Greenwich prison in New York City, having been wrongfully convicted of forgery. There he passed the time learning botany from the prison warden's son, John Torrey, whom he encouraged to study natural history. In 1824, after a pardon by Governor Clinton, Eaton founded the Rensselaer School, a science college at Troy, New York, which later became the Rensselaer Polytechnic Institute. Here he trained Torrey, who, along with two other students of natural history, James Hall and Ebenezer Emmons, were later to become original members of the New York State Geological and Natural History Survey.

In 1818, with the support of Clinton, Eaton gave a series of lectures before the State Legislature in which he stressed the need for systematic natural-resource surveys. In the 1820's, he led the way by undertaking several resource surveys in Albany and Rensselaer Counties and along the Erie Canal. The State Legislature in 1834, at the petition of several organizations concerned primarily with the discovery of coal, including the Albany Institute and the New York Lyceum, directed Secretary of State John Dix to formulate a plan to complete a 4-year survey of the natural resources of New York State and provided \$26,000 annually to fund the project. Part of the legislated charge of the new Survey was to:

... compile an accurate and complete geological survey of the State, which shall be accompanied with proper maps and diagrams, and furnish a full and scientific description of its rocks, soils and minerals...

On April 15, 1836, Governor Marcy appointed the first staff of the New York Geological and Natural History Survey. This survey was later known as the Marcy-Seward Survey.

The Legislature divided the State into four districts for this survey and

appointed a Chief Geologist for each. They were as follows: First District (Eastern Region) - William W. Mather, Civil Engineer; Second District (Northern Region) - Ebenezer Emmons, Sr., Geologist; Third District (Central Region) - Timothy Conrad, Conchologist; and Fourth District (Western Region) - Lardner Vanuxem, Geologist. Also appointed to the Survey were Lewis C. Beck, mineralogist; James E. Dekay, zoologist; John Torrey, botanist; and four geological assistants, including James Hall. The Survey's office was established in a building at the corner of Hudson Avenue and South Market Street in Albany.

As the Survey progressed, the collection of amassed fossils became overwhelming. In 1837, Conrad was appointed Paleontologist to organize and describe these specimens. Vanuxem was transferred to the Third District to replace Conrad, and James Hall was promoted to Chief of the Fourth District. Portrait drawings of the principal staff geologists of the 1837 New York State Geological and Natural History Survey are shown in figure 1.

The work of the Survey was far from complete when the legislated 4-year period ended. James Hall refused to stop his work, however, and continued as originally directed until he had completed his report on the State's paleontology. To finance the effort, he lobbied the Legislature for additional funds, which he often received, and he sold parts of the paleontology collection to finance continuation of the Survey's work in those years when the State Legislature denied support. In 1894, Hall completed his report. The result was 14 quarto-size volumes, which were published as the *Paleontology of New York*. Clarke (1921) and Aldrich and Leviton (1987) give vivid accounts of the political intrigues that surrounded Hall during his 62 years at the NYSGS.

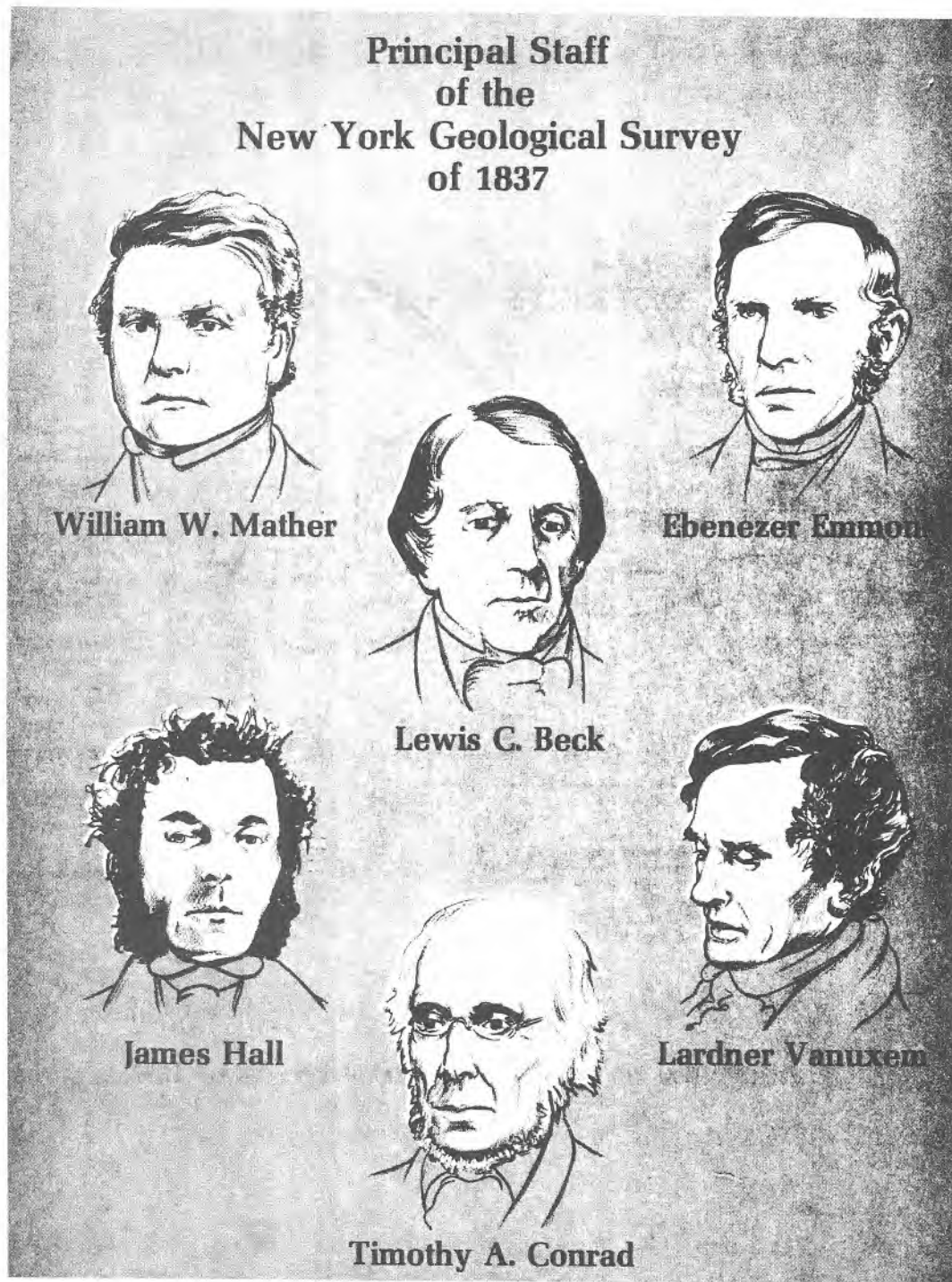


Figure 1.--Principal staff geologists of the New York State Geological and Natural History Survey after its reorganization in 1837.

## STATE CABINET

In 1843, the State Legislature named James Hall State Paleontologist and appropriated additional funds to continue the Survey. This same legislation also established the State Cabinet of Antiquities with John Gebhard, Jr., as the first Curator. The legislation did not specify which governmental agency would oversee the State Cabinet, however, nor where it should be located. To correct this oversight, further legislation in 1845 placed the State Cabinet under the aegis of the State Board of Regents. The new curator was John W. Taylor. This was, in essence, the birth of the State Museum, though it was not officially so proclaimed until 1870. When the Old State Hall was renovated to become Geological and Agricultural Hall in 1856, the collections of the State Cabinet were reorganized there under the direction of John Gebhard, Jr., who had returned to the Curator position. The next two Curators were Ezekiel Jewett (1856-65) and James Hall (1865-70).

## STATE MUSEUM

In 1870, the Legislature renamed the State Cabinet the New York State Museum of Natural History and designated James Hall as its Director. Hall meanwhile retained the titles of State Geologist and State Paleontologist. In this otherwise enviable situation as head of all operations within the Museum, he answered to three supervisors. As Director of the Museum, he responded to the Board of Regents; as State Geologist and State Paleontologist, he was responsible to the Secretary of State and the Speaker of the Assembly. This administrative tangle was corrected by the legislature in 1883, when it placed all scientists of the State Museum under the supervision of the Board of Regents.

As the Chief Geological Scientist, Hall considered the geological and

paleontological research of the Museum a product of the "Geological Survey of New York," even though no formal designation of such an internal unit of the State Museum was ever proclaimed by the State Legislature. Geological surveys were starting throughout the nation at that time with many receiving advice or direction from Hall. Thus, the New York State geological research program, became a model for design of these other state surveys. Hall and successor State Geologists, therefore, found it expedient to refer to their organization and staff as the New York State Geological Survey, a tradition that continued until 1955 when the name was made official by the Director of the State Museum.

In 1904, the Legislature consolidated the State's educational responsibilities by placing the State Department of Public Instruction into a new State Education Department within the University of the State of New York (not to be confused with the State University of New York, which is a division of the University of the State of New York) under the direction of the Board of Regents. At the same time, the scientific sections of the Museum (except zoology) were assigned titled State Scientists as their Chiefs. Thus, the State Geologist and the State Paleontologist each headed a separate unit. John M. Clarke, who held both titles during 1904-25 was, therefore, *de facto* Chief of all geological research. From 1925 until 1955, upon the retirement of State Paleontologist Winifred Goldring and the consolidation of all geological and paleontological research under the State Geologist, research in these two disciplines was administered separately under the direction of Museum Directors Charles C. Adams, and later, Carl E. Guthe. After 1955, the State Paleontologist was placed under the supervision of the State Geologist. Portrait drawings of former State Paleontologists are shown



in figure 2. Portrait drawings of former State Geologists are shown in figure 3.

By appointing State Geologists to the Directorship of the State Museum, the Board of Regents ensured that the exhibits and collections of the Museum would retain a strong geological character. In 1926, however, that tradition was broken with the appointment of Charles C. Adams, an ecologist, as the Director. This shift away from geology was made, in part, because the Education Department wanted to improve the history collections. Adams had a deep personal interest in New York's history, which inspired the Museum to obtain its great Shaker collection.

The most significant change in the administration of research within the Museum was made under the directorship of Carl E. Guthe (1943-53). The years of World War II saw a movement by several groups within other State agencies to take over the research and advisory activities of the scientific sections of the Museum. Guthe, recognizing that neither the regulatory agencies nor university departments would be able to perform the special functions of the Museum's research units, and also noting that these units needed a logical structure to attract attention in budget allocations, formulated a plan to reorganize the scientific sections. This plan was accepted by the Legislature, and, in 1945, resulted in the creation of the New York State Science Service, which included the Anthropological, Biological, and Geological sections. The Science Service was mandated to perform Museum-related research and act as a scientific advisor within its fields of competence to State agencies.

The Museum's three natural history sections were formally established as surveys in 1955, under Director William N. Fenton. All sections within the biological disciplines were consolidated into the State Biological

Survey, with Donald L. Collins, State Entomologist, as Chief. An Anthropological Survey, under William A. Ritchie, State Archaeologist, was formed to conduct anthropological and archaeological research within the State. The functions of the State Geologist's staff and the State Paleontologist's staff were placed under the direction of the State Geologist, John G. Broughton. All three Survey Chiefs reported to the Assistant Commissioner for the Museum and Science Service until 1968, when a Director of the Science Service was named. The Directors of the Science Service were Hugo Jamnback (1968-81) and Richard H. Monheimer (1981-86).

The makeup of the Science Service changed in 1979, when the Anthropological Survey was removed and placed under the Director of the Division of Historical and Anthropological Services, a counterpart to the Director of the Science Service. In 1986, the two surveys of the Science Service, the Geological and Biological Surveys, were placed beside the History and Anthropology units under a new Director of Research and Collections, Paul J. Scudiere, State Historian. This is the current (1987) administrative organization.

### EARLY MOVES AND CRAMPED QUARTERS

From its beginnings, the Geological Survey had difficulty finding space for work and specimen storage. Its first office home (1836-40) was in a building on the corner of Hudson Avenue and South Market Street in Albany and the first specimens were housed in the old State Library and the Albany Institute. Soon after the first specimens started to arrive, it became obvious that larger quarters would be needed for storage and laboratory space. Around 1840, three rooms in the Old State Hall, located on the corner of State and Lodge Streets, were made available, and the

## State Paleontologists of New York



**John M. Clarke**  
1898 - 1925



**Rudolf Ruedemann**  
1926 - 1937



**James Hall**  
1843 - 1898



**Winifred Goldring**  
1938 - 1954



**Donald W. Fisher**  
1955 - 1982

Figure 2.--Former State Paleontologists of New York.

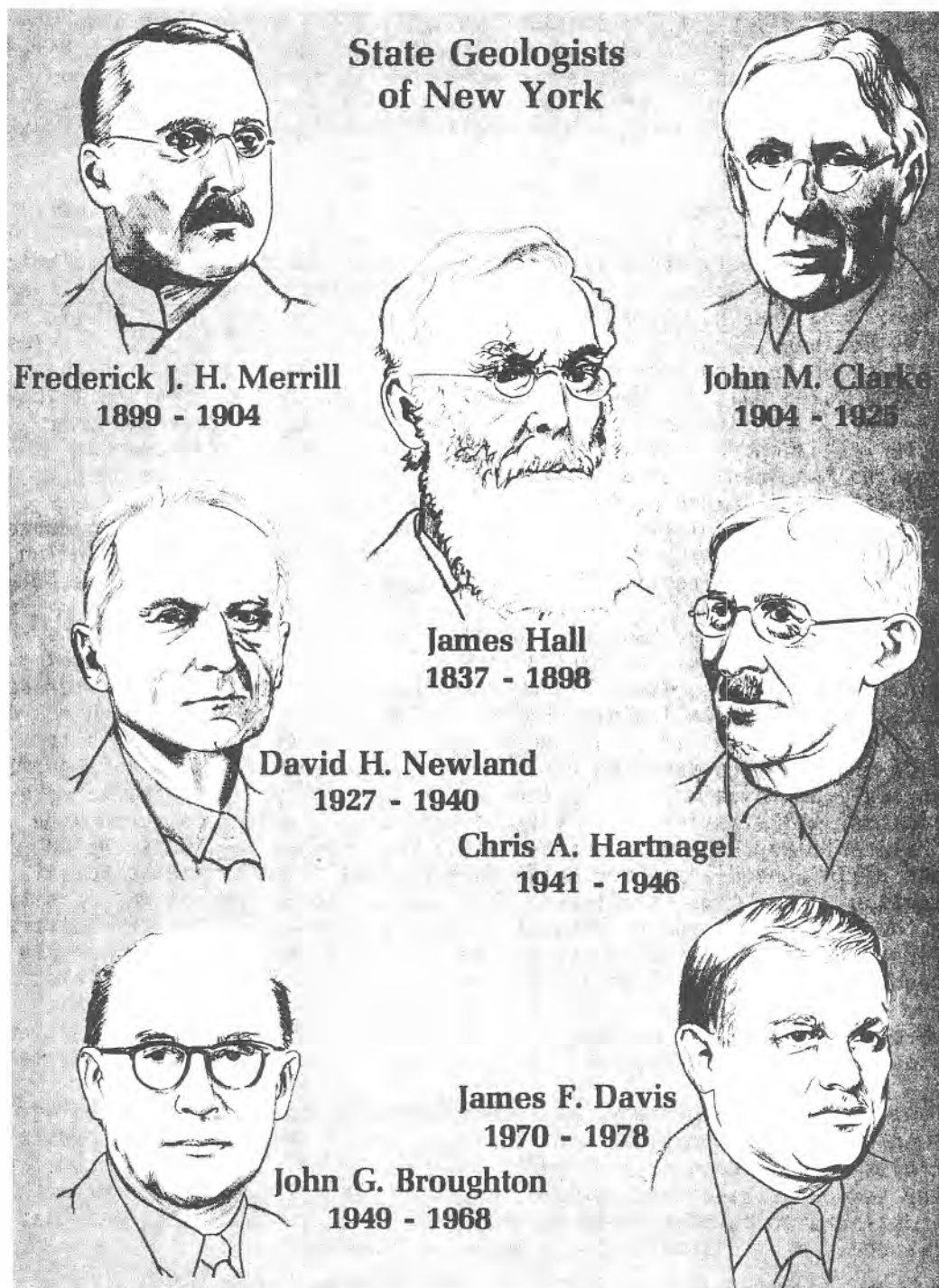


Figure 3.--Former State Geologists of New York who also served as Chiefs of the New York State Geological Survey.

first specimens were put on public display in 1845. The Survey required still more room, however, and, in 1852, Hall built his own private office and laboratories on Beaverkill, a small creek in South Albany. This building became what Hall called his "factory of paleontological students." It is now a nursery school.

In 1857, the State Cabinet took up residence in Geological and Agriculture Hall, as the renovated Old State Hall was renamed. This building became the first to house the New York State Museum. This new space soon became inadequate and specimens of the collection were stored in buildings throughout the town. In 1883, the State Legislature authorized the Museum to move from Geological and Agricultural Hall to the new State Hall at the corner of Eagle and Pine Streets. This building now houses the State Court of Appeals. The move did not actually take place until 1886, however, and as State legislative officials, also looking for more space, moved from the new Capitol back to State Hall, they displaced parts of the collection and some offices of the Museum scientists.

Shortly after the turn of this century, the Museum's collections were on display in three locations: Geological and Agricultural Hall; State Hall; and the west wing of the Capitol, where the ethnological and some of the paleontological collections were on public view. By 1909, the collections were being kept in seven separate buildings, including an old malt house on Grand Street, and one geological specimen weighing about 2 tons was stored in an unused railroad station in Menands, about 2 miles north of Albany. Fearful of loss or damage to these collections, Director Clarke fought hard to obtain a new State Museum building. As a result, space was allotted in the new Education Building on Washington Avenue, which began construction in 1910. The planned move was not

accomplished before disaster struck. In 1911, a fire in the State Capitol destroyed many valuable geological and archaeological specimens as well as much of the State Library. In 1912, the entire Museum collection was moved to the fourth and fifth floors of the State Education Building, but, as before, the allotted space was filled immediately.

When the Geological and Paleontological sections were consolidated administratively in 1955, they were cramped into the fourth floor of the State Museum within the Education Building. In 1960, the crowding was temporarily relieved when the staff and laboratories, but not the collections, of the Geology, Paleontology, and Zoology sections moved into the newly built annex on the east side of the Education Building on Hawk and Elk Streets while the Botany, Entomology, and Anthropology sections remained in the Museum. In 1979, the Science Service, the State Museum and its collections, and the State Library moved half a mile south into the newly constructed Cultural Education Center of the Nelson A. Rockefeller Empire State Plaza. This new Museum is now filled with the scientific collections and, as so many times before, needs additional storage space. At present, rock core is stored in a warehouse in Rotterdam, New York. A wet paleontological laboratory for the Geological Survey and storage space for the Biological Survey's fish collection are under construction at the Rensselaer Polytechnic Institute's new Research Center in North Greenbush, New York.

## ACHIEVEMENTS

Analysis by the Survey staff of the geological data they had collected during the early years revealed that the European System for classification of rock strata was inadequate to describe New York's sedimentary rocks. This prompted the staff to develop a stratigraphic nomenclature based on



the geographic location, composition, and fossil assemblage of each particular rock layer, a system that has become standard throughout the world.

Staff geologists also believed that the ability to confer and consult with geologists working in other States would be beneficial and, thus, met at the home of Ebenezer Emmons in Albany to form an organization to aid on communication among scientists. This led to the creation, in 1840, of the Association of American Geologists. In 1848, this organization became the American Association for the Advancement of Science, which to this day provides a forum for communication among scientists in all fields.

After the incorporation of the NYSGS into the State Museum in 1870, the geologists continued to work toward the goals outlined in the original legislation. Detailed field studies of the Adirondack Mountains and southeastern Highlands were begun. In 1901, the NYSGS published the first detailed, comprehensive map of the geological features of the State to complete and update the maps of 1843 and 1894. With the opening of the Education Building on Washington Avenue in 1912, the Survey had the opportunity to construct and improve museum displays. Exhibits of the Gilboa Devonian forest, and Cohoes mastodon, the calcite cave, the dioramas of fossil life forms, and the rock and mineral collections aroused international interest. The geologists of the NYSGS continued their scientific research and produced maps and reports that have become standards for mineralogical and paleontological investigation. Bulletins concerning economic geology, iron ore, gypsum, salt, and building stone were produced as the NYSGS continued to evaluate the resources of the State.

Geological research, both pure and applied, continues. The bedrock geology map of the State was updated in 1961 and refined in 1971. The first surficial

geology map of the State at a scale of 1:250,000 is in final compilation. Modern understanding of the evolution of the earth's crust requires an extensive resurvey of the Adirondack Mountains, a large expanse of exposed basement crust. The NYSGS, therefore, is compiling new mapping data from other geologists and is remapping the other regions of the Adirondack Mountains to update that portion of the State bedrock geology map. Since the NYSGS moved along with the State Museum into the Cultural Education Center in the Empire State Plaza in 1979, the planning and building of new exhibits for the enlarged museum has continued. Figure 4 is a photograph of the NYSGS staff, taken just before the NYSGS sesquicentennial celebration in 1986. A complete roster of permanent geological staff of the NYSGS is presented by Fakundiny (1987).

During its 150-year history, the NYSGS has amassed a collection of over 600,000 rocks, minerals, and fossils and published descriptions of the geology of New York in more than 600 bulletins, circulars, memoirs, maps, leaflets, and other special documents, as well as thousands of articles in professional journals. The NYSGS is active in the review of environmental impact statements and in cooperative programs with both federal and other State agencies, some of which are described in the following section.

## CURRENT PROGRAMS

### Museum Services

As a bureau within the State Museum, the NYSGS maintains the Museum's geology collection and provides geologic and paleontologic advice to the designers of natural-history exhibits.

### Research

Research continues in landslide and slope-stability problems, glacial geology



Figure 4.--Permanent senior staff of the New York State Geological Survey during their Sesquicentennial year, 1986. From left to right: Donald H. Cadwell, Yngvar W. Isachsen, James R. Albanese, Robert J. Dineen, Robert H. Fakundiny (State Geologist and Chief), Robert H. Fickies (Assistant Chief), Walter Mitronovas, Philip R. Whitney, William B. Rogers (Assistant Chief), William M. Kelly, Henry H. Bailey, Ed Landing (State Paleontologist), John B. Skiba (Cartographer), Lawrence V. Rickard. Cultural Education Center, which houses the State Museum, is in the background.

mapping for production of the first statewide surficial map at 1:250,000 scale, Adirondack bedrock mapping, Taconic Mountain stratigraphy and regional mapping, delineation of Outer Continental Shelf mineral resources, Cambrian-Ordovician paleontology and stratigraphy, earthquake hazards, basement tectonics, and sedimentary petrology and sedimentation.

#### **Public Advisory and Educational Programs**

Circulars and pamphlets provide information to the public and serve as resource material for secondary school earth-science curricula. Circulars, now

in preparation, describe the geology of New York State, geology used in making land-use decisions, geologic structures, and earthquake-hazard reduction.

#### **Government Advisory Service**

Radioactivity hazards dominate the geological concerns of New York State governmental agencies. Recent legislation placed the State Geologist on the Advisory Committee to the State's Low-level Radioactive Waste Disposal Commission. Radon in homes is a recent public concern that is requiring geological advice from the NYSGS to the New York State Energy Research

and Development Authority and the New York State Department of Health. The State Geologist is a member of the Technical Advisory Committee to the State Emergency Management Office's earthquake-hazard-reduction program. The NYSGS also is on the scientific advisory committees to the State Disaster Preparedness Committee on Long Island Beach Erosion and the New York State Superconducting Super-collider Program.

#### ACKNOWLEDGMENTS

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## NORTH CAROLINA

Geological Survey Section, Division of Land Resources,  
North Carolina Department of Natural Resources and Community Development,  
P.O. Box 27687, Raleigh, NC 27611. Phone 919-733-3833.

### HISTORICAL SEQUENCE OF ORGANIZATIONAL NAME:

- State Geological and Mineralogical Survey  
(Created by an Act of the Legislature, December 31, 1823.)
- Geological, Mineralogical, Botanical and Agricultural Survey  
(Created by an Act of the General Assembly of North Carolina, January 24, 1851.)
- Geological, Mineralogical, Agricultural and Botanical Survey  
(Survey reactivated in 1866.)
- Geological Survey of the State of North Carolina  
(Created by Legislature in 1891.)
- North Carolina Geological and Economic Survey  
(Created by Legislature in 1905.)
- Geological Division, Department of Conservation and Development  
(Department created by General Assembly, March 4, 1925.)
- Mineral Resources Division, Department of Conservation and Development  
(Name changed by General Assembly, 1927.)
- Geological Survey Section, Division of Land Resources, North Carolina Department of Natural Resources and Community Development  
(Name changed 1978.)

### NAMES AND TITLES OF ORGANIZATIONAL DIRECTORS AND DATES SERVED:

Denison Olmsted, 1824-25	Brent S. Drane, 1924-25
Elisha Mitchell, 1825-27	Jasper L. Stuckey, 1925-26
Ebenezer Emmons, 1851-63	Herman J. Bryson, 1926-40
Washington Caruthers Kerr, 1864-85	Jasper L. Stuckey, 1940-64
Joseph Austin Holmes, 1891-1905	Stephen G. Conrad, 1964-present
Joseph Hyde Pratt, 1905-17, 1918-24	

### A BRIEF HISTORY OF THE GEOLOGICAL SURVEYS OF NORTH CAROLINA

In June 1821, Denison Olmsted, Professor of Chemistry at the University of North Carolina at Chapel Hill, after considerable thought and study wrote to the Board of Internal Improvements concerning his idea to create a State Geological and Mineralogical Survey. A part of his proposal reads as follows:

Should the honorable Board be of the opinion that the objects specified in this communication are worthy of their attention and patronage, I hereby offer them my services during such seasons of leisure as can be spared from the exercise of my official duties at the University, and ask merely such an appropriation as shall defray the expenses of the undertaking. These would be chiefly such as would accrue from the hire of a horse and servant, and the charges of traveling; consequently they would not be great. I would beg leave respectfully to name one hundred dollars to be afterwards renewed or not, at the pleasure of the Board.



The request was declined by the 1821 Legislature and under date of January 9, 1822, Olmsted wrote to a friend:

But the Legislature (the Senate, I mean) has, it seems, saved me any trouble on their account. I, however, feel most highly gratified and greatly encouraged at the handsome manner in which my proposition was treated by the Board of Improvement; and the readiness with which the resolution was adopted by the Commons inspires hope that something may yet be accomplished at the public expense. But my feelings are too much interested in this project to yield to this failure; I hope to do something by my own exertions next summer, and trust the hospitality of the State will make amends for my poverty. If I live (as I think I can) on the charity of the people, I don't know what need I shall have of the public money; for Mr. M\_\_\_\_\_ says he will lend me a horse.

Apparently, Olmsted's interest and persistence paid off for on December 31, 1823, the Legislature passed an act stating:

There is hereby made the duty of the Board of Agriculture of North Carolina to employ some person of competent skill and science to commence and carry on a geological and mineralogical survey of the various regions of the State; . . .

That for the purpose of carrying the intention of the foregoing section into effect, a sum not exceeding two hundred and fifty dollars, be, and the same is hereby annually appropriated for four successive years, out of the unexpended balance of the agricultural fund, as created and set apart by the above recited act; . . .

Olmsted was employed and apparently spent the summer of 1824 collecting materials for his first report which was signed and dated November 10, 1824. He submitted a second report to the Board of Agriculture in 1825.

The work authorized by the Legislature of North Carolina in 1823 and carried out by Olmsted in 1824 and 1825 has often been referred to as the first geological survey in the United States. The "Olmsted Survey," financed and supervised as it was by the Board of Agriculture can hardly qualify as a state geological survey as later

established and conducted by the several states including North Carolina, but it was the first geological work including publications carried out at public expenses.

In the fall of 1825, Olmsted returned to Yale College to fill the professorship of mathematics and natural philosophy. Elisha Mitchell who had occupied the chair of Mathematics since 1818 was transferred from that position to the professorship of chemistry and mineralogy. The survey which was started by Olmsted was continued for slightly over 2 years under Mitchell during which time he presented two reports to the Board of Agriculture.

Mitchell made a determined but unsuccessful attempt to continue the work started by Olmsted as indicated by the following entry found in his diary under the date of December 28, 1827:

The Geological Survey dies a natural death at the end of this year. There is no one who takes any interest in the business, nor, in the present state of the treasury did I find there was the least prospect in succeeding in my applications to the legislature, and therefore gave it up at once.

After the close of the Survey at the end of 1827, Mitchell continued, as time permitted and opportunity presented itself, to make geological excursions over the State. His methods of work were vastly different from those of present day geologists. Without accurate maps or ample means he traveled over the country apparently more or less at random, sometimes on horseback and sometimes on foot. He stopped where and with whom he could. He carried out Olmsted's suggestion in which Olmsted stated "the hospitality of the people of the State will make amends for my poverty. If I can live (as I think I can) on the charity of the people, I don't know what need I shall have of the public money for Mr. M\_\_\_\_\_ says he will lend me a horse." Mitchell, however, did not always have a horse.

Mitchell is best remembered for his work on the physical geography of the State. He made his first measurement of the height of Black Mountain in 1835. In 1849 he described the altitudes of the peaks of the Black Mountains, the Blue Ridge Mountains and their general topographic features. He lost his life on Saturday, June 27, 1857, while trying to establish the height of Black Mountain, now Mount Mitchell, height 6,684 feet.

At the close of the survey conducted by Olmsted and Mitchell there was no state supported geological work for several years. However, some interest did continue for Governor Dudley in 1828, Governor Morehead in 1844, Governor Graham in 1846 and 1848, and Governor Manley in 1850-51, made strong recommendations to the General Assembly that the Geological Survey be reestablished.

On January 24, 1851, the General Assembly passed an act creating a survey and authorizing the Governor to appoint a suitable person to make a "Geological, Mineralogical, Botanical and Agricultural Survey of the State," and to prepare for publication reports containing the results of his investigation, and when practicable to deliver lectures on these subjects in the villages of the State. The survey was to be supported by an appropriation of \$5,000 per year to be paid upon warrant of the Governor out of the State Treasury. Publications were to be paid for out of the State Treasury over and above the \$5,000 appropriated for the Survey.

Governor David S. Reid appointed Ebenezer Emmons as the first official State Geologist of North Carolina on October 8, 1851. Emmons began his work in January 1852 and served as State Geologist until his death on October 1, 1863. Prior to coming to North Carolina, Emmons was one of four geologists appointed to the New

York State Survey and placed in charge of the second district.

The purpose of the newly created Survey was to investigate the geology, natural history, and natural resources of the State. Most of the work in the field, office and chemical laboratory was done by Dr. Emmons who was geologist, mineralogist, paleontologist, agriculturist and chemist to the survey. Ebenezer Emmons, Jr., was appointed Assistant Geologist in 1852 and apparently served in that capacity until April 1866 when he resigned.

The most important work of the Survey was directed towards the development of the mineral, mining and agricultural interest of the State. The work in general geology consisted of an examination of the formations of the Coastal Plain and Piedmont plateau; that in paleontology was devoted to the Coastal Plain and the Deep River and Dan River coal fields; while that related to minerals and mining was limited largely to the Piedmont plateau. Very little work was done west of the Blue Ridge Mountains.

During Emmons' tenure as State Geologist a number of reports of scientific value were prepared and published. The most important of his reports on the geology of North Carolina was *Geology of the Midland Counties of North Carolina*, a report of 351 pages, 9 plates and 7 maps published in 1856.

After Emmons' death in 1863, W. C. Kerr was appointed State Geologist by Governor Z. B. Vance in 1864. The Survey was nominally continued until April 1865, but during the war years after April 1861, the State Geologist and his assistants were engaged in procuring munitions and economic mineral products needed by the people of the State in carrying on the "War of Northern Aggression."

Between April 1865 and April 1866, the Survey for all intents and purposes was defunct. However, the Survey was reactivated in 1866 as the Geological,

Mineralogical, Agricultural and Botanical Survey to be supported by an appropriation not to exceed \$5,000 per year. Governor Jonathan Worth reappointed W. C. Kerr State Geologist on April 4, 1866, and he served in that capacity until his death in 1885, except for 1 year during 1882-83, which he spent with the U.S. Geological Survey.

Professor Kerr entered upon his work as State Geologist with great enthusiasm and proved to be a wise and public spirited citizen. In the face of severe criticism, with only poor roads and without good maps he made an excellent record as State Geologist. His interest and enthusiasm for his work is shown by the fact that during the season of 1866 and 1867 he traveled more than 4,000 miles, mostly on horseback, in carrying out the work of the survey. Most of the work performed was largely in the nature of reconnaissance. The main part of his work was devoted to drainage, topography and geology, but agriculture and minerals were also carefully studied.

Kerr prepared and published a number of important reports on the geology and mineral resources of North Carolina. His work which is best known and has attracted the most widespread attention includes his *Report of the Geological Survey of North Carolina*, Volume I, 1875; his papers relating to the action of frost on superficial materials; and his papers on the unequal erosion of the banks of streams as affected by the rotation of the earth.

Following the death of W. C. Kerr, the Survey suffered another lapse of support. However, J. A. Holmes, Professor of Geology and Natural History at the University of North Carolina took a keen interest in the geology of the State and kept alive an interest in a State program of geological study.

As a result of Holmes' interest and activity, the Legislature of 1891 created

a Geological Survey of the State of North Carolina which Survey was to have as its function "the thorough examination of the nature and extent of the mineral and timber resources of the State." The Governor was authorized to appoint a suitable person to serve as State Geologist, who in turn was authorized to appoint assistants as needed. A biennial report was to be presented to the Governor and Legislature and reports covering the work on minerals, forests and special subjects were to be prepared and presented to the Governor. The Survey was to be supported by an appropriation of \$10,000 per year.

On May 1, 1891, J. A. Holmes was appointed State Geologist and immediately set about organizing the Survey and securing the services of the best assistants possible with the funds available. He firmly believed that the best way to improve the economic status of North Carolina was through understanding and the proper use of its natural resources. Accordingly, he instituted programs of work designed to result in industrial growth and economic advancement of the State.

During Holmes' tenure as State Geologist the program of the Survey was directed mainly towards improving and enlarging the mining industry of the State. Approximately 25 technical reports were issued--the major portion of which dealt with minerals, mines and mining.

Holmes believed that a Geological Survey directed to "mineral and timber resources" was too restricted for the work he considered necessary for the State's growth and development. In 1905 he secured the repeal of the 1891 law creating a Geological Survey and the passage of an act creating a Geological and Economic Survey.

The newly created Geological and Economic Survey was authorized to engage in a wide range of studies including mineral, forest and fishing



resources; examine road building materials; classify soils; examine streams and water powers; examine water supplies of the State with special reference to deep or artesian wells; and cooperate with the U.S. Government Bureaus and Departments on topographic mapping and other work of scientific value. The new Survey became effective March 1, 1905, and represents the first truly comprehensive natural resources department in North Carolina State government.

Professor Holmes resigned the position of State Geologist in the fall of 1905 to accept a position with the U.S. Geological Survey in charge of laboratories for testing fuels and structural materials. Holmes was the first Director of the U.S. Bureau of Mines and served in that capacity from 1910 until his death in 1915. He was author of the slogan "Safety First," and worked tirelessly to improve safety in underground mines.

Upon the resignation of J. A. Holmes, Dr. Joseph Hyde Pratt was appointed to the position of State Geologist by Governor R. B. Glenn. Dr. Pratt had been associated with Professor Holmes as State Mineralogist on the North Carolina Geological and Economic Survey since the middle of 1897. He in fact had assisted Holmes in laying the foundation policy for the expanded responsibilities of the survey, and he immediately took advantage of the opportunity to enlarge the program of work.

The publications of the Survey between 1905 and 1925 include, in addition to a number of valuable bulletins and volumes on geology and minerals, reports on forests and forest fire prevention, terracing of farm lands, water power, drainage, fisheries and the fishing industry, and public roads. Dr. Pratt also initiated cooperative work with the U.S. Geological Survey that resulted in the publication of two of the survey's most important reports.

Volume III, *The Coastal Plain of North Carolina*, published in 1912 and Volume V, *The Cretaceous Formations of North Carolina*, published in 1923.

Dr. Pratt was a highly respected and influential public figure during his time and it is very probable that the Geological and Economic Survey, between 1905 and 1925, affected the economic welfare of the State of North Carolina as much or more than any other State agency. Dr. Pratt resigned as State Geologist in February 1924 because of poor health.

Upon the resignation of Dr. Pratt, Brent S. Drane, a civil engineer, was appointed to complete the remainder of Dr. Pratt's term.

On March 4, 1925, the General Assembly passed an act creating the Department of Conservation and Development. The duties of this new department included among others: (1) take over the powers and duties of the Geological and Economic Survey, (2) promote conservation and development of natural resources, (3) promote a more profitable use of lands, waters and forests, and (4) promote the development of commerce and industry. Relative to geology and minerals the act stated, "It shall make such examination, survey and mapping of the geology, mineralogy, and topography of the State, including their industrial and economic utilization as it may consider necessary."

The Geological Division was one of four divisions in the Department of Conservation and Development. In 1927 the General Assembly added several additional programs to the department and in the course of this reorganization the Geological Division was renamed the Mineral Resources Division.

When the Department of Conservation and Development became effective in the spring of 1925, Dr. Jasper L. Stuckey, who had joined the staff of the Geological and Economic Survey as assistant geologist in July



1924, was designated State Geologist. Dr. Stuckey served as State Geologist until September 30, 1926, when he resigned to accept a teaching position at North Carolina State College.

Herman J. Bryson was employed as State Geologist effective November 1, 1926, and served until he resigned April 13, 1940. During the 14 year period Mr. Bryson served as State Geologist interest in geology and mineral resources was at a low stage and geological and mineralogical investigations at both the federal and state levels were poorly supported financially. Mr. Bryson had no assistants and only the work he could do was carried out. As a result, very little was accomplished during this period.

Following the resignation of Mr. Bryson, Dr. J. L. Stuckey was reappointed and assumed the position for State Geologist on July 1, 1940, and served in that capacity until he retired on July 1, 1964.

During the 24 years that Dr. Stuckey served as State Geologist the fortunes of the Survey improved considerably and much progress was made in the understanding and use of the State's geology and mineral resources. A number of studies on economic minerals were published including reports on olivine, feldspar, mica, chromite, and spodumene. Many of these studies were cooperative efforts with the U.S. Geological Survey and the Tennessee Valley Authority. Coopera-

tion was begun in 1941 for the study of ground-water resources and continues today in another state agency. Cooperation was renewed with the U.S. Geological Survey for topographic mapping.

Perhaps the most important accomplishment during Dr. Stuckey's tenure was the publication of the *Geologic Map of North Carolina* in 1958, scale 1:500,000 in color, along with *Explanatory Text for Geologic Map of North Carolina*, Bulletin 71. After his retirement, Dr. Stuckey authored a book entitled *North Carolina: Its Geology and Mineral Resources*, 1965, 550 pp.

Upon Dr. Stuckey's retirement, Stephen G. Conrad was appointed State Geologist, effective July 1964. During his tenure the Division of Mineral Resources, has undergone several organizational name changes, finally being reorganized as the Geological Survey Section in the Division of Land Resources, Department of Natural Resources and Community Development.

Since Mr. Conrad's appointment, over 60 reports and maps have been published by the Survey, some in conjunction with other federal and state organizations. A new *State Geologic Map of North Carolina*, scale 1:500,000 was published in 1985, and in 1988 a long-term goal of achieving 100 percent coverage of the state by 7.5 minute topographic maps was realized.

## NORTH DAKOTA

North Dakota Geological Survey, University Station,  
Grand Forks, ND 58202-8156. Phone 701-777-2231.

### HISTORICAL SEQUENCE OF ORGANIZATIONAL NAME:

North Dakota Geological Survey, 1895

### NAMES AND TITLES OF ORGANIZATIONAL DIRECTORS AND DATES SERVED:

E. J. Babcock, State Geologist, 1895-1900  
Frank A. Wilder, State Geologist, 1901-02  
Arthur G. Leonard, State Geologist, 1903-32  
Howard E. Simpson, State Geologist, 1933-38  
Frank C. Foley, State Geologist, 1939-41  
Wilson M. Laird, State Geologist, 1941-69  
E. A. Noble, State Geologist, 1969-78  
Lee C. Gerhard, State Geologist, 1978-81  
Don L. Halvorson, State Geologist, 1982-85  
Sidney B. Anderson, Acting State Geologist, 1985-present

### HISTORY OF NORTH DAKOTA GEOLOGICAL SURVEY

By David W. Brekke

#### HISTORICAL DEVELOPMENT

The North Dakota State Constitution in 1889 directed that a University and School of Mines be situated in Grand Forks. The position of State Geologist, and with it the North Dakota Geological Survey (NDGS), was created by an act of the North Dakota Legislature in 1895, 6 years after statehood. This position was to be held by the Professor of Geology at the University. The Geological Survey was directed to make a

... complete account of the mineral kingdom... including the number, order, dip and magnitude of the several geological strata, their richness in ores, coals, clays, peats, salines and mineral waters, marls, cements, building stones and other useful materials, the value of said substance for economical purposes, and their accessibility.

Other provisions related to the chemical analysis, curation and display, and preservation of materials collected by

the Survey in carrying out its duties. A geologic map of the state was to be constructed as soon as practicable. The School of Mines was formally opened in 1897 and the Survey received its first legislative appropriation in 1899 in the amount of \$600 for the biennium.

#### ORGANIZATIONAL DESCRIPTION

The NDGS is administratively under the North Dakota Board of Higher Education through the President of the University. However, the NDGS has a legislative appropriation that is separate from that of the University. The Survey is organized into an Administrative Division and a Geology Division. The Geology Division is divided into a Subsurface Section and a Surface Section. Offices are located in Leonard Hall, the geology building on the University campus. The NDGS maintains a large core and sample library as well as extensive files of basic data on both surface and subsurface geologic data, including well logs and cores from oil and gas exploration. The current staff of 23 includes 10 geologists

(8 full-time and 2 part-time) and 1 petroleum engineer.

### PROGRAM DESCRIPTION

In order to carry out its mission of understanding the geology of North Dakota for the purposes of proper resource management, several program areas have been established. Some of these date to the beginnings of the Survey. Early programs focused on the state's deposits of lignite, clays, cement rock, and the location and quality of water resources. Efforts were made to map areal extent and thickness, determine reserves and production, and evaluate quality and burning characteristics of the vast lignite deposits. Field and laboratory studies were made of the location and quality of clays for use as brick and stoneware, as well as cement rock for use in manufacturing hydraulic cement. Since North Dakota's climate is semiarid, water resource studies were an important program in the early development and populating of the state. These studies continue today.

Current Survey programs include several defined areas such as subsurface and surface geology, environmental geology, paleontology, and statutory responsibilities as a regulator and technical advisor. The subsurface geology program consists of detailed studies of subsurface geology, environments of deposition, depositional history, distribution, and other properties of the subsurface rocks in North Dakota. Oil and gas production and engineering studies, reservoir characteristics, an extensive computer database gleaned from oil-well drilling and production statistics, and other topics related to oil in the state are all part of the program. The surface geology program includes appraisals of the geology of near-surface mineral resources, ground-water resources, landforms, and glacial stratigraphy. Our county geologic studies program is

basically a reconnaissance mapping effort that has been underway since 1960. This program is almost completed and is being updated by a more detailed 1° latitude by 1° longitude map series. Our environmental geology program involves studies of specific geologic problems and situations that have potential to cause environmental damage; these include such things as oilfield wastes, natural geochemical hazards, sanitary landfills, and other waste products and sites. Our paleontology program consists primarily of studies of near-surface fossils with emphasis on excavation of important sites and preservation of certain significant sites.

The NDGS is charged with a variety of regulatory responsibilities with authority to enforce certain rules and regulations granted through the North Dakota Industrial Commission. The Office of State Geologist issues permits and requires performance bonds for several natural resource activities. These activities include exploration and production of nonfuel subsurface minerals, underground injection for solution mining, coal exploration, exploration and production of geothermal energy, and underground storage and retrieval of nuclear and other waste material. The NDGS provides technical geological services to other state regulatory agencies and advisory boards.

### HISTORICAL HIGHLIGHTS

E. J. Babcock, the first State Geologist, was appointed in 1895. He was a chemistry instructor who was later named Director of the School of Mines. The new office of State Geologist provided for neither additional salary nor funds with which to operate. However, Babcock donated his time, expenses, and his chemistry laboratory to conduct new studies and continue earlier studies of lignite and clay deposits. The collapse of agricultural

prices in 1893 pointed to the need for the diversification of North Dakota's economy. Babcock argued repeatedly for the need for practical development of mining and geology. He used the first Survey appropriation, granted in 1899, to publish the First Biennial Report in 1901--a summary of the previous 10 year's work. This report contained information on the topography and geology of North Dakota, water resources, clay deposits, lignite deposits, and an optimistic discussion of future natural resource possibilities. At the time, it was considered one of the best public documents ever issued in the state, and it created wide public interest. In 1902, the duties of State Geologist were assumed by Dr. Frank A. Wilder, the first professional geologist to hold the position. He published the Second Biennial Report, which was devoted almost entirely to lignite and enjoyed two printings for a total of 4,000 copies.

Dr. Arthur G. Leonard, who had been Assistant State Geologist of Iowa, was appointed State Geologist of North Dakota in 1903. Leonard is considered to be the father of geologic study in North Dakota. A scholar, he brought to the Survey a tireless and single-minded concentration on the problems of the state's geology. During his 30-year tenure as State Geologist, extensive studies and systematic mapping of lignite, clays, cement rock, and water resources were conducted with little or no appropriations. In 1904, a publication exchange was initiated with other agencies and societies. This became the basis for the present Geology Library at the University. The first NDGS geologic map of North Dakota was published in 1906 in the Fourth Biennial Report, an issue devoted to clay deposits and brick manufacturing. Howard E. Simpson, the state's first ground-water geologist, was hired in 1909. His investigations of ground water were to earn him a

reputation throughout the plains region for the next 25 years. On several occasions during the 1920's, the only appropriation given the NDGS was for artesian water investigations.



Dr. Arthur Gray Leonard, State Geologist of North Dakota, 1903-32. University Relations.

Dr. Leonard recognized that the duty of the Survey was not only to promote the development of North Dakota's natural resources but also to discourage the investment by citizens in proposals that had little chance of success. He also appreciated the educational value of the Survey and many of the early publications were written in such a way that they were understandable to the teachers in the state's public schools. This goal was not always attainable, but Leonard was very patient with teachers who inquired about details. He also demonstrated an understanding of the concept of "land-use," which places him well ahead of his time. He recognized the needs of practical men, such as water well drillers, for good information on the geologic conditions anticipated in



certain areas, and he made an effort to accommodate their inquiries in detail. About 700 copies of each biennial report were earmarked for distribution to schools, and additional copies were set aside for answering inquiries from people involved in the direct development of natural resources. Dr. Leonard died in late 1932.

Howard E. Simpson was named State Geologist in 1933. In the same year, the Civil Works Administration, Federal Emergency Relief Administration, Emergency Administration of Public Works, and National Resources Board began their activities in North Dakota. They utilized the NDGS as the key to their programs and the Survey became more active than at any time in its history prior to that time. Since the funds for these activities became available after the close of the field season, the first months were spent in repairing the ravages of the years without funding. Many articles were finally cleaned and catalogued; this included 16,000 library items, 5,900 museum items, 15,000 maps, and field notes. Simpson died in 1938, and Frank C. Foley, who was then Assistant State Geologist, held the office of State Geologist from 1939 until 1941.

Dr. Wilson M. Laird came to North Dakota in 1941 and was named State Geologist at the age of 26. At the time, he was the only permanent Survey employee although there was a long tradition of hiring University students on a part-time basis, especially for summer field work. An increase in political stature occurred when the 1941 State Legislature enacted an oil and gas conservation law and designated the State Geologist as enforcer of the regulations. Most of the Survey's work during the war years and post-war years was carried out as cooperative ventures in water resource studies with the U.S. Geological Survey (USGS) which published any resulting reports. Laird began detached service

with the USGS in Montana in 1944 on studies of oil and gas possibilities. He worked in Manitoba in 1949 on a study of the geologic formations present there. This work had given him an unusual opportunity to become acquainted with the strata of the Williston Basin before oil was discovered in North Dakota. Laird became President of the Association of American State Geologists in 1950.



Dr. Wilson M. Laird, State Geologist of North Dakota, 1941-69. University Relations.

The discovery of oil in North Dakota in 1951 brought about an increase in funding and personnel for the Survey and, at the same time, a similar increase in student interest in the geological sciences developed. It became apparent to the University that both organizations needed expanded facilities. A new building dedicated to the geological sciences was constructed in 1964. Laird and a committee of NDGS staff and Geology Department faculty put a lot of effort into designing a true geology building that would

respond to the needs of geologists. The resulting building was named Leonard Hall, in honor of Dr. A. G. Leonard. The NDGS occupies most of the top floor of Leonard Hall. Laird resigned in 1969 to eventually become Director of the Exploration Committee of the American Petroleum Institute. He was given the rank of Professor Emeritus of Geology by the University of North Dakota.

Dr. E. A. Noble became State Geologist the year the 1969 State Legislature enacted laws concerning the reclamation of lignite mined lands. The NDGS at that time became an advisor to the state on reclamation issues. This led the Survey to conduct many studies throughout the 1970's of problems associated with the reclamation of lignite mines. The studies continue today with emphasis on abandoned mine lands. Coincident with the reclamation studies was a cooperative drilling project begun in 1975 with the USGS to evaluate the lignite resources of western North Dakota. This program provided public information in many areas of 16 counties during four drilling seasons. In 1975, the Survey was designated an advisor and enforcer of regulations pertaining to nonfuel subsurface minerals and coal exploration. Noble left the Survey in 1978 to work for the USGS.

Dr. Lee C. Gerhard was appointed State Geologist in 1978 and presided over the oil boom of the latter part of the decade. It soon became apparent that the core library facilities were being overtaxed due to the large influx of new oil-well cores. A new and much larger core and sample library was designed and built in 1980. This facility, the Wilson M. Laird Core and Sample Library, includes laboratory space for the preparation and analysis of cores.

Dr. Don L. Halvorson was appointed State Geologist in 1982. During his tenure, NDGS obtained use of and

eventually acquired its own computer system for the purpose of well-record management and geologic research. The Survey was designated the enforcer of solution mining injection wells. A new 1<sup>o</sup> atlas series mapping program began in 1984.

Sidney B. Anderson was appointed Acting State Geologist in 1985 and continues in that capacity today. The current programs functioning at NDGS are mentioned in a previous section.

### OIL AND GAS INVOLVEMENT

The NDGS involvement in oil and gas development dates to 1908 when investigations were made into reports of natural gas in Bottineau County. The gas was determined to be a form of marsh gas coming from the base of the glacial drift, and a private company was set up in 1910 to supply this gas to a small community in the area. The 1911 State Legislature passed an oil and gas conservation law prohibiting natural gas production unless the wells were tied to a pipeline. It appears that the law was a repercussion from complaints by neighbors who were disturbed by the noise resulting from the practice of promoters opening up wells for the benefit of potential investors. The first wildcat oil well in the state was drilled in 1915 in Ward County. The well was abandoned after reaching a depth of 244.5 feet in late 1916. The NDGS received numerous inquiries about oil in North Dakota, and several investigations were conducted over the next few years. As a result, Dr. A. G. Leonard published Bulletin 1, *Possibilities of Oil and Gas in North Dakota*, in 1920. A dry hole drilled to 10,281 feet by the California Company in 1938 eventually turned out to be only 1,866 feet from a producer drilled in 1956. Apparently, mud was being circulated at the time the producing zone was penetrated and any shows were overlooked. This 1938 well was also the first well in North



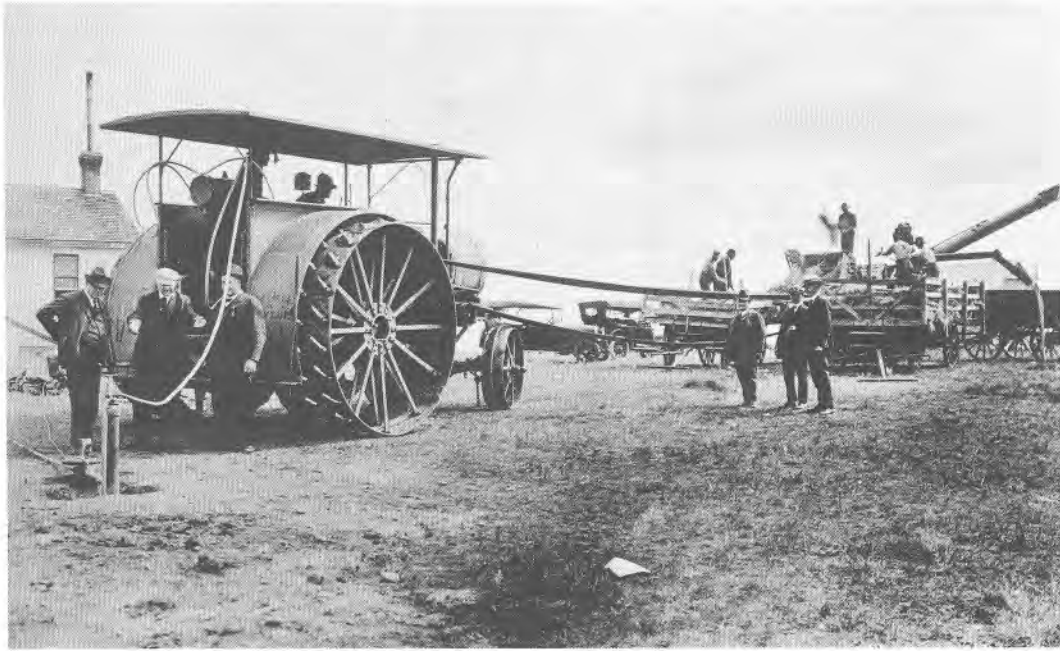
Composite picture from a prospectus extolling the use of gas for farm use. The gas well was drilled in 1919 by the Great American Gas & Oil Co., near Mohall, Renville County, North Dakota.

Dakota on which an electric log was run.

The 1941 Legislature enacted another oil and gas conservation law based on the then Model Act drawn up by the Legal Committee of the Interstate Oil Compact Commission. This law designated the North Dakota Industrial Commission as the regulatory authority and named the State Geologist as advisor and enforcer of the regulations. Dr. Laird was instrumental in seeking the passage of this legislation. At the time the statutes were enacted, the only oil and gas activity was a small gas field in the southwestern part of the state. Oil was discovered in Amerada Petroleum Corporation's No. 1 Clarence Iverson well in Williams County 10 years later. One pint of free oil was recovered from the test tool in the Devonian Duperow Formation, although the well was later completed as a producer in the Silurian Interlake Formation in 1951. There-

after, followed a 75-mile string of successes on the Nesson Anticline for Amerada. NDGS enjoyed an increase in activities following the discovery of oil. The first petroleum engineer was hired, the first core library was authorized, and a sizeable increase in funding allowed the hiring of 15 additional staff. Branch offices to handle oil-well inspections were established in Bismarck and Williston.

Oil production increased steadily until 1966 when new discoveries failed to replace the natural decline of the major producing areas. A slow decline occurred until the oil boom of the mid- to late-1970's. As a result of this tremendous increase in drilling activity, and greatly increased production, the State Legislature in 1981 decided to relocate the oil and gas regulatory function of the Survey to Bismarck as a separate agency of the North Dakota Industrial Commission. NDGS continues to maintain for its own use, and



Threshing scene in 1919 near Mohall, North Dakota, of a 60 hp gasoline engine pulling a 42-inch separator, the engine being operated by natural gas from the wellhead at left.

for public use, a set of updated well records and well logs of every well drilled in the state as well as receiving all oil-well cores. The State Geologist continues as technical advisor to the Industrial Commission and as enforcer for other natural resource regulations. The NDGS continues to advance knowledge of the geology of North

Dakota through programs in surface and subsurface geology of the Williston Basin, petroleum geology, environmental geology, paleontology, and geochemistry.



## OHIO

Division of Geological Survey, Ohio Department of Natural Resources,  
Fountain Square, Building B, Columbus, OH 43224. Phone 614-265-6605.

### HISTORICAL SEQUENCE OF ORGANIZATIONAL NAME:

Geological Survey of Ohio  
Ohio Geological Survey, 1837-1949  
Division of Geological Survey, 1949-present

### NAMES AND TITLES OF ORGANIZATIONAL DIRECTORS AND DATES SERVED:

William W. Mather, Principal Geologist, 1837-38  
John S. Newberry, State Geologist, 1869-74  
Edward Orton, State Geologist, 1882-99  
Edward Orton, Jr., State Geologist, 1900-06  
John A. Bownocker, State Geologist, 1906-28  
Wilber Stout, State Geologist, 1928-46  
George W. White, State Geologist, 1946-47  
John H. Melvin, State Geologist and Division Chief, 1947-57  
Ralph J. Bernhagen, State Geologist and Division Chief, 1957-68  
Horace R. Collins, State Geologist and Division Chief, 1968-present

### OHIO GEOLOGICAL SURVEY

By Michael C. Hansen

The Geological Survey of Ohio was authorized by legislative action on March 27, 1837. William Williams Mather was appointed Principal Geologist.

The Mather Survey conducted field work for the seasons of 1837 and 1838 and published results of these endeavors in two annual reports both bearing the publication date of 1838. The first Annual Report is little more than a brief but surprisingly accurate reconnaissance sketch of Ohio's geology.

The second Annual Report contains considerable information gathered primarily during the field season of 1838. The future importance of mineral industries founded upon the state's abundant supplies of coal, limestone, clay, sandstone, and iron ore was foreseen. Mather predicted that coal would

become the most important mineral industry of the state.

Perhaps the most significant accomplishment of the first Geological Survey of Ohio was the delineation of the general stratigraphic sequence in the state and the basic geological structure. From these data more accurate assessment of the state's mineral resources was possible, and prevailing notions, such as the occurrence of coal in western Ohio, could be dispelled on the basis of firm information.

The accomplishments of the Mather Survey must be regarded highly on their own merits; however, when the several factors below are kept in mind, these accomplishments assume greater significance.

1. The geology of Ohio was essentially unknown.
2. The Survey only lasted for a year and a half.
3. No adequate base maps were in existence and few known elevations were tabulated.

4. Travel was difficult, roads were poor, and members of the Survey were regarded suspiciously by many residents.

After termination of the first Survey in 1838, numerous attempts were made to reactivate the Geological Survey. These attempts failed, however, and 31 years passed before a geological survey again became a reality in Ohio.

At the encouragement of Governor Rutherford B. Hayes and others, Captain Alfred Lee of Delaware County introduced into legislature in 1869 a bill calling for the establishment of a Geological Survey of Ohio. This bill was passed in March 1869, and John Strong Newberry was chosen to serve as State Geologist.

Newberry's plan for the Survey was to publish four volumes: the first two were to consist of two parts, geology and paleontology; the third volume was to report on economic geology; and the fourth to consider agriculture, botany, and zoology.

The geological work done in Ohio under Newberry's direction was the foundation for most later geologic studies, including studies of mineral resources, stratigraphy, and paleontology. Newberry's work must be considered representative of one of the most significant eras of Ohio geology.

The principal accomplishments of the Newberry Survey were (1) development of a stratigraphic classification for Ohio from which our modern classification has developed; (2) establishment of the age and correlations of many stratigraphic units; (3) first statewide analysis of Ohio geology on a county basis; (4) first official geologic map of the state; (5) first comprehensive analysis of Ohio fossils; these studies formed, in part, the basis for development of the stratigraphic classification; (6) first systematic investigations of the glacial geology of the state; and (7) presentation of important aspects of economic geology, particularly coal.

In 1882, with publication of Volume IV and the end of Newberry's tenure, his chief assistant, Edward Orton, became State Geologist. Orton's long-awaited volumes on economic geology met with favor by the legislature, and a need and benefit were seen in maintaining the Geological Survey on a continuous basis. On April 12, 1889, the legislature established the third organization of the Geological Survey, with Edward Orton remaining as State Geologist.

In 1890, the First Annual Report of the Third Organization was published by Orton. The primary emphasis in this report dealt with the new information on oil and gas with comments on stratigraphic revisions. Orton presented his prophetic views on the appalling waste of natural gas in the state and pleaded for curtailment of these practices.

In 1893, Volume VII appeared and was divided into two parts: part I, economic geology, contained new and additional information on the stratigraphy, clays and coals of Ohio; part II treated botany, archaeology, and paleontology. In essence, part II was a completion of the work promised but never completed by the Newberry Survey. Chapters by R. P. Whitfield and E. O. Ulrich on paleontology were prepared for Volume III, part II, but never published by the Survey. Additional paleontological work was deemed necessary by Orton, and reports by C. L. Herrick, A. F. Foerste, and E. W. Claypoole, and A. A. Wright appeared. Gerald Fowke treated the archeology of Ohio, and W. A. Kellerman and W. C. Werner prepared the botanical report. The botanical report was originally scheduled for Volume IV (1882), prepared by H. C. Beardsley, but the manuscript had been lost.

The year 1893, marked the end of active Geological Survey work under Orton and the end of an era in Ohio Geology. Orton continued to hold the

position of State Geologist in an honorary capacity, as no appropriations were made and no active investigations were carried out. Orton died in October 1899, having been incapacitated by a series of strokes, thus ending 30 years of service to the Ohio Geological Survey. In December 1899, Edward Orton, Jr., was appointed State Geologist to fill the unexpired term of his father and was reappointed in 1901 and 1904.

In 1900 the Survey was reorganized and became known as the Fourth Organization, which continues to the present. This reorganization was not a formal legislative one but was a change in procedural matters enacted under the direction of Edward Orton, Jr. Prior to the Fourth Organization, the Survey had no office space or equipment; the business of the Survey was carried out in the home or office of Edward Orton, Sr. A permanent office at Ohio State University, stocked with necessary equipment, gave the Survey its first permanent headquarters.

The focus of the Survey was on economic geology, reflecting the interests of Edward Orton, Jr., who is considered the founder of ceramic engineering. Reports were now issued individually, as bulletins, and bound into volumes only when sufficient materials had been published.

Edward Orton, Jr., resigned his position as State Geologist in 1906, and John A. Bownocker was appointed to take his place. The tenure of John A. Bownocker as State Geologist marks an important time in the history of the Survey, as geological investigations on many diverse subjects were published and the Survey was maintained continuously, in contrast to the sporadic investigations during the previous century.

With the death of J. A. Bownocker in 1928, Wilber Stout was appointed State Geologist, becoming the first, full-time State Geologist. Unfortunately, Stout's appointment coincided with the

Great Depression that was to affect activities for more than a decade.

During Stout's tenure as State Geologist, bulletins appeared on clay, shale, dolomite and limestone, brine, ground water, iron, flint, coal, and marl. Nearly all of these reports were authored by Stout or Raymond Lamborn. Had financial conditions in the state been more favorable, the Survey under Stout's direction would have undoubtedly published considerably more reports.

Upon the retirement of Wilber Stout in 1946, George W. White was appointed State Geologist. White remained in office only a year and a half before accepting the position of Chairman of the Department of Geology at the University of Illinois. The Survey remained small during White's brief tenure. However, he made a significant and partly successful plea before the legislature to increase appropriations for the Survey.

John H. Melvin was appointed State Geologist in 1947, upon the resignation of White, and was successful in increasing Survey appropriations more than twofold in the late 1940's.

In 1949, the Survey became one of the seven originally chartered divisions in the newly organized Department of Natural Resources. The Survey offices remained in Orton Hall at Ohio State University, where they had been since 1904. Mineral resources and regional geology continued to be the primary emphasis of the Survey.

In 1957, Ralph J. Bernhagen was appointed State Geologist. Investigations on mineral resources and regional geology continued, and the technical staff remained at a level between 15 and 20, as it had since 1948.

In 1968, Horace R Collins was appointed State Geologist, the tenth individual to hold the position in the 141-year history of the Survey. Under Collins' tenure, annual appropriations have increased approximately seven-

fold, with a concomitant quadrupling of staff size. Geochemistry and physical laboratories were added to the basic physical plant along with a 27,000-square-foot core and sample warehouse. A coring rig for the investigation of bedrock stratigraphy and deep coal and other mineral resources as well as a shallow auger rig for glacial studies also were acquired. In 1981, a county mapping program funded by mineral severance taxes was instituted whereby maps of bedrock and glacial geology and various derivative maps are being prepared for each of the 88 counties in the state.

The need for continuing study of Ohio's geology and mineral resources was perhaps best stated by Edward Orton, Sr.:

As to what remains to be done in Ohio geology, it is difficult to speak. The science of geology is constantly lengthening its cords and strengthening its stakes. Every line of investigation opens up larger questions than those which it directly undertakes to settle. New methods of research are coming into use, and the old problems must be reconsidered by their aid. It is only the generalities of our geology that have been thus far attacked. Deeper and more thorough work will be demanded in every subdivision of every field.



## OKLAHOMA

Oklahoma Geological Survey, University of Oklahoma, Board of Regents,  
830 Van Vleet Oval, Rm. 163, Norman, OK 73019.  
Phone 405-325-3031.

### HISTORICAL SEQUENCE OF ORGANIZATIONAL NAME:

"Geological and Natural History Survey" of the Territory of Oklahoma.  
(This was an organization in existence before Oklahoma was a state, and  
was, therefore, not part of the current OGS, an Oklahoma state agency.)

### NAMES AND TITLES OF ORGANIZATIONAL DIRECTORS AND DATES SERVED:

#### Directors

Charles Newton Gould, 1908-11, 1924-31  
Daniel Webster Ohern, 1911-14  
Charles William Shannon, 1914-23

Robert H. Dott, 1935-52  
Carl Colton Branson, 1954-67  
Charles John Mankin, 1967-present

### HISTORY OF THE OKLAHOMA GEOLOGICAL SURVEY, 1908-87\*

By Connie Smith,  
Information Specialist

#### THE EARLY YEARS: 1908-35

The State of Oklahoma has an established history of recognizing the importance of geology in its future. When State fathers framed the Constitution of Oklahoma in 1907, provision was made in Article V, Section 38, for the establishment of a "State Geological and Economic Survey." Oklahoma is the only state that made such a constitutional provision for a survey.

Under an enabling act developed by Charles Newton Gould, passed by the First Legislature, then signed into law by Governor Charles N. Haskell on May 29, 1908, the objectives and duties of the new bureau included study of geological formations and mineral deposits, publication of reports, and "consideration of such other scientific and

economic questions as, in the judgment of the Commission shall be deemed of value to the people."

Gould came to Oklahoma in 1900 to teach geology at the University of Oklahoma but also worked with the "Geological and Natural History Survey" of the Territory of Oklahoma. The Territorial Survey was established in 1898 when what was to become the State of Oklahoma was still divided into Oklahoma Territory and Indian Territory.

Gould, already familiar with the mission of the Survey through his participation in development of the enabling act, was selected by a three-man State Geological Commission as the first director of the new agency. Within 1 hour of his appointment, Gould secured five geologists to work for the Survey, and by the end of that summer nine parties were involved in field work in the new state. One group, led by Assistant Director Lon L. Hutchison, investigated oil and gas fields, while other parties in the early

\*Much of this history was compiled from *A History of the Oklahoma Geological Survey, 1908-1983*, by Elizabeth A. Ham, OGS Special Publication 83-2.



Men waiting to fill their water bottles at Bromide Springs, Platt National Park, Oklahoma.



First geological field party in Oklahoma. In camp in the Gypsum Hills of Blaine County, Oklahoma, August 1900. Left to right: Paul J. White, Roy Hadsell, and Charles N. Gould.

days examined limestone, sandstone, clays, building stone, gypsum and salt, granite and gabbro, lead and zinc, tripoli, marble, coal, and asphalt, and engaged in basic mapping.

Gould resigned from the Survey in 1911 to go into the oil business as a consulting geologist but returned to the OGS directorship in 1924. While in the oil business, Gould was involved in oil and gas exploration in Oklahoma and did work that led to the development of the Panhandle Gas Field in Texas, the South Bend Oil Field in Texas, and the huge Augusta-Eldorado District in southern Kansas.

From 1911 to 1914, the Survey was under the direction of Daniel Webster Ohern, who had been Director of the University of Oklahoma's Department of Geology. Ohern also left to join the oil industry and turned the directorship over to Charles William Shannon, who had been with the OGS as a field geologist since 1911.

During the terms of both Ohern and Shannon, work begun during the Gould years continued. During the early 1900's the U.S. Geological Survey also was very active in Oklahoma with a number of projects underway.

For a short period in 1923-24, the Survey ceased to exist after Governor Jack Walton vetoed the budgeted appropriation. In this interim period, there was an attempt by Shannon to keep work going under a self-sustaining Bureau of Geology. Charles Elijah Decker, Professor of Paleontology at OU, acted as custodian of the Survey inventory during the time of limbo. Walton was impeached and convicted, and the Survey was reinstated under the Board of Regents of the University of Oklahoma. The State Geological Commission was abolished at this point.

Gould, the "Father of Oklahoma Geology," then returned to head the Survey in 1924, and his motto was, "Get as much geological information as possible to as many people as possible,

in the shortest time possible, at the lowest cost possible." A major contribution during Gould's time was the massive, multivolume, multi-authored, county-by-county Bulletin 40, *Oil and Gas in Oklahoma*, published in 1928 and 1930. It has been said that this volume could be updated, but never equaled in scope.

During Gould's subsequent 7 years as Director, 27 bulletins and 9 circulars were issued before appropriations were cut off again in 1931 by Governor Bill Murray. "Daddy" Decker again was put in charge of Survey collections until funding was restored 4 years later.

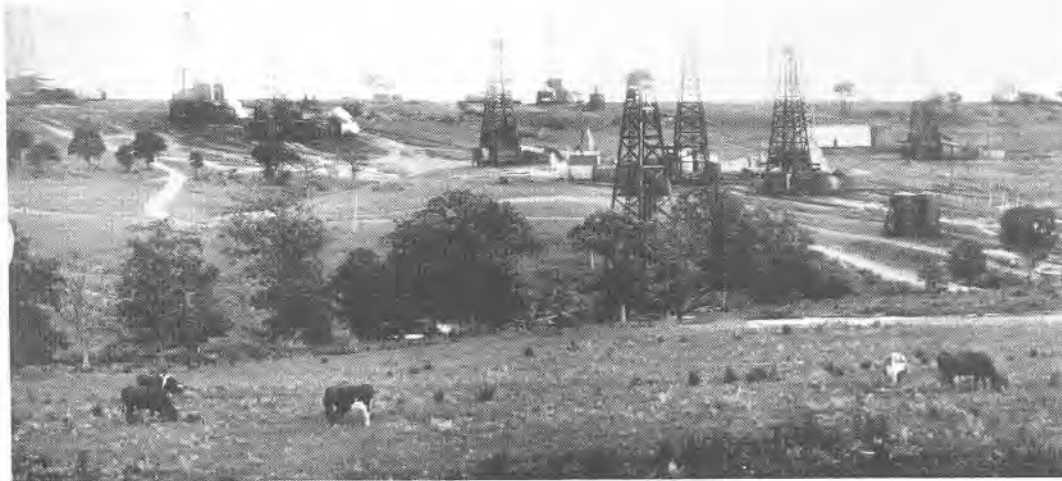
During these early years, the OGS explored the new state with a view to developing the resources. The Survey's promotion of mineral and industrial development was important to early economic growth. Sources of fuel also were a primary consideration, and coal, the leading source of energy in the world at the time, was plentiful in Oklahoma. In 1900 coal and coke represented 90 percent of Oklahoma mineral production.

By 1931, the end of Charles Gould's second term as Director, 90.4 percent of Oklahoma's mineral production was from petroleum and natural gas. The earliest reported oil discovery in what is now Oklahoma was in 1859, the same year Col. Edwin L. Drake drilled his commercial well near Titusville, Pennsylvania. In Oklahoma commercial drilling for oil did not begin until 1884, with two wells near Tahlequah and Atoka. Oklahoma's first commercial discovery of oil was the Nellie Johnstone No. 1, which was drilled in 1897 on the Caney River, just northwest of early-day Bartlesville. The well was drilled to a depth of 1,320 feet and produced between 50 and 75 barrels of oil a day. Due to a lack of storage facilities, the well soon was capped.

Commercial production of natural gas began in 1904 and rose to more than 203 million cubic feet in 1923. During



Mining near Miami, Oklahoma, 1911. This was in the old Picher Field Area, at one time the world's leading producer of lead and zinc.



Scene in the Cushing Field, near Oilton, Oklahoma. Photographer - That Man Stone.

Permission received from Western History Collections, University of Oklahoma Library for use of these prints.

these early years, the young Survey maintained a well-log file, a file of newspaper clippings on oil development in more than 2,000 sections of land, a continuously updated oil and gas map full of color-coded pins, and a production-record book, in addition to extensive field-study and publication programs. Five oil and gas maps also were issued at irregular intervals from 1908 through 1931.

Water was scarce in parts of Oklahoma during the early years, and the Survey often received requests for

assistance in finding water. Water studies included investigations of reservoir sites and analyses of surface water, well water, and spring water. Shannon sent a party to make a survey of the Canadian River, and to record flooding and flood damage, depth to water table, water usage, and stream changes along waterways from the Texas Panhandle border to Norman.

Gould, Ohern, and Shannon all had a strong feeling for the need for conservation at a time when natural resources must have seemed virtually



inexhaustible. Shannon said that "there is scarcely a line of work where waste is not evident." These early directors laid a firm foundation at the OGS for work that to this day is concerned with the conservation and wise use of Oklahoma's natural resources.

#### THE DOTT YEARS: 1935-52

After Governor Murray's imposed 4-year hiatus, the Survey was reactivated in 1935. Robert H. Dott was named Director and continued to build upon the work of the early directors. He found, however, that many of the previous studies were either reconnaissance in nature, incomplete and in need of revision, or published and out of print. During his tenure, Dott also began publication of a mimeographed, informative periodical known as *The Hopper*, which later turned into the Survey's current bimonthly publication *Oklahoma Geology Notes*.

During the years of the Great Depression, Dott's emphasis was on nonfuel mineral resources. In December 1935 a statewide Mineral Survey began with \$376,000 of government funds channeled through the Works Progress Administration (WPA), a program to provide jobs for out-of-work citizens. Six-hundred relief workers and 60 nonrelief workers spread across the state focusing on projects in the categories of culture and water resources, road and construction materials, and general minerals. Although the Mineral Survey did not make any spectacular discoveries, Carl Branson said in 1958 that the information acquired made an "important file which is drawn upon for all related survey work."

Dott was interested in finding new ways to use Oklahoma's minerals and promoted the use of such "humble materials" as clay, glass sand, and stone.

"Unused raw materials and unemployed men are worthless in

themselves, but together they can make prosperity," he wrote. The results of his efforts provided valid, current, and usable information to active and potential producers of Oklahoma's mineral resources. Topics found in the list of publications from that time include barite, dolomite, volcanic ash, limestone, glass sands, phosphates, iron ores, and numerous other "humble materials." During Dott's administration an Industrial Research Laboratory was established at the OGS. One direct result was the building of a rock-wool plant at Sand Springs.

In the early 1940's much of the work was geared to war needs, and Dott was named Chairman of an Association of American State Geologists Advisory Committee on matters in which State Geologists could be of assistance to government agencies during the war.

During his tenure as Director of the OGS, Dott recognized the need to save rock samples and cores taken from wells that were drilled. The cores and samples were examined by company geologists and engineers, then discarded to make room for new material. In 1936 Dott made the recommendation that a library be established, and donations soon were being received from industry and government agencies. The Core and Sample Library quickly became an important research facility for the state and, in the years since, has experienced steady growth and expansion of its collection.

#### WILLIAM EUGENE HAM: 1952-54

William E. Ham, the first and, as of now, only native Oklahoman to administer the OGS, was named Acting Director of the Survey after Dott's resignation in 1952. Ham was a petrologist, structural geologist, stratigrapher, field geologist, sedimentologist, economic geologist, geomorphologist, and authority on the Arbuckle Mountains. He came to the OGS in 1941, after teaching geology for 2 years at OU, and remained



Charles Newton Gould, OGS Director,  
1908-11, 1924-31.



Daniel Webster Ohern, OGS Director, 1911-14.



Charles William Shannon, OGS Director,  
1914-23.



Robert H. Dott, OGS Director, 1935-52.

with the Survey until his death in 1970. He had a B.S. degree and an M.S. degree in geology from OU, and a Ph.D. in geology from Yale University.

Ham was much in demand for extracurricular activities and, as have many others at the OGS, carried the knowledge of Oklahoma geology to the nation and to the world through articles, field trips organized and guided, sessions chaired, meetings attended, and other activities.

As Charles J. Mankin, current OGS Director, says "Bill Ham put the Oklahoma Geological Survey on the map." Ham's work with professional geologists, educators, businessmen, and the public did much to build the high reputation for public service that is synonymous with the OGS.

Ham was in demand as an economic geologist and issued a number of works on minerals that combined scientific geology and practicality. He consulted over the telephone and in the field with producers and would-be producers, and gained vast knowledge of their needs and problems.

He was an authority on the Arbuckle Mountains, working in that area throughout his years at OGS, and basing his doctoral dissertation at Yale University on the Arbuckles. Ham's studies in the area included iron ores, glass sands, and carbonates. He also was involved in a cooperative program with the USGS to investigate rocks below the "Wilcox" sands as an aid in oil exploration.

Ham was an authority on carbonate rocks, and organized and led a symposium on carbonates for AAPG. He was editor of the landmark AAPG Memoir I on carbonate rocks and was invited to lecture on and study carbonate-rock formation at the Bermuda Biological Station. He also joined a group of experts who sailed from the Lerner Laboratory on Bimini to examine carbonates being formed in the Caribbean seas. He traveled

throughout the world studying carbonate rocks and attending and speaking at international conferences.

Although Ham published more than 100 articles and reports while at the OGS, three of his outstanding works were: *Basement Rocks and Structural Evolution of Southern Oklahoma*, OGS Bulletin 95, with R. E. Denison and C. A. Merritt, 1964; *Modern Concepts and Classification of Carbonate Rocks*, American Association of Petroleum Geologists Memoir 1, 1962; and *Paleozoic Epeirogeny and Orogeny in the Central United States*, with J. L. Wilson, American Journal of Science, 1967. During 1963-64, he served as a distinguished lecturer for the American Association of Petroleum Geologists, speaking at more than 30 universities and AAPG affiliated societies all over the United States.

In early 1954, Ham's wishes to leave administration and return to his work were granted, and Carl Colton Branson became the new Director of the OGS. Ham was named Associate Director in 1959.

#### **CARL COLTON BRANSON: 1954-67**

Carl Colton Branson joined the faculty of the OU School of Geology in 1950 and was named Director of the School in 1954. That year the leadership of the School and the OGS was joined, as Branson directed the activities of both groups. Branson relinquished the directorship of the School in 1963, again becoming a professor. In 1972 he retired to the rank of Professor Emeritus.

Branson was Director of the OGS until 1967, when he gave up this post to become a research geologist for the Survey.

One of Branson's major contributions was building up the University of Oklahoma's Geology Library, a joint venture of the School and the Survey.

In directing the Survey, Branson, as he himself said, "continued the wise policies of his predecessors," giving



William E. Ham, OGS Acting Director, 1954.



Carl C. Branson, OGS Director, 1954-67.



Charles J. Mankin, OGS Director, 1967-present.



mineral investigations first priority. Field and laboratory investigations continued on the "humble materials" and an updated mineral map by John Warren was published as GM-1, the first in the OGS "GM" (geologic map) series. Uranium came into the picture and was much in demand. A report on this subject was prepared and issued as Mineral Report 27.

Branson proposed that each county report contain a "description of subsurface geology and adequate subsurface maps" as an aid to the oil and gas industry, and in 1955 hired the Survey's first petroleum and subsurface geologist, Louise Jordan, founding a section that has continued to grow in importance.

Also during the Branson years, Circular 54, by Arthur H. Doerr, examined the effects of coal mining on the Oklahoma landscape. The publication was a forecast of coming interest in environmental geology and the importance that would be placed on this subject.

Evaluation of the state's water supply continued during the Branson years, as well as an impressive array of other basic scientific studies that were reported upon in 33 bulletins and circulars.

#### **CHARLES JOHN MANKIN: 1967-PRESENT**

A Texan by circumstance, Charles J. Mankin migrated north and joined the faculty at OU in 1959. Mankin had received his B.S. (1954), M.A. (1955), and Ph.D. (1958) degrees from the University of Texas at Austin; had worked as a special instructor for Shell Oil Co.; had held the position of Instructor of Geology at the University of Texas; and was a geologist for the New Mexico Bureau of Mines and Minerals before becoming an Assistant Professor at the California Institute of Technology for 1 year.

After joining the faculty at OU, he began work at the OGS as a part-time geologist. In 1963 Mankin advanced to an Associate Professorship and was named Acting Director of the School, becoming Director in 1964. With his move to Director of the OGS in 1967, the School and the Survey were again joined under one administrator until 1977, when Mankin gave up directorship of the School. In 1978, he also became Director of OU's Energy Resources Center, now renamed the Energy Resources Institute (ERI), again assuming a dual role at OU. He served as Director of both OGS and ERI until 1987, when he relinquished the ERI post to give full attention to an ever-increasing work load at the Survey.

Mankin has carried forth and greatly enlarged the tradition of service established at the OGS from the earliest times. He is on a number of boards and committees, including the National Research Council of the National Academy of Sciences, and has furthered the Survey's mission through participation in many scientific, academic, and governmental organizations. With the recent focus on fossil fuels Mankin has been called upon numerous times to testify in congressional hearings and present facts and opinions to the nation's leaders. In 1981 he was appointed by U.S. Interior Secretary James Watt to a five-member fact-finding board, the "Commission on Fiscal Accountability of the Nation's Energy Resources."

He was the 1987 recipient of the Ian Campbell Award, given annually by the American Geological Institute in recognition of singular performance in, and contribution to, the profession of geology. The award was presented to him by Kenneth S. Johnson, OGS Associate Director, at the 1987 GSA Annual Meeting in Phoenix, Arizona.

Johnson, who earned a B.S. in geology, a B.S. in geological engineering, and an M.S. in geology from

OU, joined the OGS in 1962 and has been with the Survey since, except for a period from 1965-67 when he completed work on a Ph.D. from the University of Illinois.

Johnson has been especially active in the fields of economic geology and mineral resources, serving for a time as Director of the Oklahoma Mining and Mineral Resources Research Institute. In 1978 he became Associate Director of the OGS in addition to his other duties. He is a much-sought-after speaker and is popular with industry, professional geologists, rock clubs, and civic groups. He has taken an active interest in presenting geology to the lay public.

During Mankin's time as Director, traditional Survey programs have grown and advanced, taking new directions as the needs of the State and country have changed. Mineral resources are still of great interest to the OGS, and in 1972 the Survey was one of the sponsors of a symposium entitled "Mineral-Development Opportunities in Oklahoma."

County reports still are being published and updated, and ongoing projects include studies of gypsum, salt, underclays in the eastern Oklahoma coal fields, sand and gravel, limestone, granite, and material for the manufacture of firebrick and ceramics. The Survey also houses the offices of the Oklahoma Mining and Mineral Resources Research Institute (OMMRFI), which is funded by the U.S. Bureau of Mines. This is one of a number of minerals institutes formed in states across the country to conduct and support research on minerals- and mining-oriented problems, and maintain a data bank of information on mining and mineral prospects.

Oil and gas still play a major role in Oklahoma's economy, and at the OGS much emphasis has been placed on this area. Thomas W. Amsden's Bulletin 121 on the stratigraphy, petrography, paleontology, chemical characteristics,

porosity, and permeability of the Hunton rocks in the Anadarko Basin remains a seminal work. Survey researchers have looked at enhanced-oil-recovery projects, heavy-oil deposits, and petroleum-source-rock potential of asphalt deposits in the Ouachita Mountains in recent years. Hydrocarbon-source potential and temperature history of the black shales of the Devonian-Mississippian Woodford Formation also have been important projects, as was a study of methane in coal beds for use in rural communities.

Fine-tuning now is in progress on a computerized file of Oklahoma oil and gas fields, and a new oil and gas map is one of the Survey's recent publications.

Environmental geology is and has been part of the Survey's work for many years. Studies have included mining activities, evaluations of the quality and quantity of water in abandoned zinc mines, surface disposal of industrial wastes, and investigations of abandoned coal-mine lands. A recent project looked at the hazards associated with the collapse of abandoned lead and zinc mines in northeastern Oklahoma.

A geophysical observatory was added to the Survey in 1978 when the University of Oklahoma suspended funding for its OU Earth Sciences Observatory and operation was transferred to the OGS. The facility was then renamed the Oklahoma Geophysical Observatory (OGO) and was expanded and modernized by the OGS.

The Observatory was built in 1961 by Jersey Production Research Company then turned over to the University of Oklahoma in 1965 after Jersey Research became part of Humble Oil and Refining Company in 1964.

The Observatory site near Leonard, south of Tulsa, was selected because of its semi-isolation from human interference. Ninety percent of the Oklahoma Geophysical Observatory's activities involve receiving, recording, and transmitting data on seismic

impulses. The central facility has 7 seismometers, 3 of which are long-period and 4 of which are short-period recording instruments. The seismic responses are recorded on 14 paper-drum recorders and one digital recorder.

Seven volunteer-operated field stations containing seismometers are located at strategic positions around the State, and 3 radiotelemetry stations are located in close proximity to Leonard. A report cataloging all earthquakes in Oklahoma is published annually in *Oklahoma Geology Notes*.

The OGO has 1 of 11 geomagnetic stations located in the United States, and recently was selected by the National Oceanographic and Atmospheric Administration (NOAA) to be part of the National Crustal Monitoring Network. In subsequent years, data obtained from the OGO and five other North American sites will be used to determine the relative motion of the North American Plate with respect to the other plates on the earth's surface.

In addition to these high-tech investigations, many projects from the Survey's early days are ongoing. Studies of water (including the cooperative work with the U.S. Geological Survey) and basic geologic investigations and mapping still occupy a considerable amount of staff time.

The Core and Sample Library, which remains an important section in the OGS, expanded rapidly in the early 1980's when many petroleum exploratory and development wells were drilled in Oklahoma. Since much of Oklahoma's future petroleum production will come from improved recovery of hydrocarbons in existing fields, the cuttings and cores in the library will be especially important to industry.

The library contains more than 25,000 boxes of cores taken from about 2,500 wells, and samples from about 35,000 wells. A computer file of the core data was made available in early 1988.

This file assists users in determining the availability of cores of any particular formation in any area of the state.

A truck-mounted drilling rig was added to the Survey fleet of vehicles in 1981, allowing geologists to collect valuable information from selected locations throughout the State.

Public service is, as always, an important part of OGS activities, and a busy sales desk reflects the need for published geologic information. The Survey staff gives frequent lectures, conducts field trips for various groups, and answers a steady stream of written and telephoned requests for information.

The OGS has played an important role in providing geologic data that help Oklahoma industries explore for and develop the state's mineral resources. When Mankin began as Director in 1967, Oklahoma attained its first billion-dollar-year in mineral production; about \$950 million was from oil and gas production, and the remaining \$69 million was from all other minerals. As the years passed, the annual mineral production soared, reaching \$2 billion in 1974, \$4 billion in 1978, and between \$10 billion and \$11 billion each year in 1982, 1983, and 1984. Throughout this time period, oil and gas have been dominant, accounting for up to 97 percent of the State's mineral economy each year.

The OGS and OU's Geological Information Systems (GIS) are engaged in a major cooperative effort in the development of a Natural Resources Information System (NRIS) for the State of Oklahoma. GIS was formerly a part of the University of Oklahoma's Energy Resources Institute but, in 1987, was attached to the OGS for management oversight.

Current efforts in the NRIS program are directed toward the development of data bases for petroleum and coal resources and production;

nonfuel minerals and water will be included in future years. The development of natural resources has been and will continue to be an important component of Oklahoma's economy. To develop these resources wisely, it is necessary to have available accurate data that are easy to access.

In the system now are an Oil- and Gas-Field Production file, a Petroleum Well History file, and a Coal Data file that is being developed in cooperation with the U.S. Geological Survey as part of the National Coal Resources Data System (NCRDS).

Basic mapping continues at the OGS with surface mapping in progress in Kay, Washita, and Alfalfa Counties, and regional geologic mapping in progress in the Ouachita Mountains, the Wichita Mountains, and the Hollis Basin. The COGEOMAP project in the Ouachitas is a joint effort of the Arkansas Geological Commission, the USGS, and the OGS. This important study will produce detailed surface and regional-subsurface geologic maps of the Ouachita Mountains to aid in understanding the geologic history of this complex terrain, and to evaluate the mineral- and energy-resource potential in the region.

Although the coal mining industry in Oklahoma is small in comparison with major coal-producing states, it has been an important factor in the economy of eastern Oklahoma since before statehood. In 1986, the state's coal production hit an 11-year low, reflecting large national excess productive capacity. But in 1986, more Oklahoma coal was consumed by the State's utilities than at any time in the past 20 years.

The primary thrust of the OGS coal investigation program consists of mapping individual coal seams and collecting point-source information on coal thickness, physical and chemical properties of the coal, overburden thickness and its physical and chemical

properties, and thickness and quality of any accompanying underclay. Field mapping is complete and reports on five pairs of counties and one individual county in eastern Oklahoma are in line for publication. The first, on Craig and Nowata Counties, was published in December 1986.

The OGS addresses environmental issues through its continuing cooperative water-study program with the USGS and through such studies as the recent assessment of stability problems in the abandoned underground mines in the old Picher Field area of northeastern Oklahoma. This project was a joint effort of the U.S. Bureau of Mines and the State Geological Surveys of Oklahoma, Kansas, and Missouri. At one time the largest zinc-producing area in the world, the old mining district was left with more than 1,000 shafts, 481 of which were identified as being open or in some stage of collapse. Suggestions for remedial action were included in OGS Circular 88, which resulted from this study.

Several programs are being initiated at the Survey to expand activities in the future. Among these are studies of major oil and gas reservoirs to evaluate the opportunities for enhanced-oil-recovery operations. The great amount of hydrocarbons that remains in reservoirs after primary and secondary recovery attempts represents a challenge to geologic and engineering study.

Also, some of the state's major aquifers have been degraded locally by natural contamination or by agricultural, industrial, or municipal (landfill) activities: new programs will evaluate the source and extent of such degradation, and will work on restoration of the aquifers.

New engineering-geology studies will focus on mapping and characterizing the areas in the state where natural or manmade hazards (such as karst areas, landslides, or



underground mines) exist and could adversely impact present or future use of the land.

During the mid-1980's, a great oil boom in Oklahoma, and around the world, came to an end, leaving in its aftermath vacant office buildings, abandoned oil rigs, and a number of failed banks. This era of recession found the OGS with a director much like its first director, Charles N. Gould, in his outlook on the future of Oklahoma.

Like Gould, Mankin is a true believer in Oklahoma's potential, but both expressed a realistic view--

Oklahoma in the early days imported nine-tenths of its manufactured articles, and this was not good. Little seems to have changed in the 1980's. And both directors, as well as the directors that served in the years between, are strong advocates of diversity in the Oklahoma economy.

If the past is any indication of the future, the Oklahoma Geological Survey will continue to build upon its firm foundation of service and research, helping Oklahoma and Oklahomans to the best use of their natural resources.

## OREGON

Oregon Department of Geology and Mineral Industries, 910 State Office Building,  
1400 SW Fifth Avenue, Portland, OR 97201. Phone 503-229-5580.

### HISTORICAL SEQUENCE OF ORGANIZATIONAL NAME:

Oregon State Bureau of Mines created, 1911  
Renamed Oregon Bureau of Mines and Geology, 1913  
Incorporated into School of Mines at Corvallis, 1923  
Oregon Mining Survey created without staff or office, 1925  
State Mining Board created, without staff or office, 1929  
Oregon Department of Geology and Mineral Industries created, with  
offices in Portland, Baker, and Grants Pass, 1937

### NAMES AND TITLES OF ORGANIZATIONAL DIRECTORS AND DATES SERVED:

Earl K. Nixon, June 3, 1937 - May 1, 1944  
F. W. Libbey, May 1, 1944 - October 31, 1954  
Hollis M. Dole, November 1, 1954 - March 20, 1969  
Raymond E. Corcoran, March 24, 1969 - January 31, 1977  
Ralph S. Mason, February 1, 1977 - October 1, 1977  
Donald A. Hull, November 30, 1977 - present

### OREGON DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES

#### PROGRAMS

##### Introduction

The mission of the Oregon Department of Geology and Mineral Industries is twofold: (1) to develop geologic information for the State, and (2) to disseminate that information to a diverse audience. The Department also regulates selected activities of a technical and geologic nature. The Department is the only agency of State government responsible solely for subsurface resources.

The Department employs a staff of professional geologists, engineers, chemists, cartographers, and editors who conduct or manage various programs involving geologic and topographic mapping, appraisal of mineral resources and geologic hazards,

regulatory functions, and information dissemination.

The central office in Portland includes a specialized analytical laboratory to support field projects, a publication section including a cartographic facility to prepare a variety of maps and other publications, a library of published and unpublished data on the geology of Oregon, and a sales office where publications may be purchased.

Since the Department and its programs have a strong field orientation, field offices are maintained in Albany, Baker, and Grants Pass.

##### Geologic Mapping

Geologic maps provide the basic earth-science framework for a multitude of practical activities, including appraisal of mineral resources, identification of geologic hazards (earthquakes, volcanoes, and landslides), inventory of ground-water resources, and design of manmade structures (dams, power plants, roads, and buildings). The

continuing preparation of geologic maps is a central function of the Department, as provided by Oregon Revised Statutes.

### **Mineral Resources**

An improved knowledge of mineral resources is needed (1) to further economic development goals; (2) to achieve realistic land-use planning for Federal, State, and private lands; and (3) to encourage conservation of non-renewable resources. The Department is instructed by Oregon Revised Statutes to survey and inventory the mineral resources of Oregon.

### **Petroleum and Natural Gas**

As supplies of petroleum and natural gas in established producing areas are exhausted, the nation will look to frontier areas such as Oregon for new reservoirs of hydrocarbon resources. The continued discovery of these nonrenewable resources will further the national goal of energy independence. Wildcatters will continue to test areas in Oregon that have not been previously explored.

### **Geothermal Energy**

The development of geothermal-energy resources in Oregon is in a preliminary stage. Utilization is currently concentrated at Klamath Falls and Lakeview, and future expansion will depend on the discovery of new reservoirs. Large areas of the state, especially the Cascade Range in western Oregon and portions of Harney, Lake, and Malheur Counties in southeastern Oregon, are geologically favorable for such discoveries.

### **Technical Support Services**

**Laboratory:** Modern earth-science programs require facilities for both chemical and physical laboratory testing of rock samples. Department field studies are integrated with a variety of analytical techniques for

identification, assay, measurement, and age determination of minerals and rocks. The Department continues to work with a variety of universities, Federal agencies, and private laboratories to minimize equipment costs and to increase the volume of samples that can be processed.

Major improvements to laboratory facilities are currently being made to improve the safety, quality, and scope of analytical services provided to support field projects. In past years, the Department's laboratory has functioned primarily as an assaying facility for metallic-mineral ores. The analytical capabilities are being broadened (1) to handle systematic physical testing of samples for evaluation of the quality of deposits of clay, talc, silica, limestone, and other industrial minerals; and (2) to provide whole-rock chemical analyses that are needed to support geologic mapping projects.

**Publications:** The dissemination of geologic, geochemical, and geophysical information is done most effectively by the publication of maps and reports that are sold to users. Consistency and reliability of data are assured through a review process by specialists whose geologic perspectives, experience, and expertise are applied to data and interpretations in their final stages of preparation. To assure that information is used to the greatest extent possible in meeting the needs of the State, the Department publishes a bimonthly magazine, *Oregon Geology*, plus special papers, bulletins, geologic maps, and open-file reports.

**Library:** The Department's geologic library functions as a central repository for both published and unpublished geologic information on Oregon and adjacent states. The library is technical in nature, focuses effort on geological data not readily available from other outlets, and coordinates its more general activities with those of the State Library. In addition, the library stores

for public access various legal references to mineral law and a variety of maps of Oregon and the adjacent offshore area.

### **Reclamation of Mining Sites**

Reclamation of mined lands is necessary to prevent development of undesirable land, water, and air conditions detrimental to the safety, health, welfare, and property rights of the general public. The goal of Oregon's Mined Land Reclamation Program is to assure beneficial subsequent use of mined lands that is consistent with the interests of property owners and Federal, State, and local governments; realistic in terms of the limitations and potential uses of the land; and equitable in terms of industry needs.

It is essential that the current usefulness, future productivity, and scenic values of all land and resources affected by mining operations be protected through reclamation. Oregon's interests in air, water, and land resources require a positive regulation program closely coordinated with other agencies and aimed primarily at future beneficial use. Authority to regulate the reclamation of mined lands is conferred upon the Department by Oregon Revised Statutes.

### **Drilling Regulation**

The development of energy minerals such as natural gas, petroleum, and geothermal energy requires careful regulation to insure conservation of the resources; to protect the correlative rights of mineral owners; and to protect the safety, health, and welfare of Oregonians.

Because geology plays such a significant part in the formation of the resource and in the design and operation of wells, geologic expertise is properly an integral part of the regulatory procedure.

Authority to regulate drilling for oil, gas, and geothermal exploration

and production is assigned to the Department by Oregon Revised Statutes. Staff expertise in deep-well technology and experience in the geology of the State are needed for the complex decision making of this activity.

## **HISTORY**

### **The Early Years: 1937-41**

The State Legislature finally created a full-fledged Department in 1911, nearly 40 years after Thomas Condon had been appointed State Geologist. After several name changes, the Oregon Bureau of Mines and Geology was incorporated into the School of Mines at Oregon Agricultural College in Corvallis. Although the Bureau conducted studies and published fourteen bulletins between 1914 and 1923, its activities were somewhat hampered by overlapping authorities and difficulties with budgeting. In 1923, the Bureau turned all of its files over to the college and disbanded. In an attempt to remedy this situation, the Legislature in 1925 and again in 1929 created an Oregon Mining Board but provided neither of them with offices or staff.

In the spring of 1987, the Legislature created the present Department of Geology and Mineral Industries and for the first biennium appropriated \$60,000 for the Department, along with an additional \$40,000 that was earmarked for grubstakes for placer miners and for administering the "Grubstake Act" during the biennium.

The first meeting of the Department's Governing Board, which had been appointed by the Governor, took place on April 7, 1937, about a month after the Department had been created. The Board members had been chosen partly because of their interest in mining and geology and partly by reasons of regional representation.



By June 8, 1937, after interviewing numerous candidates, the Board selected Earl K. Nixon to be the first Director of the Department. Earl Nixon was a mining engineer with wide experience in many parts of the world. At the time of his appointment, Nixon was operating a placer mine in Josephine County. The mine was running smoothly and making a profit, but Nixon sensed that the new job, even though it paid substantially less than he was making, might offer some excitement and a wider range of activities and challenges than washing gravel with a very large hose. In this he was not to be disappointed. From his first moment in the driver's seat, the new Director, with the full cooperation of the Board (which met ten times during the first year), launched a blizzard of programs and projects. To accomplish as many tasks as possible in the shortest time, Nixon established a 44-hour work week for the Department and kept the office open during noon hours to accommodate both local and out-of-town patrons and also to receive phone calls originating in other time zones. For many years, thanks to flexible work schedules, the Portland office was open from shortly after 7:00 a.m. until 5:30 p.m. Professional staffers working on rush projects in the evening reported incoming calls far into the night.

Earl Nixon was the miners' friend and champion, but he also realized that too much was too much at times. Placer mining along the Rogue River and its many tributaries reached a peak during the Depression years, and as a consequence, much muddy water was introduced into the river. Fishermen objected, because the muddy water made fishing difficult, if not impossible. On one hand, fishing in those trying years was largely for food, not sport; on the other hand, placer mining was the only work that hundreds of unemployed men could find. Clearly, a compromise

was needed. Earl Nixon, buffeted by both parties, finally hammered through a program that let the miners work during the week but required them to shut down on weekends, allowing the water to clear for the nimrods. He was also concerned over the damage caused by bucketline dredges and commissioned several studies on methods for alleviating the usual pollution from the tailing piles.

By the time Earl Nixon resigned in 1944, the Department was firmly established as a vital part of State government, and its broad objectives had been clearly enunciated. World War II was well along, the Department was functioning smoothly, and Nixon left to return to private industry and its postwar problems.

One of the difficulties in working up a history of the Department is the problem of trying to depict, as accurately as possible, not only what happened way back then but also how and why these events were accomplished. Take travel around the state, for instance. In the 1930's, only the major highways were blacktopped, and cars had no heaters, automatic transmissions, power steering, or power brakes. Tire chains, axes, saws, and shovels were standard equipment the year round. Traveling a thousand miles in those days was an act of endurance and often raw courage.

In the drafting room where maps were made, the cartographer struggled with linen tracing cloth for his base maps and put up with India ink that either dried on the pen in hot, dry weather or refused to dry promptly when applied in wet weather. The Department's Portland office had no air conditioning for 40 years. Crude, short-run multicolored maps were produced with a hectograph purchased from Montgomery Ward. The hectograph smelled like horsehide and looked like tired, tan Jello. The map was drawn on a master sheet of paper with various-

colored special pencils, laid face down on the tacky surface of the hectograph, and rubbed gently. After the master sheet was removed, clean sheets of paper could be placed on the surface, and as many as twenty copies could be "lifted" from the gelatinous surface. After a run, the surface of the gelatin was washed, and the gelatin was heated to fluidity and poured back into the shallow tray. During the heating process, the office reeked with very gluey smells, giving rise to the nickname "Boiled Horse" that stuck.

Electric typewriters were unknown, and the office copier had not yet been invented. Stenographers aged visibly when turning out long reports with five or more carbons. Most communication was by mail, or, in emergencies, by telegram. Telephoning the field offices just wasn't done, and letters and memos served instead. Some field office recipients of mail from Portland would, on occasion, simply append a reply to the bottom of the memo and fire it back. One such memo grew to a length of more than a yard as codicils to the originals were taped to the bottom and sent out again. One fringe benefit of all this writing back and forth was that letters tended to be brief, pithy, and devoid of any unnecessary prose.

Department fire assay offices were established in 1937 in Grants Pass and Baker and provided analyses for the precious metals gold and silver and the base metals copper, lead, and zinc. The service was limited by Governing Board action to two samples per month taken from mines and prospects from within the state. There was no charge for this service, but the results of the assays were placed on file and could be examined by the public if desired.

In 1938, the Baker and Grants Pass assay offices must have been the busiest places in both towns. In June 1938, for instance, the two offices had nearly 1,200 visitors and accepted more than 450 samples for assay. Since nearly

every prospector wanted "the works," this meant that the hapless assayers, who usually worked without assistants, had to turn out 2,250 analyses. No wonder the lights in the back rooms burned brightly far into the night.

Starting in 1938, only a few months after its organization, the Department began issuing monthly *Press Bulletins*. This series was replaced, starting in January 1939, with a monthly publication, *The Ore.-Bin*, which was distributed free to libraries, universities, colleges, and legislators. The tone for *The Ore.-Bin* was established in the first edition by the Department's first Director, Earl K. Nixon, who, in a preface, declared: "The State Department of Geology and Mineral Industries will use *The Ore.-Bin* to advise the public of the work of the Department and of new and interesting developments in mining, metallurgy, and geology." This policy has been followed by successive directors and editors, although many recent articles have described concepts and discoveries undreamed of when the first copy came off the press in the Department's back room.

The Department's policy of prompt dissemination of data resulting from its studies or from other studies deemed of value to the State is implemented in various ways. *The Ore.-Bin* (later the *Ore Bin* and then *Oregon Geology*) provides a most convenient vehicle for this purpose, since timely material can be substituted easily at the last minute for less urgent articles. Also the number of pages can be increased, if necessary, to include critical information.

Since the Department has a long-established track record of getting the word out quickly, it has been able to attract numerous authors of studies of interest to the Department. The author provides much valuable information at little or no cost to the State in exchange for having his work published and distributed promptly to the scientific

community and the public generally. In some cases, the Department has provided "gas and grub" money to graduate students working on field problems compatible with the Department's objectives.

#### The War Years: 1942-45

Partly because it was created during the depths of the Great Depression and partly because it was shortly to be immersed in the chaos of World War II, the Department operated from the beginning on a 5½-day, 44-hour week. These were the standard hours for the office-bound staff. Out in the field, staff geologists worked far longer hours every day, and if they were located some distance from home base, they put in a 7-day week. No compensatory time was ever taken, and it is doubtful that it would have been granted if it had been requested. The 44-hour week was finally cut back to 40 hours on January 1, 1948.

Trying to operate during World War II was difficult at all levels. Gasoline and tires were rationed, speed was reduced to 35 miles per hour, no travel after dark was permitted within 100 miles of the coast, and many restaurants and service stations were closed on weekends. In the office there were shortages of many types of paper and equipment, servicemen were practically nonexistent, and even paper clips were scarce. Office help fled to the shipyards and other war industries. "Rosie the Riveter" was very real, weather forecasts were banned, wages were frozen, and rumors were a dime a dozen.

In addition to its strategic and critical minerals investigation programs, the Department participated in many war-time advisory duties, providing information on a wide variety of subjects to local, State, and Federal agencies. There was little to laugh at during the war; on one occasion, however, the gloom was inadvertently

lifted when a newly minted Federal official solemnly inquired about the status of the State's brass mines.

World War II came as no surprise either to the Department or to the mining companies having international operations. Wars are fought with metals, and any disruption of the normal trading patterns in these commodities, such as those taking place from 1933 onward in Germany, were a clear signal of trouble ahead. Although the United States was not to enter the war until December 1941, the Department starting in 1937 had undertaken studies of minerals of critical and strategic importance to the war effort. Reports on the period from Pearl Harbor to V-J Day found the Department almost exclusively engaged in purely war efforts. In addition to investigations in the field for strategic and critical minerals, much time was spent assisting State and Federal agencies on war-related projects such as the various stockpile programs, access roads, underground shelters, and even a project to use locally available mineral pigments for creating camouflage paints. The newly installed spectrographic laboratory was also called on frequently for analyses of materials used in local defense plants.

Trying to operate the Department during this period, with severe restrictions on travel, shortages of laboratory and office equipment and supplies, and the general uncertainty about nearly everything, was a frustrating experience for the management and staff alike. Field work was even further hampered by the prohibition, enforced on December 11, 1941 (the day war was declared on Germany and Italy), against releasing weather reports. Also, although most of the professional staff members were granted occupation deferments, obtaining field and office assistants proved to be most difficult.



One of the most time-consuming projects undertaken by the Department was the installation of the Federal critical-minerals stockpile program for chromite. After a great many meetings with chrome miners, local officials, and the Federal agencies charged with the procurement of war minerals, the Department was able to arrange for the opening of three chrome depots at Grants Pass, Coquille, and Seneca. Because the mines had been idle since the close of World War I, many of them required extensive rehabilitation before going into operation. Roads had to be constructed to some, mine and mill buildings needed to be erected for most, and start-up funds were required for nearly all of the operations. If the program was to be effective, prompt action was required. The Department's Director, Earl Nixon, was ideally suited for cutting red tape, inspiring the doubters, and encouraging everyone to top-speed activity. The result was that the stockpiles began receiving ore in the shortest possible time.

During World War II, travel was difficult. A speed limit of 35 miles an hour, coupled with difficulties in obtaining gas and meals en route, essentially doubled the travel time between distant points. Service stations rarely opened before 9:00 a.m. and often closed early when fuel allotments were exhausted. Some stations in small towns "saved" gas for their local customers, and out-of-towners were often turned away. Motel and hotel rooms in towns having some war-related activity were difficult to get. Weather forecasts were banned from the radio and the press, making winter travel dangerous and uncertain. Travel by car was pretty much restricted to daylight hours because of blackout regulations. Air-raid alerts could delay traffic for an hour or more, a serious development if one hoped to arrive at one's destination before dark.

### **The Postwar Years: 1946-56**

In the postwar years, the Department engaged in a continuing series of hitherto unexpected endeavors. The atom bombs that signaled the end of World War II also rang up the curtain on the Atomic Age, and the rush for radioactive minerals was on. The Department was besieged by professional and novice prospectors, all clamoring for information on where to look for uranium and where to have their samples tested. The Cold War dulled any hope for an unbroken peace; the Federal government once again worried about domestic sources of critical and strategic minerals, and again the Department began coordinating efforts to get Oregon chrome miners back into production.

The restrictive wartime controls were not removed until 18 months after the war was over. Price and wage ceilings enforced by the Office of Price Administration were lifted, and the Department and the economy in general prepared for the postwar period. No sooner had the fears felt during World War II subsided than they were replaced by those associated with the Cold War. The Department was required to set up a Civil Defense organization and to establish the succession to the office of the Director in the event that he became a casualty. A new wave of requests for assistance in locating survival sites in abandoned mines and other equally fatuous projects began arriving at the Department.

### **The Space-Race Years: 1957-66**

Many people were lying flat on their backs on the ground to view it in the crisp evening air. Right on schedule it appeared, dim at first, then brightening a bit and slowly dimming again--and then it was gone. That evening in 1957 marked, for most people, the beginning of the Space Race Years, a period of continuing excitement, wonder, and



tinges of fear. The Russians started it all off with Sputnik, a tiny, grapefruit-sized, beeping, earth-orbiting satellite, and once again the world braced itself against the unknown.

Aside from the very real scientific accomplishment of lofting an earth-orbiting satellite, the political significance, in terms of national security, was enormous. National pride was at stake, too, and the United States began a crash program to get something into space as quickly as possible. Inevitably, the Department was swept up in several phases of this activity, which ultimately led to the first successful landing of an astronaut on the Moon.

A direct by-product of the Department's space-age activity was the compilation of large amounts of data on volcanism and volcanic features, particularly those to be found in central Oregon, where the abundance and variety of fresh extrusive material has created an almost perfect laboratory and museum of Holocene volcanism. After this intensive investigation, the Department became even more convinced that in the not-too-distant future there would be renewed volcanism somewhere in the state, probably at some point along the axis of the high Cascades or in central Oregon. The Space-Race lifted everybody's eyes up to the skies, but in Oregon quite a few people also began taking furtive looks at our snow-covered volcanoes.

Almost 4 years before the first human footprint appeared on the surface of the Moon, the Department hosted the Lunar Geological Field Conference in Bend. In August 1965, nearly 80 geologists, geophysicists, and astronomers from nine foreign countries and the United States gathered for a full week of discussions, field trips, and demonstrations. Russian scientists had been invited but canceled at the last minute, apparently due to the fact that the United States had launched Gemini 5 the day before the

conference opened (Cooper and Conrad completed 120 orbits during the conference, a record far surpassing the 60 revolutions made earlier by the Russians).

### **The Stewardship Years: 1967-Present**

The Stewardship Years began with the administration of Governor Tom McCall, who campaigned much of his life for the protection of the environment. Known as the "Liveability Governor," Tom McCall sponsored legislation leading to the creation of the Willamette Greenway, the Department of Environmental Quality, statewide land-use planning, the Bottle Bill, and the Beach Bill. All of these actions had their impact on the activities of the Department, since they were concerned with the vulnerability of the Earth's surface to the increasing onslaught by human activities. For the next 20 years, the Department was to be busily engaged in providing geologic information on the capabilities and liabilities of the land for State and local governments as they struggled with making land-use decisions.

The regulatory and administrative duties of the Department were increased significantly during the stewardship years. The Oil and Gas Conservation Act, which had become law in 1953, was strengthened and enlarged with the appearance of new challenges, particularly those associated with the successful development of the State's first gas well. In 1971, two pieces of legislation were passed: (1) the Mined Land Reclamation Act, which ensured that all opened pits would be reclaimed upon abandonment, and (2) the Geothermal Resources Act, which nominated the Department to monitor all wells drilled for geothermal energy. Both Acts were enhanced several times by later legislation.

The enabling act that created the Department required it, among other

things, to initiate and conduct studies and surveys of the geologic and mineral resources of the State, to evaluate their commercial utility, and to consider and study kindred scientific and economic questions in the field of geology and mining that are deemed to be of value to the people of Oregon. At its inception, the Department had few regulatory duties; 40 years later, however, the Department found that it was encouraging and assisting the mineral industry at the same time it was regulating several segments of the same industry such as oil, gas, and geothermal exploration and open-pit mining operations. This unique situation prompted an attorney, after he had served on the Governing Board, to remark,

The one thing that I feel distinguishes the Department of Geology from any other State or Federal agency is that it tries to help people rather than hinder them. The Department makes a point of working with industry in resolving its problems, rather than trying to stop it.

As the Stewardship Years progressed, the Department found itself increasingly involved with interagency projects and particularly with cooperative programs with county and local governments. The Department functioned both as a scientific research and investigative body and as a service arm of State government, providing geologic information to both the public and private sectors. Most local governments in the state had no staff geologists and relied heavily on the Department to provide information and assistance when needed or to recommend where suitable professional services might be obtained. Although the Department supplied a great deal of information in the form of mapping, analysis of ores and minerals, and overviews of regional geology, it did not normally attempt to provide in-depth and detailed site-specific information. This is the province of the private consultant

having special skills and knowledge for specific problems, usually of an ad hoc nature. The Department has always enjoyed a close relationship with private consultants and has hired many of them as the occasion warranted.

In the early 1960's, the Department began what was to become an almost nonstop program of the assessment of the geologic capabilities and hazards of the State's lands. It was becoming increasingly apparent that construction of all types was taking place on sites of questionable geologic integrity and that local governments had no adequate guidelines for making specifications and conditioning permits. Starting with a modest project in the Tualatin Valley in 1967, the program of geologic appraisal of the land spread during the 1970's to cooperative work for all of the coastal counties and many other areas around the State.

Resistance at various levels to the findings produced by these studies sometimes developed. Landowners objected to having their lands identified as being within a flood plain. Homeowners complained when it was pointed out that houses built at the mouths of narrow canyons might be damaged by flooding. Local governments were reluctant to change procedures for a wide variety of reasons.

However, in addition to pointing out areas of concern or potential problems, the Department's studies have provided local governments with geologic and engineering data useful in helping new industries select appropriate building sites. The studies have also identified and characterized deposits of minerals, principally crushable stone and sand and gravel, that are critical to community development.

During the 1980's, the Department has continued to network its activities with evolving policy decision making and to aggressively pursue the development and dissemination of new data.

The Department actively participated in numerous policy-oriented bodies, including those for water management, offshore resource management, disposal of high-level nuclear waste, underground injection, National Forest planning, and others. It pursues cooperative activities with the U.S. Forest Service and the Bureau of Land Management through creative memos of understanding. The Department co-chairs the Federal-State Interagency Task Force on Gorda Ridge with the Minerals Management Service. It also chairs the State Map Advisory Council, designed to coordinate mapping, Geographic Information Systems (GIS) development, and Land Records development for the State.

The Department Laboratory has been refurbished to emphasize industrial minerals analysis and includes XRD equipment. Regional mineral assessments pursued by the State are based on strong field efforts leading to new in-house or cooperative analytical data. Department technical files are transitioning into computerized treatment, with emphasis on personal computers. Currently, computerized graphics and desktop publishing are being pursued.

#### CHRONOLOGY OF PRINCIPAL ACTIONS BY STATE LEGISLATURE

- 1872--First State Geologist, Dr. Thomas Condon, is appointed.  
1911--Legislature creates Oregon State Bureau of Mines.  
1913--Legislature renames Bureau the Oregon Bureau of Mines and Geology and expands its responsibilities.  
1923--Bureau is incorporated into School of Mines at Corvallis.  
1925--Legislature creates Oregon Mining Survey but without office or staff.  
1929--Legislature creates State Mining Board but without office or staff.

1937--Legislature creates State Department of Geology and Mineral Industries with offices in Portland, Baker, and Grants Pass (ORS Chap. 516).

1939--Legislature creates Rogue River Coordination Board, naming Director as Secretary.

1941--Legislature creates Spectrographic Laboratory with installation in Portland office.

1953--Legislature adopts Oil and Gas Conservation Act (ORS 520) and assigns regulatory responsibilities.

1965--Legislature passes an act (ORS 517.410) requiring agencies to consult with the Department before issuing leases for mining or for oil and gas exploration.

1971--Legislature passes the Geothermal Resources Act (ORS 522.101) assigning regulatory authority to the Department.

1971--Legislature passes Mined Land Reclamation Act (ORS 517.750) and assigns enforcement responsibility to the Department.

1981--Legislature expands Mined Land Reclamation Act to include nonaggregate minerals.

1981--Legislature amplifies provisions of Geothermal Resources Act to include unitization.

1987--Legislature revises surface mining act to provide for bonding of aggregate sites up to the total cost of reclamation.

#### CHRONOLOGY OF PRINCIPAL PROJECTS UNDERTAKEN BY THE DEPARTMENT

- 1937--Crash program for "war minerals" such as mercury, chromite, manganese, tungsten, antimony, and coal.  
1937--State "grubstaking" program for gold prospectors.  
1937--First bulletin, *Mining Laws of Oregon*.  
1938--First bulletin on oil and gas (Clarno Basin).

- 1939**--Assists in creating Rogue River Coordination Board.
- 1941**--Full wartime footing starting December 8 (day after Pearl Harbor).
- 1942**--Commencing of operation of spectrographic laboratory.
- 1943**--Consolidation of assay equipment from Baker and Grants Pass at Portland.
- 1943**--Beginning of Coos Bay coal project.
- 1944**--Ferruginous bauxite discovered by Department in Washington County and south of Salem in Marion County. Preliminary findings published in August.
- 1946**--Investigation and testing of expansible shales started in northwest Oregon by Department.
- 1947**--Series of studies on nickel laterites in southwestern Oregon begun.
- 1948**--First Pacific Northwest Metals and Minerals Conference held in cooperation with AIME.
- 1951**--Chrome stockpile begun in Grants Pass.
- 1953**--Oil and Gas Conservation Act passed.
- 1953**--Governor asked by Department to form Western Governors' Mining Advisory Council
- 1954**--The cooperative mineral industry annual canvass begun by U.S. Bureau of Mines.
- 1955**--Investigation of uranium deposits conducted in southern Oregon.
- 1956**--Bend-High Cascades map, the first of many volcanic studies, released.
- 1956**--Attention directed to mineralized areas in Western Cascades.
- 1957**--First report on volcanism in the Cascades released.
- 1958**--Staff petroleum engineer hired.
- 1960**--"Target geology" policy to study specific areas adopted by Department.
- 1960**--First sand and gravel resource study (in the Salem area) conducted.
- 1960**--First Gold and Money Session hosted with AIME.
- 1961**--Department becomes involved in lunar landing project with NASA and assigns staff geologists to study lunar geology in central Oregon.
- 1961**--Department publishes first of a series of *Ore Bin* guides to geology of state parks.
- 1965**--International Lunar Geological Field Conference held at Bend.
- 1966**--First of a series of land-use studies released.
- 1968**--Department hosts Andesite Conference.
- 1968**--"Year of the Meteorite" announced.
- 1968**--First regional oil and gas assessment study released.
- 1971**--Geothermal Resources Act passed.
- 1971**--Mined Land Reclamation Act passed.
- 1971**--Department becomes advisor to Nuclear Siting Council.
- 1972**--First of a series of numerous, jointly funded geologic-hazards studies conducted.
- 1979**--Large scale geothermal investigation of Cascades Range begun.
- 1979**--Department charged with coordinating Federal and State mapping through chairmanship of State Map Advisory Committee.
- 1979**--Department reorganizes and places geologists into Program 1, Mined Land Reclamation into Program 2, and administration and support services into Program 3.
- 1981**--Cooperative effort with U.S. Forest Service to map mineralized 7.5-minute quadrangle in northeast Oregon initiated.
- 1983**--Extensive regional oil and gas assessment of parts of western Oregon begun.
- 1985**--Department initiates industrial minerals program and begins reorientation of laboratory effort.
- 1987**--Legislation to bond chemical leach aspects of precious metals mining passed.



## PENNSYLVANIA

Bureau of Topographic and Geologic Survey, Department of Environmental Resources, P.O. Box 2357, Harrisburg, PA 17120. Phone 717-787-2169.

### HISTORICAL SEQUENCE OF ORGANIZATIONAL NAME:

- "First Survey" - Geological and Mineralogical Survey, 1836-42;  
State Geological Survey, 1851-58
- "Second Survey" - Geological Survey of the State, 1874-95
- "Third Survey" - Topographic and Geologic Survey Commission,  
1899-1914
- "Fourth Survey" - Pennsylvania Topographic and Geologic Survey,  
1919-present

### NAMES AND TITLES OF ORGANIZATIONAL DIRECTORS AND DATES SERVED:

#### Director and State Geologist

Henry D. Rogers, 1836-42, 1851-58  
J. Peter Lesley, 1874-87  
Richard R. Hice, 1909-18  
George H. Ashley, 1919-46  
Ralph W. Stone, 1946

Stanley H. Cathcart, 1947-53  
Carlyle Gray, 1953-61  
Arthur Socolow, 1961-86  
Donald M. Hoskins, 1986-present

### PENNSYLVANIA'S HISTORICAL DEVELOPMENT<sup>1</sup>

The Pennsylvania Geological Survey, formally known as the Bureau of Topographic and Geologic Survey of the Department of Environmental Resources, is one of only a very few Commonwealth of Pennsylvania Executive Branch agencies whose history can be traced to the first half of the 19th century. The beginnings of the Pennsylvania Survey are traced to a meeting held September 30, 1826, in the hall of the Franklin Institute, Philadelphia. Called by Peter A. Browne, the meeting was to discuss a geologic survey of Pennsylvania. Although a Committee of Philadelphia citizens was formed at the 1826 meeting no further action toward a survey of the

state was taken. In late February 1832 the Geological Society of Pennsylvania was formed. Composed of the prominent citizens and scientists of Philadelphia, it established a Committee On The State Geologic Survey which sent a message to the Pennsylvania Legislature urging the creation of a topographic, geologic and mineralogic survey of the state. Similar messages were sent in 1833 and 1834 stating that the Society was prepared to undertake the survey and accept funds appropriated by the Legislature.

In 1835 the Governor's "Message to the Legislature" resulted in a Legislative Committee report and bill. The bill was introduced by Philadelphia Representative Charles Trego who later became a geologist of the survey. The enactment was signed by Governor

<sup>1</sup>This history of the Pennsylvania Geological Survey is excerpted in part from Volume 18, Number 1 of *Pennsylvania Geology*, February 1987, by Donald M. Hoskins, Clifford H. Dodge, William D. Sevon and Roger T. Faill, supplemented by Arthur A. Socolow.

Ritner on March 29, 1836. Pennsylvania was thus the ninth state to enact legislation for a geological survey and in 1836 joined Georgia, Maine, and New York whose legislative bodies had also created geological surveys in that year.

The Geological Survey of Pennsylvania created in 1836 was the first of four legislatively authorized surveys of the Commonwealth.

#### THE FIRST GEOLOGICAL SURVEY OF PENNSYLVANIA

The First Geological Survey of Pennsylvania began field work in May 1836 and field campaigns were conducted each year until April 1842 when the Legislature did not appropriate funds for further field work. Appointed State Geologist was Henry Darwin Rogers, age 26, and Professor at

the University of Pennsylvania. Assistant Geologists were the younger James C. Booth, at 24, and John F. Frazer, of Rogers' age. Booth and Frazer both left the Pennsylvania Survey after 1 year, apparently due to Rogers' requirement that they be assistants rather than equal colleagues, as was the procedure with the geologists of the four New York districts, whose Survey also began in 1836. Booth then became the State Geologist of Delaware. Frazer returned to academic duties at the University of Pennsylvania. In their first year, however, Booth, Frazer and Rogers established the basic geologic framework for subsequent mapping in the Appalachian Mountain States.

Before disbanding in April 1842, the corps of geologists increased to twelve, among whom was Charles Trego, the legislator instrumental in the passage



Henry Darwin Rogers,  
Director, 1836-42, 1851-58

of the authorizing law. Peter W. Shaeffer, later a prominent anthracite coal geologist, and J. Peter Lesley, later State Geologist of the Second Pennsylvania Survey were also members of the corps.

Rogers received a small appropriation in 1843 to prepare a set of final maps and reports. Delivered to the Secretary of the Commonwealth in 1847, they were still unpublished in 1851 when citizens interested in the development of anthracite, and urged on by Peter Shaeffer representing anthracite area interests, prevailed on the Legislature to reinstate Rogers as State Geologist and continue work. By then Trego, who was reelected in 1842 to the Pennsylvania Legislature and had apparently blocked Rogers' many funding requests to the Legislature during the mid and late 1840's, was no longer a Member.

The First Geological Survey of Pennsylvania recommenced in 1851 with Shaeffer and Lesley as part of the corps with most of the work focused in the anthracite areas. They were aided by the Swiss national M. E. Desor and by Leo Lesquereux, a paleobotanist. After 1852 most geological duties were accomplished by Rogers and his nephew, William; Lesley had left in 1852, after personal differences with Henry Rogers. William Rogers, Jr., was assigned to measure and prepare numerous sections for his uncle. Field work ended in the fall of 1854 and in 1855 Rogers received a 3-year appropriation to publish the map and report. He then again left for Scotland where the magnificent two volume report and maps on Pennsylvania were printed. William, Jr., remained in the field collecting and describing sections for his Uncle Henry, who was in Scotland arranging for the printing of the maps, copper plate and color lithograph illustrations, and voluminous text. The 1858 map of Pennsylvania is described as being one of the finest

examples of the new process of chromolithography which was first used in 1851 in Europe. The Geologic Map of Pennsylvania of 1858 may have been the first State Geological Survey map using this process.

Rogers and his two assistants were able in the first year of work to subdivide the States' great thickness of rocks in the Appalachian Mountains into twelve groups of rocks which were easily distinguishable from each other on clearly visible lithologic criteria. The nine older groups were further grouped into Rogers' Appalachian System. The three younger groups were included in the Carboniferous System. As a result of their first year's labors, the First Geological Survey of Pennsylvania was destined to set the geologic framework for all subsequent mapping in the states along the Appalachian Mountains. During the second year of the First Survey, Rogers renamed these groups as Formations and called each by a Roman numeral, from I to XII. This subdivision of formations into the numerical classification, with but a few modifications, was used by all geological assistants of the First Survey and by all subsequent Pennsylvania Surveys, until the 1930's. Other Geological Surveys of the Appalachian States and the U.S. Geological Survey also used this nomenclature into the 1900's.

Major geologic discoveries made in the subsequent years of the First Survey included the finding that the anthracite coals were of the same age and origin as the bituminous coals, even though of markedly different chemical and physical character. The use of topography in determining the underlying geology was discovered in 1838, as was the origin of brown iron ores. Dr. Robert Jackson, a physician and later Chief Surgeon of the Army of the Cumberland during The War Between The States, was a First Survey Assistant from 1838 to 1841; he determined that the iron ores in the many limestone valleys of

central Pennsylvania originated from the accumulation of the insoluble iron resulting from solution of limestone. In addition, the discoveries of the First Pennsylvania Geological Survey prompted a major new branch of the science of geology--structural geology.

The staff of the First Pennsylvania Survey was instrumental in the formation of the Association of American Geologists, later to become the American Association for the Advancement of Science. At the founding meeting in 1840 six of the eighteen attendees were members, or had been members, of the First Pennsylvania Survey. They were Henry Rogers, Charles Trego, James Booth, Martin Boyé, Robert Rogers, and Alexander McKinley

#### THE SECOND GEOLOGICAL SURVEY OF PENNSYLVANIA

The discovery and exploitation of mineral wealth in Pennsylvania accelerated during the decade that followed publication of H. D. Rogers' *Final Report* of 1858. Pennsylvania's industrial growth and the discovery of oil prompted public demand for more complete and detailed geologic information about the State's coal, petroleum, iron ore, and other mineral resources. With this in mind, the Pennsylvania Legislature approved a bill on May 14, 1874, to establish the Second Geological Survey of Pennsylvania.

The legislative act creating the Second Geological Survey provided for a Board of Commissioners, which was authorized to select a State Geologist and to approve all of his plans and major recommendations in operating the Survey. The Board of Commissioners selected J. Peter Lesley (1819-1903) to the post of State Geologist and Director of the Second Geological Survey.

Lesley, a native of Philadelphia, was eminently well qualified and widely respected among his peers. He

was professor of geology and mining at the University of Pennsylvania and was, at the time of his appointment, an acknowledged expert in several fields of geology, particularly coal and petroleum. His broad knowledge of Pennsylvania geology developed during his years with the First Survey and thereafter as a geologic consultant. He was a pioneer, if not the pioneer in the use of topographic and structure contouring and aneroid altimeters in geologic mapping. Lesley was a respected author of many articles, reports, and publications prior to the organization of the Second Survey. Perhaps most notable were his *Manual of Coal and its Topography* and *Iron Manufacturer's Guide*, published in 1856 and 1859. He was actively involved with many scientific organizations, including the American Association for the Advancement of Science, the American Philosophical Society, and the National Academy of Sciences (of which he was a founding member).

In 1909, H. M. Chance, in a biography written for the American Philosophical Society, said of Lesley:

Probably no public organization was ever less bound by the red-tape of officialism than this survey corps, whose members he left untrammelled, unhampered, trusting each other to do his duty, thus placing each in a position where he was driven to do his best, where he would be ashamed to do less.

Assistants of the Second Survey read like a "Who's Who" and included C. A. Ashburner, E. W. Claypole, E. V. d'Invilliers, Persifor Frazer, W. G. Platt, Franklin Platt, J. J. Stevenson, I. C. White, and Arthur Winslow, all of whom, in addition to J. P. Lesley, were "original founders" of the Geological Society of America when this society was founded in 1888. Other well known geologists of the Second Survey were J. F. Carll, H. M. Chance, J. H. Dewees, F. A. Genth, T. S. Hunt, Leo Lesquereux, B. S. Lyman and Frederick Prime.





J. Peter Lesley,  
Director, 1874-87

Lesley's style and philosophy pervaded every aspect of the Survey and developed largely as a result of his break with H. D. Rogers. Where Rogers had amassed draft reports, sketch maps and cross-sections from his assistants for the purpose of publishing a definitive final report, Lesley published reports from each district or project as soon as the material could be assembled and edited.

During the two decades that it operated, the Second Survey published nearly 120 atlases and volumes, comprising numerous maps, drawings, columnar sections, and cross sections and more than 25,000 pages of printed matter. In addition, it produced a "Grand Atlas" (in six parts) and a geologic map of Pennsylvania (scale, 1 inch = 6 miles). The publications of the Survey are practical and not theoretical, a condition imposed by Lesley.

Some of the most striking yet accurate geologic maps of the Second Survey were prepared for the anthracite coal fields, where more detailed information was available. The use of

multiple colors on these maps to distinguish surface and subsurface features was unsurpassed at that time by any other State surveys or the newly formed U.S. Geological Survey. During its anthracite studies, conducted between 1880 and 1889, it began the first large-scale, systematic use of structure contours and it constructed a number of topographic base maps on which to compile the extent of deep mining.

By the time it ended, the Survey had spent almost two-thirds of its entire budget of nearly \$1.6 million on publishing; the other third went to office and field expenses, as well as salaries.

The lack of accurate topographic base maps is often cited as "the fundamental defect" of the Second Geological Survey. From the start of the Survey, Lesley and members of his staff tried to demonstrate both the need and value of topographic maps. As early as 1884, the U.S. Geological Survey (USGS) and U.S. Coast and Geodetic Survey offered to participate in a cooperative program with Pennsylvania for the purpose of conducting compre-

hensive topographic and triangulation surveys of the State.

### THE THIRD GEOLOGICAL SURVEY OF PENNSYLVANIA

The Third Pennsylvania Geological Survey was established as the Topographic and Geologic Survey of Pennsylvania by Legislative Act on April 28, 1899. The act established a commission of three unpaid citizens to confer and accept cooperation with the USGS for the purpose of preparation and completion of contour topographic and geologic maps of the state. The Third Survey resulted from pressure on the Legislature when enough people of the State appreciated the desirability of having an accurate topographic map of the State and the economic value of a cooperative arrangement with the USGS. One of the first products of this arrangement was the Pottsville 15-minute topographic quadrangle map surveyed in 1889 and published in 1891.

A legislative enactment of May 13, 1909, authorized the establishment and maintenance of a topographic and geologic survey of the State and the appointment of a State Geologist with an annual salary not to exceed \$3,000. Richard R. Hice was appointed State Geologist. Funding ceased in 1914.

Hice, a brick manufacturer and founder of the American Ceramic Society, directed Third Survey efforts primarily towards coal, gas, and oil. Hice's philosophy was: "The primary purpose of a Geological Survey is the encouragement of the mineral production of the State." In 1911, he entered into agreement to cooperate with the U.S. Geological Survey in collection of the mineral statistics of the State, a cooperative effort which now exists with the U.S. Bureau of Mines.

The U.S. Geological Survey was already involved in various topographic and geologic projects in Pennsylvania when the Third Pennsylvania Survey



Richard R. Hice,  
Director, 1909-18

was created. The cost of publication and the responsibility for scientific control of those projects was borne by the Federal Survey. M. R. Campbell was the supervisor in charge of Pennsylvania geologic work from 1900 to 1904 when George H. Ashley, then a U.S. Geological Survey employee, took charge until 1910.

Geologic work during the first cooperative year included mapping the Uniontown and Masontown quadrangles as well as the Gaines and Elkland quadrangles. These were published as part of the monumental geologic folio series by the USGS, many of which are still frequently referred to.

Most of the geologic work by the Third Survey was done in the western part of the State and was oriented almost exclusively toward economic resources. Seventeen volumes totaling 3,200 pages were published by the Third Survey itself. One of the most important works published was a report on the Broad Top coal field by Gardner in 1913 which still remains the primary source of information about this area.

#### THE FOURTH GEOLOGICAL SURVEY OF PENNSYLVANIA

On June 7, 1919, the present Topographic and Geologic Survey was created as a bureau within the Department of Internal Affairs, and on September 1 of that year, George H. Ashley assumed the office of State Geologist. It was natural that George Ashley was named State Geologist of the newly created Fourth Survey because he had worked in Pennsylvania for the first two decades of this century in charge of the USGS cooperative program of the Third Survey. Ashley had worked with bituminous coal during this period.

However, it was in natural gas, not coal, that the new survey made its first mark. The McKeesport gas field was discovered in August 1919 and it promised to be a rich field. Ashley soon



George H. Ashley, Director, 1919-46

visited the area and, despite his warnings that excessive drilling would lead to large losses, drilling proceeded at a rapid pace. Within 2 years the over developed McKeesport field was largely depleted.

Coal, on the other hand, was not to be ignored. Ashley's instigated culm bank and river-coal studies. The Highway Department's need for limestone as road building material in northwestern Pennsylvania was also an early focus for the new organization.

Publishing at first was frustrated by a very slow state printing office, thus much of the early material was issued in mimeographed form.

Foremost in Ashley's overall plan was to produce a new Atlas of Pennsylvania, comprising both a topographic and a geologic map of each quadrangle. Ashley, by the end of the first year, had hired four geologists. Ten years later the number of geologists had grown to nine, a size at which the survey remained through the ensuing 25 years. One of the better known staff members was Bradford Willard, a paleontologist. Another staff member

was Ralph W. Stone who wrote, among other reports, *Building Stones of Pennsylvania*. In the 1920's, Charles H. Behre extensively studied geology of the slate belt in Pennsylvania and proposed a significant stratigraphic interpretation. Anna I. Jonas worked through the 1920's and 1930's in southeastern Pennsylvania and was, along with Stose, an enthusiastic and vociferous proponent of the overthrust concept as applied in the Piedmont and Reading Prong.

In the early years of the Fourth Survey, Ashley contracted with 13 cooperating geologists to produce geologic maps. These geologists included such luminaries as Florence Bascom, Ralph L. Miller, Edgar T. Wherry, and Charles R. Fettke. Cooperative projects with the USGS involved Stose, M. J. Munn, G. B. Richardson, and M. E. Johnson, among others.

When he took office, quadrangle topographic maps existed for only 56 percent of the state and thus the choices for geologic mapping were somewhat restricted. As a consequence, Ashley continued the cooperative topographic mapping program with the USGS.

In lieu of a completed Atlas of Pennsylvania, Ashley planned a single geologic map of the entire state which was finally published in 1931, done largely by G. W. Stose and O. A. Ljungstedt who were cooperative geologists of the USGS. Much of this map was taken directly from the work of the Second Survey, but it also included the new USGS work in the crystalline terrane of southeastern Pennsylvania and the extensive mapping in the bituminous coal fields in the southwestern portion of the state.

In 1923 a cooperative program with the U.S. Geological Survey was initiated to ascertain the ground-water resources for the entire state. Six regional reports, and a statewide report, were completed over the next 18 years.

Those volumes are now being replaced by detailed county and regional, basin-wide reports as part of the continuing cooperative program with the USGS Water Resources Division.

George H. Ashley retired from the Pennsylvania Geological Survey on August 31, 1946, ending a 27-year career as State Geologist. By this time the topographic mapping of the state at the 1:62,500 scale was nearly complete. His plan for an atlas of the entire state was much further from fruition, but geologic mapping is perforce a much slower activity. Even so, 11 atlases and 6 county reports were published, along with 19 general geology reports, 27 on mineral resources, 7 on ground water, and 130 progress reports.



Ralph W. Stone, Director, 1946

Stanley H. Cathcart was the next State Geologist, taking office on January 1, 1947, at the end of Ralph W. Stone's largely ceremonial 4 months as chief geologist of the Survey.





Stanley H. Cathcart, Director,  
1947-53

Oil and gas studies had been an important part of the Survey's activity over the years, in which Cathcart had been a major contributor. Charles Fettke continued his studies, particularly on the Bradford oil field. Cathcart instituted a series of annual reports listing the data from the recently drilled deep wells. Also begun at this time was an annual report on the production of minerals in Pennsylvania.

Stanley Cathcart died in 1953. Ralph Stone once again stepped in as Acting State Geologist for 7 months until the next State Geologist was appointed.

Carlyle Gray, a member of the staff since 1949, became Acting State Geologist in October 1953, and was formally appointed as State Geologist in October 1955. It was during this time that a change in focus and structure of

the Pennsylvania Geological Survey occurred, with new objectives being defined.

The depression and the ensuing war years had brought most of the quadrangle mapping in Pennsylvania to a halt. In the mid-1950's, a determined program of atlas geologic mapping was restarted at the instigation of Carlyle Gray. Perhaps most important was the change of mapping scale to that of the new 7.5-minute series of topographic maps.

Areas underlain by the carbonates of the Great Valley in Lebanon County were the first quadrangle mapping target because of their importance to the steel industry. It was also decided to map two corridors across the Valley and Ridge province, one north-south and the other east-west because so little work



Carlyle Gray, Director, 1953-61

had been done in the central part of the state.

While geologic mapping was reestablished as a core program mineral and energy resource investigations continued. An extensive study on the Cornwall iron mines was commenced, along with a variety of other geologic subjects including the glacial geology of northwestern Pennsylvania. In the late 1950's, studies on groundwater also became widespread across the state.

Two new volumes were brought out in the late 1950's, designed for the amateur as well as professional geologist. These two volumes, *Mineral Collecting in Pennsylvania* and *Fossil Collecting in Pennsylvania*, describe the locations where minerals and fossils can be collected in Pennsylvania. They are the Survey's two perennial "best sellers," and have been revised and updated a number of times over the years.

The most recent geologic map of the state at that time was the 1931 version, much of which was based on Second Survey work. Gray did not want a new

version to be based on such dated material, but despite all of the work the Third and Fourth Surveys had done up to that time, large areas of the state had not been evaluated since before the turn of the century. Accordingly, the entire geologic staff reconnaissance-mapped the entire state, and compiled the new data on 15-minute quadrangle maps. From these maps, a new geologic map was assembled, more detailed and colorful than any of its kind before, and published in 1960. Exhibited at national and regional meetings of the Geological Society of America the bright contrasting colors of the 1960 map, urged by Arthur Socolow, caused considerable comment, in part because it did not follow the color scheme used in past years by the USGS and many other states. Yet the striking colors permitted Pennsylvania's complex structural and stratigraphic relationships to stand out. Many other states have since adopted this technique.

With Carlyle Gray's resignation in September 1961, Alan R. Geyer was designated as Acting State Geologist for the next 3 months.

Arthur A. Socolow, a former professor of geology who had served as Economic Geologist for the Survey since 1957, was named State Geologist at the end of 1961. During his ensuing 25 years, the Survey continued to grow, and expand its activities into new areas of environmental research, geologic education, and public service. In 1971, as the long-standing Department of Internal Affairs was abolished, the Topographic and Geologic Survey was assigned to its present administrative home, the Office of Resources Management of the newly created Department of Environmental Resources. The basic mandate of the Survey, as first stated in 1929 continued unchanged: "To undertake, conduct, and maintain the organization of a thorough and extended survey of the State, for the

purpose of elucidating the geology and topography of the State.”

While greatly expanding the role of environmental geology and geologic services, geologic mapping remained the cornerstone of the Fourth Survey's diverse activities during Dr. Socolow's years as State Geologist. During the 1960's and 1970's, mapping in the Valley and Ridge province of central Pennsylvania focused on the major population centers of Williamsport and Altoona as well as on the corridors originally proposed by Gray. Early in Socolow's tenure it was decided that additional mapping was needed to complete the northern part of the bituminous coal fields unmapped in the earlier USGS efforts. This new mapping served as the base for a new series of county coal atlases which feature coal crop lines, mined-out areas, and structure contour lines. Detailed mineral resources studies focused on

Pennsylvania's valuable industrial minerals as well as potential metallic resources, such as zinc, lead, and uranium. A large Atlas of Mineral Resources incorporated much of the resulting data and mapping and has helped to sustain Pennsylvania's mineral industry, the largest east of the Mississippi River. In the late 1960's detailed geologic mapping was begun in suburban eastern Pennsylvania, as well as the Pocono Mountain area of the northeast, because of the expanding population growth there.

The Fourth Survey initially did not work in the Anthracite region in eastern Pennsylvania because of the cooperative mapping program with the USGS. However, after the USGS ceased its work there in the 1970's, and with new interest in the low sulfur anthracite reserves, the Pennsylvania Survey initiated a program of



Arthur A. Socolow,  
Director, 1961-86

anthracite area mapping and reserve calculations.

The Oil and Gas Division began to acquire computer capability to handle the massive volume of data provided by industry ever since the hemisphere's first oil well at Titusville in 1859. Regional maps and stratigraphic interpretations were issued by the Survey to encourage new exploration and development of oil and gas. Located at the Survey's branch office in Pittsburgh, the Oil and Gas Division, with its extensive collection of well logs and well sample cuttings, has become a center for service to the oil and gas industry as well as state and federal regulatory agencies.

By the mid-1970's, it was felt that sufficient modern geologic mapping had been accomplished so that a revision of the 1960 geologic map of Pennsylvania was in order. By that time 7.5-minute topographic quadrangle maps were available for the entire state as a result of an accelerated cooperative program with the USGS. Whereas the 1960 state geologic map used only 15-minute maps as a base for compilation, the new compilation used the modern accurate 7.5-minute maps. A large amount of reconnaissance mapping, in areas still unmapped in detail, was accomplished by the many staff members assigned to the project, utilizing aerial photographs with field checking. As a result of the compilation of all recent mapping and stratigraphic studies on the accurate base maps, the 1980 state map delineated 185 rock units as compared to only 120 on the 1960 version. Again, contrasting bright colors helped to accentuate structural and stratigraphic relationships.

In furthering the policy that public awareness of geology is needed to support ongoing technical programs, Socolow instituted three new popular publications series. *Pennsylvania Geology*, a bimonthly magazine begun in 1969, provides timely announce-

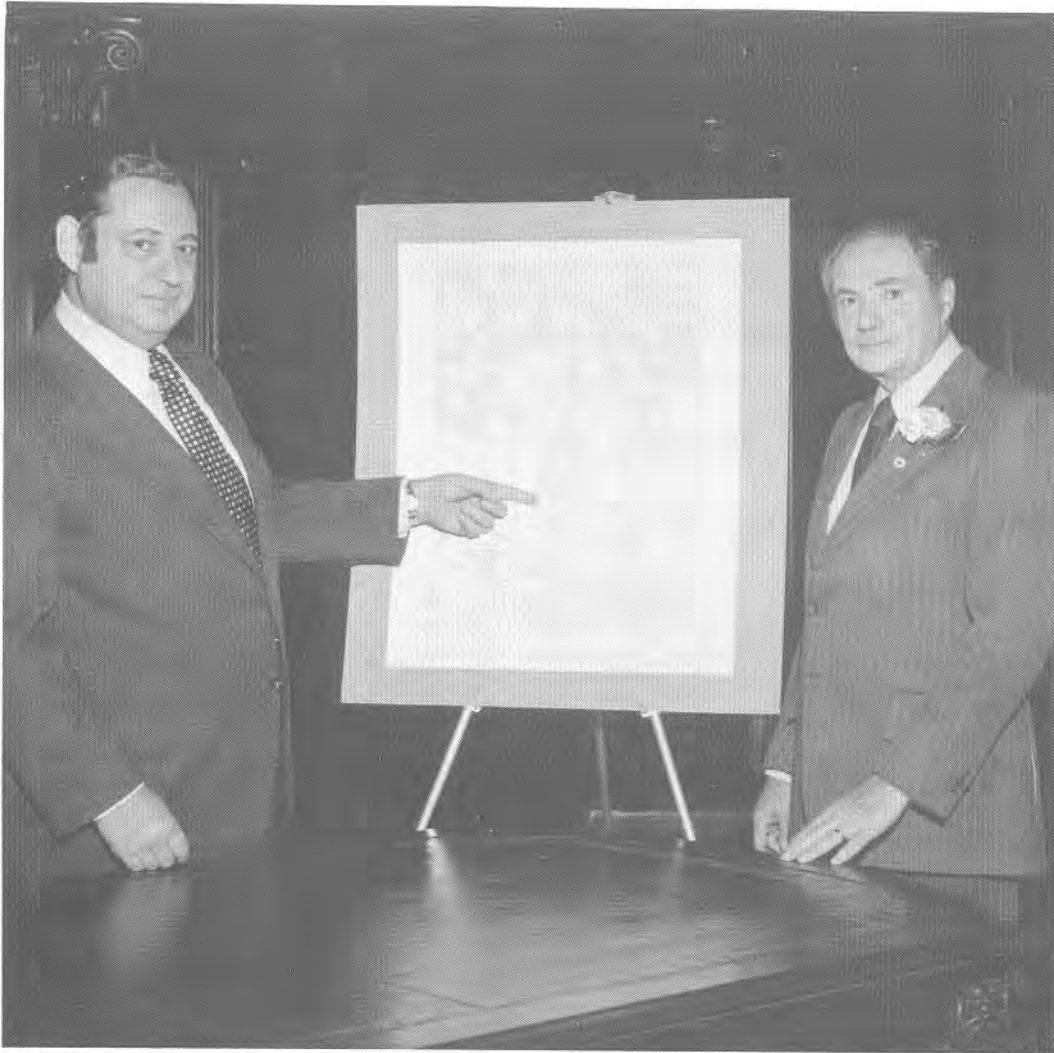
ments and geologic descriptions for both professional and amateur geologists and interested laymen. The Educational Series, initiated in 1962, discusses in nontechnical terms, broad aspects of geology of widespread interest, such as coal, the ice age, groundwater, geologic hazard, and the role of geology at the Gettysburg battle. Geologic Park Guides were begun in 1969 and now number 19. These guides describe in nontechnical language the geology within and surrounding various State Parks throughout the state.

The distribution of free fossil and mineral sets, initiated in the early 1950's, was streamlined and expanded. That program created an indelible image of goodwill for the Survey throughout Pennsylvania but had to be abandoned for economic reasons when the distribution volume exceeded 20,000 sets per year in the early 1970's.

The need to examine and anticipate the effects of man's activities on our environment and the geological factors involved has steadily increased over the years and led to the creation of the Environmental Geology Division in 1968. It joined the Survey's existing Geologic Mapping, Oil and Gas Geology, and Mineral Resources Divisions, and conducted a program of environmental services as well as topical environmental projects. The Division's first report, in a new Environmental Geology series, was the *Engineering Characteristics of the Rocks of Pennsylvania* in which each of the rock units delineated on the 1960 State Geologic Map was described and subsequently updated for the 1980 State map. Environmental geology atlases for two urban areas (Harrisburg and York) were published, and two volumes on over 500 outstanding scenic geologic features in Pennsylvania have continued to be best sellers.

Preparation of county topographic maps at a scale of 1:50,000 was initiated in the late 1970's as an augmentation of





Celebrating complete coverage of Pennsylvania with 7.5-minute topographic maps in 1973, State Geologist Arthur Socolow presents to Governor Milton Shapp the final map of the series.

the cooperative topographic mapping program with the USGS. These maps were particularly well received by planners and local officials. A detailed and comprehensive tectonic map compilation was started in the early 1980's; this will incorporate the latest geophysical data and structural concepts of the modern era.

The Water Well Drillers Licensing Act of 1956 started the Survey on a massive accumulation of individual well logs which enabled the Survey to

develop a broad program of groundwater services and regional groundwater studies. A continuing cooperative program with the USGS provided additional regional and stratigraphic groundwater studies.

On June 23, 1972, disaster struck the Pennsylvania Survey. Tropical storm Agnes dumped 16 inches of rain on central Pennsylvania causing the Susquehanna River to inundate the newly renovated Survey quarters under 13 feet of water. The havoc was total!



1973 flood in progress at Survey building.



Office area after flood.



Library stacks after flood.

Furniture was left in a jumbled tangle, partly caught in the network of the suspended ceiling where the acoustical tile had turned to mush. Walls and partitions lay in contorted shapes. Manuscripts and records had floated to incredible heights. And all was covered with a mixture of silty muck and black, pitch-like industrial oil. In the library some 40,000 volumes had become a mound of paper pulp and glue; 100,000 topographic and geologic maps were destroyed as well. The x-ray, chemistry, and microscope labs were in total carnage.

It took 5 years to fully recover from the flood. Only some manuscripts in progress had been salvaged. With state and federal emergency financing, all furnishings and equipment were eventually replaced. A heart-warming response from libraries and individuals throughout the country replaced the publications series so vital to research. Throughout the debacle the Survey staff patiently and heroically pitched in to rebuild, while continuing to serve the public. Eventually, everything was replaced, resulting in a Survey with state-of-the-art equipment. But Socolow



Map library after flood.

stresses that this is not the recommended way to modernize a Survey.

Arthur A. Socolow retired in August 1986, having completely rebuilt the Survey from the disastrous flood experience and leaving the Survey with a full-time staff which had expanded to 43, an annual budget of over \$2 million, and a record of 364 geologic reports and maps published during his tenure.

After serving as Assistant State Geologist for 18 years, Donald M. Hoskins, a veteran of 28 years service with the Survey, was appointed the fifth State Geologist of the Fourth Survey on January 8, 1987.

#### THE NEXT 25 YEARS

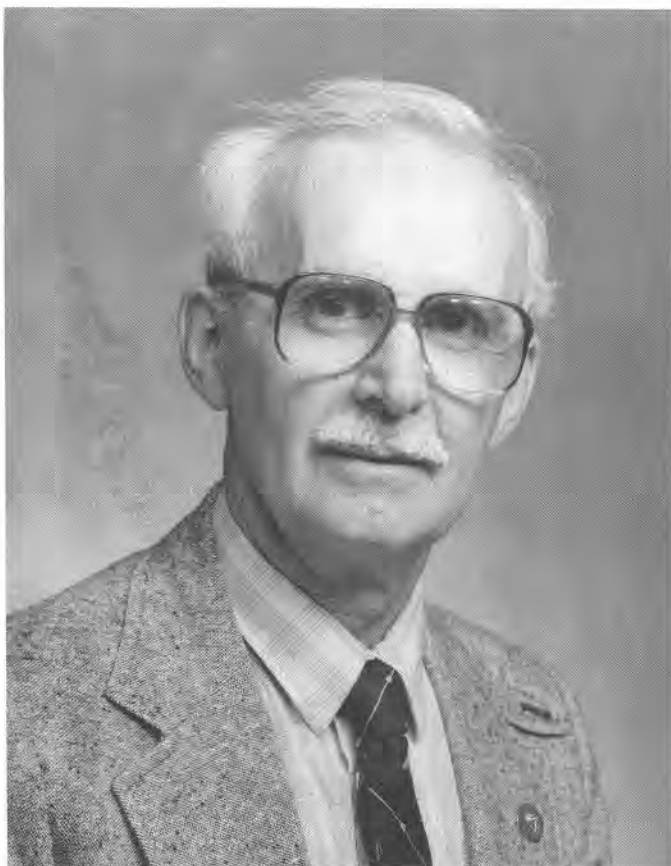
The main reason the Fourth Survey has persisted and grown is because its objective has been one of continuing

service to the Commonwealth in particular, and the geological community in general. This objective continues to be paramount and as a result the Pennsylvania Survey of the next quarter century will likely be similar in many ways to the last 25 years.

The Survey will maintain a strong commitment to public service, with a greater emphasis on assisting other state agencies in utilization of basic geologic mapping and data in the resolution of the growing environmental problems of disposal of toxic and radioactive waste and in the use of our most precious resource, water.

The core program of geologic mapping will continue with early emphasis in the Piedmont of southeastern Pennsylvania and with the production of a new "Grand Atlas" of





Donald M. Hoskins,  
Director, 1986-present

1:100,000 maps. Initially, these will be of surficial geologic units, but by the beginning of the 21st century, new bedrock and surficial geologic maps covering the whole state will have been produced.

Much of this new mapping will be supported by computers and geographic information systems that will allow the Survey to handle massive digital databases. Water management will require that groundwater resources and quality be mapped more rigorously with reports being prepared on regional water basin areas reflecting natural flow systems rather than artificial quadrangle and political boundaries.

Pennsylvania's fossil fuel resources will also continue to be a major focus of effort as the Commonwealth seeks to exploit its bountiful resources.

The widely used quadrangle topographic maps will continue to be updated through the ongoing cooperative program with the USGS.

The Survey will move towards closer cooperation with Pennsylvania's colleges and universities in accomplishing needed geologic mapping and other research. The long-standing cooperative relationships with the USGS in topographic mapping, water resource investigations, and geologic mapping will be continued where there is a cooperative commitment of the U.S. Geological Survey and the Pennsylvania Geological Survey for mutual benefit to the citizens of Pennsylvania.

## RHODE ISLAND

Office of the State Geologist, Department of Geology, The University of Rhode Island, Kingston, RI 02881. Phone 401-792-2265/2184.

### HISTORICAL SEQUENCE OF ORGANIZATIONAL NAME:

Jackson Survey, 1839-40  
 Natural Resources Survey of Rhode Island, 1909-13  
 Office of the Associate State Geologist for Marine Affairs, 1975- Jan. 1985  
 Office of the State Geologist, Aug. 1985

### NAMES AND TITLES OF ORGANIZATIONAL DIRECTORS AND DATES SERVED:

Charles T. Jackson, Geological and Agricultural Surveyor, 1839-40  
 Charles Wilson Brown, Superintendent, 1909-13  
 \*Alonzo W. Quinn, "Unofficial State Geologist," 1940-77  
 Robert L. McMaster, Associate State Geologist for Marine Affairs, 1975-85  
 J. Allan Cain, State Geologist, 1985-present

\*During the period from roughly 1940 to the mid-1970's Alonzo (Lon) W. Quinn, Professor of Geology at Brown University, served as "unofficial State Geologist" and was responsible for compiling the state bedrock geology map, published in 1971 by the U.S. Geological Survey in cooperation with the Rhode Island Development Council (USGS Bulletin 1295).

## RHODE ISLAND

### Historical Development

Although articles on the geology of Rhode Island date back at least to 1808, the first major study was Charles T. Jackson's 1840 *Report on the Geological and Agricultural Survey of the State of Rhode Island*; its 312 pages included listings of fossils, minerals, and special localities within the state. Jackson's specimen collection was donated to the Franklin Society of Providence which published, in 1887, a *Report on the Geology of Rhode Island* that summarized publications on Rhode Island geology but did not include a geologic map in its 130 pages.

A significant development occurred when Professor Charles Wilson Brown of Brown University organized a Natural History Survey of Rhode Island in 1909. The Rhode Island Bureau of Industrial Statistics published some of his findings in its Annual Reports for 1909 and 1910, but there seems to have

been no wide dissemination of the information.

In the absence of a State Geological Survey much of the history of geological activity in Rhode Island focuses on the contributions of the U.S. Geological Survey. In 1899, N. S. Shaler, J. B. Woodworth and A. F. Foerste published a 402-page USGS Monograph (No. 33) on the *Geology of the Narragansett Basin*, which is a major part of the state of Rhode Island. This was followed in 1917 by B. K. Emerson's USGS Monograph 597 which described the *Geology of Massachusetts and Rhode Island*. These works, together with the USGS 1891 *Topographical Atlas of the State of Rhode Island and Providence Plantations*, provided the foundation for later work by the USGS and others.

After a period of relative quiescence there was a renewed burst of geological activity in the 1940's when the Rhode Island Industrial Commission (later the Rhode Island Port and Industrial Development Commission) published,

in cooperation with the USGS, geological bulletins on the geology and ground-water resources of Providence (1945), Pawtucket quadrangle (1948), Woonsocket (1950), and Georgiaville quadrangle (1951). Major figures in this work were Quinn (who was also Chairman of the Mineral Resources Committee from its organization in 1943 until 1951) and W. B. Allen (chief of the USGS Rhode Island office from 1948 to 1965). The Port and Industrial Development Commission also published, in 1944, revised in 1950, a *Bibliography of the Geology of Rhode Island* prepared by Quinn and D. H. Swann. This 26-page listing included more than 270 items dating from 1808.

During the 1940's, 1950's, and 1960's the USGS continued its geologic quadrangle mapping program, and has now published 21 bedrock and 16 surficial geology quadrangle maps (out of 36 that include at least a part of Rhode Island). Major figures in this effort were Quinn and G. E. Moore Jr. (bedrock); J. P. Shafer and J. H. Smith (surficial).

State agencies (for example, the Rhode Island Water Resources Coordinating Board, of which Quinn was Vice-Chairman from 1955 to 1967) also published important geological information, dealing primarily with water resources. Ground-water management in Rhode Island is the responsibility of several agencies: the former Rhode Island Statewide Planning Program, now the Division of Planning, Rhode Island Department of Administration, focuses on water resources policies; the State Department of Health is responsible for drinking water quality; the Rhode Island Water Resources Board (W.R.B.) is responsible for long-range planning and development of major water supply facilities; the Department of Environmental Management (D.E.M.) is responsible for the registration of well-drillers and is the water-pollution



Alonzo (Lon) W. Quinn, May 28, 1899 - April 8, 1977. "Unofficial State Geologist" of Rhode Island, 1940-77. Chairman, Mineral Resources Committee of the Rhode Island Industrial Development Commission from 1943-51. Member, Water Resources Commission of Rhode Island from 1951-53 and Vice-Chairman of the Water Resources Coordinating Board from 1955-67. Instructor and Professor of Geology, Brown University, 1929-68; Department Chairman from 1940-61; Professor Emeritus, 1968-77.

control agency for the state. The USGS Water Resources Division office in Providence (headed since 1968 by Herbert E. Johnston) collects geohydrologic data and investigates water resources chiefly in cooperation with the W.R.B. and D.E.M. All these agencies have produced numerous reports, but a key publication was W. B. Allen's 1953 *Ground-water Resources of Rhode Island* (Rhode Island Development Council Geological Bulletin 6).

The major role of Alonzo Quinn as "Mr. Rhode Island Geology" and "unofficial State Geologist" from the 1940's to the mid-1970's has been pointed out above; one of his last contributions was *Rhode Island Geology*

for the *Non-Geologist*, published in 1973 by the Rhode Island Department of Natural Resources. For a period of some 20 years, until retirement in 1966, Clarence E. Miller, Chairman of the Geology Department at The University of Rhode Island also provided many of the services to the state that otherwise would have been the responsibility of the State Geologist. After his retirement his manuscript on *Minerals of Rhode Island* was edited by O. Don Hermes and published as two volumes in 1971 and 1972 by The University of Rhode Island. J. Allan Cain succeeded Miller as Department Chairman in 1967 and continued the tradition of responding to individual and group requests for information, identifications, specimens, etc.

The appointment in 1975 of Robert L. McMaster as Associate State Geologist for Marine Affairs was a welcome sign to many that the state, through its governor, was at least somewhat aware of the importance of its geology and mineral resources. McMaster's main effort during his tenure was a multiyear study (in cooperation with the Connecticut Geological Survey) of offshore non-energy mineral resources, funded by the Minerals Management Service, Department of the Interior. McMaster's activities as Associate State Geologist were in addition to his research and teaching duties as a professor at The University of Rhode Island's Graduate School of Oceanography and were carried out without a separate state budget. With increasing environmental awareness in the state (waste sites, landfills, ground-water management, radon levels, open spaces, coastal development, for example) McMaster felt that a "land-based" State Geologist was needed and in his resignation letter so recommended to the governor.

In August 1985, Governor DiPrete appointed Cain the first State Geologist, *sensu stricto*, of Rhode Island.



Robert L. McMaster, appointed Associate State Geologist for Marine Affairs by Governor Noel on December 15, 1975, served until January 1985.

Apart from a modest sum to help support teams mapping bedrock and Quaternary geology (from the Department of Environmental Management, administered through the Statewide Planning Program), no operating budget was provided. Consequently, the day-to-day activities of the State Geologist from 1985 through mid-1988 were funded through the Geology Department at The University of Rhode Island.

With the active cooperation of Daniel W. Varin, Associate Director of Administration for Planning (who also served in many ways as "unofficial State Geologist" before the current appointment), future State Geologist's budgets will be submitted to the governor as part of the budget proposed by the Division of Planning.

#### Current Activities

The major focus since 1985 has been the support and coordination of mapping teams that will produce a new state bedrock geology map and the first state Quaternary geology map,





J. Allan Cain, first Rhode Island State Geologist, *sensu stricto*. Appointed August 1985 while also serving as Chairman of the Geology Department, The University of Rhode Island.

consistent with those of Connecticut and Massachusetts. These are multiyear projects and, in addition to state funds, have been supported by the USGS (including a COGEOMAP grant and assignment of USGS personnel to assist in the Quaternary mapping program), with assistance from the Connecticut Geological Survey. The bedrock program is guided by John Rodgers of Yale and is being conducted by O. Don Hermes and Daniel P. Murray of U.R.I., and L. Peter Gromet of Brown University. The Quaternary program involves Janet Stone and Betty London of the USGS and Jon C. Boothroyd of The University of Rhode Island. Some of the data from these activities are being digitized into the Geographical Information System's ARC/INFO program at U.R.I. These and other data will be extremely valuable in, for example, aquifer management and a state-wide radon study that is just beginning.

Complementing these mapping activities the offshore minerals program directed by Robert L. McMaster, in cooperation with the Connecticut Survey, continues to be funded by Minerals Management Service. In addition to coring and seismic studies, the program involves discussions with the Rhode Island Coastal Resources Management Council, and others, on the need for nongeologic input in any assessment of the feasibility of offshore mining of sand and gravel.

### The Future

Once budgetary procedures are stabilized and reasonable funding is provided, the major goal will be to expand from an "Office of the State Geologist" to a Rhode Island Geological Survey. Meanwhile, depending on experience with the Division of Planning, it may be that the State Geologist's Office should be based formally at The University of Rhode Island with the State Geologist submitting budget requests through the Academic Vice President, Provost or similar administrator.

When considering the possibilities for further growth and development of the Office of the State Geologist, it is encouraging to remember that Rhode Island has not only an official state rock (cumberlandite) and an official state mineral ("bowenite") but also a most appropriate official state motto: Hope!



Green Hall on the campus of The University of Rhode Island, location of the Office of the State Geologist.

## SOUTH CAROLINA

South Carolina Geological Survey, South Carolina State Budget and Control Board,  
Division of Research and Statistical Services, 5 Geology Road, Columbia, SC 29210.  
Phone 803-737-9440.

### HISTORICAL SEQUENCE OF ORGANIZATIONAL NAME:

Geological and Mineralogical Survey of South Carolina, 1825-26  
Agricultural Survey of South Carolina, 1842-43  
Geological and Agricultural Survey of the State of South Carolina, 1843-60  
South Carolina Geological Survey, 1901-61  
Division of Geology, South Carolina State Development Board, 1957-74  
South Carolina Geological Survey, South Carolina State Development Board,  
1974-79  
South Carolina Geological Survey, South Carolina State Budget and Control  
Board, 1979-present

### NAMES AND TITLES OF ORGANIZATIONAL DIRECTORS AND DATES SERVED:

Lardner Vanuxem, Professor, Geology and Mineralogy, USC, 1825-26  
Edmund Ruffin, Agricultural Surveyor of the State, 1842-43  
Michael Tuomey, State Geological Surveyor, 1843-46  
Oscar M. Lieber, Mineralogical, Geological and Agricultural Surveyor, 1856-60  
Earle Sloan, State Geologist, 1901-10  
M. W. Twitchell, State Geologist, 1911-12  
Stephen Taber, State Geologist, 1912-47  
Laurence L. Smith, State Geologist, 1947-61  
Henry S. Johnson, Jr., Chief, Division of Geology, 1957-61  
Henry S. Johnson, Jr., State Geologist, 1961-69  
Norman K. Olson, State Geologist, 1969-present

### HISTORY OF THE SOUTH CAROLINA GEOLOGICAL SURVEY

By N. K. Olson and H. S. Johnson, Jr.

The earliest State-sponsored work of a geologic nature in South Carolina was a 1-year "Geological and Mineralogical Survey of South Carolina" made in 1825-26 by Lardner Vanuxem by order of the Legislature. Vanuxem apparently spent much of his time collecting and cataloging specimens of the rocks and minerals found in the State. Heavy emphasis was placed on the Piedmont section of the State to the practical exclusion of the Coastal

Plain areas, and a collection of more than 500 specimens was made.

In his report to the Legislature, Vanuxem discussed the limestones of the Piedmont, which were at that time being mined and burned in many small operations to make lime. He also reported on pyrite (as a source of sulfur) and gold in what was then called the Spartanburg and Abbeville districts and further mentioned the possibility of using marl to increase production on poor soils as had already been done in New Jersey.

With the submission of Vanuxem's report in 1826, State-sponsored geologic investigations ceased in South Carolina until 1842, when the Legislature

ordered an "Agricultural Survey of the State" and Edmund Ruffin, Esquire, of Virginia, was appointed "Agricultural Surveyor of the State" by Governor Hammond. After 1 year, Ruffin submitted a report on the *Commencement and Progress of the Agricultural Survey of South Carolina* and then resigned. Much of Ruffin's efforts were concentrated on geologic investigations of the marls of the Coastal Plain and on educating farmers to use the marl on poor soils to increase agricultural yields.

When Ruffin resigned in 1843, Mr. Michael Tuomey was commissioned by Governor James H. Hammond to continue Ruffin's work and to make a "Geological and Agricultural Survey of the State." In 1846 Tuomey submitted a *Report of the Geology of South Carolina*. This report, published in 1848, presented the results of the first real study of the geology of the State.

Apparently, from the publication of Tuomey's report until 1856 no geologic work was done in South Carolina. In 1856, however, Oscar M. Lieber was appointed "Mineralogical, Geological, and Agricultural Surveyor." He published an annual report on the geological survey of South Carolina in 1856 and for each of the three following years. With the exception of minor investigations in Beaufort and Colleton Counties, Lieber's work was almost exclusively in the Piedmont. His reports are highly generalized and contain long discourses on types and origin of ore deposits in the light of the knowledge of his day.

Lieber's investigations ceased in 1859 and from then until 1904 no geologic investigations were carried on in South Carolina under State sponsorship.



Figure 1.--Earle Sloan (right), South Carolina State Geologist (1904-10) at Eutaw Springs, South Carolina, with R. A. Bassler, Curator of Geology, National Museum of Natural History. Middle Eocene Santee Limestone forms the background. The original photograph was owned by Sloan's daughter Mrs. Cecil L. Wittson (Charlotte Seaborn Sloan) of Charleston, who, before her death in 1985, graciously allowed Dr. K. E. Peters, senior compiler and editor of SCGS Bulletin 41, permission to use it.

From 1904 until 1910, Earle Sloan served as State Geologist of South Carolina (fig. 1). During this period four of Sloan's reports were published by the State, the most complete of these being *Catalogue of the Mineral Localities of South Carolina*, published in 1908.

In 1911, M. W. Twitchell succeeded Earle Sloan as State Geologist and held this position for 1 year. He was also head of the Department of Geology at the University of South Carolina during this period.

Dr. Stephen Taber became head of the Department of Geology at the University of South Carolina in 1912 and also served as State Geologist. Dr. Taber served in this capacity until his retirement in 1947.

Dr. L. L. Smith followed Taber as head of the Geology Department at the University and also acted as State Geologist. From 1912 on there were no funds appropriated for geologic field investigations, and the State Geologist served principally in an advisory capacity on a part-time basis.

When the State Development Board began work in 1945, it soon recognized a need for geologic investigations, particularly those of an economic nature, in South Carolina. Arrangements were made with Dr. B. F. Buie of the Department of Geology, University of South Carolina, and a series of summer investigations were begun.<sup>1</sup>

In June 1957 the State Development Board hired Henry S. Johnson, Jr., formerly with the U.S. Geological Survey, to head the new Division of Geology. The modern South Carolina Geological Survey began with Johnson's geologic field reconnaissance, mapping, drilling, and description of stratigraphic localities. He developed a working network of "project geologists" -- mostly professors who worked summers and vacation periods--and

together they produced an impressive number of publications, drill logs and related data on a meager budget. In 1961 then-Governor Ernest Hollings agreed to a letter request from Dr. L. L. Smith to transfer the title of State Geologist to Mr. Johnson.

In November 1969, Mr. Johnson resigned to become an independent geological consultant. He was succeeded by Norman K. Olson, formerly General Industrial Geologist with Southern Railway System. Mr. Olson inherited two permanent, full-time staff members--one geologist and one secretary. In 1974, the enabling legislation (Act 1053) for the South Carolina Geological Survey was signed into law by Governor John West. The State Geologist was a key advisor to legislative committees during the formation of the South Carolina Mining Act (1974) and the South Carolina Oil and Gas Act (1977). South Carolina Geological Survey geologists have had important advisory roles to the Governor's Office and the General Assembly on issues of radioactive waste (high-level and low-level) siting and with toxic chemical wastes since 1970. Since the early 1970's, most of the field investigations and reports have been accomplished by the Survey's Geologic Mapping and Mineral Resources sections.

In the three decades, 1957-87, of the modern Survey, the value of mineral production in South Carolina, according to the U.S. Bureau of Mines, went from \$22.2 million to \$314.4 million (preliminary figure). The 1980 value represented the greatest increase of a decade, 3.5 times over the 1970 value, much of it from inflation.

In 1985, Piedmont Mining Co., began gold production at the old Haile Mine, once the largest producer of gold east of the Mississippi River. From 1942 to 1985, South Carolina mines produced

<sup>1</sup>Foregoing account by Henry S. Johnson, Jr., 1959, *Geologic Notes*, v. 3, no. 5.



only industrial (nonmetallic) minerals. As of 1989, the Palmetto State will have three operating gold mines with a combined annual output of approximately 180,000 troy ounces, the nation's largest.

As of 1988, the South Carolina Geological Survey has a permanent, full-time staff of seven geologists, one geologic technician, one administrative assistant, and one secretary. The Geologic Map of South Carolina is progressing toward a goal of completion

of field work and final editing by the end of calendar year 1991. The Mineral Resources Section is continuing its program of field and laboratory evaluation of selected mineral resources (e.g., talc and vermiculite) and assistance to new and expanding industry. The South Carolina Geological Survey is also committed to an expanded earth science education program in cooperation with the Center for Science Education, University of South Carolina.

## SOUTH DAKOTA

South Dakota Geological Survey, Department of Water and Natural Resources,  
Science Center, University of South Dakota, Vermillion, SD 57069.  
Phone 605-677-5227.

### HISTORICAL SEQUENCE OF ORGANIZATIONAL NAME:

South Dakota Geological and Natural History Survey, 1893-1932  
South Dakota Geological Survey, 1932-present

### NAMES AND TITLES OF ORGANIZATIONAL DIRECTORS AND DATES SERVED:

J. E. Todd, State Geologist, 1893-1907  
Ellwood C. Perisho, State Geologist, 1907-15  
Freeman Ward, State Geologist, 1915-26  
E. P. Rothrock, State Geologist, 1926-57  
Allen F. Agnew, State Geologist, 1957-63  
Duncan J. McGregor, State Geologist, 1963-81  
Merlin J. Tipton, State Geologist, 1981-present

### HISTORY OF THE SOUTH DAKOTA GEOLOGICAL SURVEY

By Merlin J. Tipton, State Geologist

The history of the Geological Survey has been influenced by its three interrelated objectives--science, economics, and education, and the changing emphasis among them. The development of these objectives has been a product of technological, financial, and personal factors. Based upon these factors, the history of the Survey from 1893 to the present can be divided into six periods.

The first period, 1893-1903, represented the pioneer efforts to establish a foundation for the Survey as a State scientific institution. Established by the legislature on March 6, 1893, the Survey was placed under the jurisdiction of the Board of Regents of Education. The Professor of Geology and Mineralogy at the State University in Vermillion was chosen the State Geologist. The activities that the Survey would conduct included:

- ▶ Investigations of the geology, natural resources and physical features of the State,
- ▶ Complete analyses of mineral resources and their potential productivity,
- ▶ Geologic, geographic, and topographic mapping, and
- ▶ Collection of rocks, minerals, plants, animals, and fossils to display in the museum and to exchange with other scientific and educational institutions.



J. E. Todd on a reconnaissance survey of the Badlands area.

The first task undertaken by the first State Geologist, James E. Todd, was the collection of currently known data. The data were compiled from older literature, personal communications with other geologists, well drillers, prospectors and others, and actual surveys of the State. Lack of funds, personnel, and equipment, however, allowed Todd to make only a few reconnaissance surveys. During this period the first publication of the State's geology and the first geologic map of the State were completed. By 1898, Todd felt it necessary to purchase books and a few simple tools such as a camera, compass, and drafting instruments for the Survey. In 1902, the Survey and the museum were moved from University Hall to the new Science Hall and for the first time several assistants were hired. Though Todd was limited in what he could accomplish, he realized the necessity of long-range planning, and optimistically outlined goals for the future such as a study of the State's mineral resources and the study and conservation of artesian water.

During the second period, 1903-14, the Survey expanded its role in Natural Science education with geology being only one of several fields addressed. Ellwood C. Perisho, the State Geologist during this period, concentrated the Survey's studies in the fields of botany, zoology, archaeology, paleontology, and geography. Lack of time and funds also plagued Perisho; for instance, from 1905 to 1907, no funds were appropriated. Most of the investigations made during this period were directed toward the collection of plant, animal and fossil specimens, for the museum. Perisho did, however, continue Todd's work with mineral resources and conservation of artesian water. In 1909, Perisho was appointed Dean of the College of Arts and Sciences at the University of South Dakota. In order to administer his multiple duties, Perisho employed Stephen S. Visher as

Assistant State Geologist and William H. Over as Assistant Curator of the Museum. Over became the first full-time Survey employee with no teaching duties at the University. Perisho viewed the Museum and other aspects of the Survey's work as a great educational asset for the people of the State.



A private drilling crew has just completed construction of an artesian well with a cable tool rig.

The third period, 1915-26, was one of temporary expansion. With increased funding and a staff of trained geologists, Freeman Ward, the State Geologist, changed the method of work from reconnaissance to more detailed investigations of both the subjects and the geographic areas. Informing the public of the Survey's work was very important to Ward. To speed up this process, Ward initiated a new publication policy which included two types of reports: circulars to report on individual phases of investigations, and bulletins for more detailed and formal reports on completed projects. During the earlier periods, the State Geologist was required to make biennial reports to the Board of Regents of Education. However, in 1919, legislation was passed whereby these reports would be given directly to the Governor. With the advent of World War I, there came a major push to investigate the distribution, quality, quantity, and accessibility of the State's natural resources, specifically minerals and oil.

With more funds now available, an oil geologist and a full-time secretary were hired. The Survey was also able to purchase additional equipment such as plane tables, stadia rods and camping gear. In the past much of the Survey's transportation, needed during field studies, was supplied by local residents. In 1926 however, the State Highway Commission agreed to furnish cars and drivers. During this period the first geologic structure map of western South Dakota was completed. The Survey seemed well established for the future, through its investigating structures to aid in the search for oil and gas and other activities such as topographic mapping, sand and gravel studies, and conservation of artesian water.



Geologist using a plane table and stadia rod for geologic mapping.

During the next period, 1926-39, however, the Survey was affected considerably by the Great Depression. E. P. Rothrock, the State Geologist during this period, was forced to work with no appropriations from 1927 to 1929 and very limited funding from 1929 to 1937. In 1926, the museum was transferred from the Survey to the

University. To save time and expenses, in 1930 the Survey began to print its own publications. Rothrock sought, through collection, interpretation and application of geologic information, to make South Dakota a more livable and prosperous State. The Survey, therefore, concentrated its efforts in subject areas that would benefit the State, such as continued sand and gravel surveys; investigations dealing with coal, oil, water, and later gold; location of local water supplies; measuring water levels; assessing irrigation possibilities; and Missouri River development. In 1934, the Survey began its geophysical work by purchasing a resistivity machine to aid in some of these investigations.



Geologists using a resistivity machine during an aquifer study.

Under the guidance of Rothrock, the fifth period 1939-57, was a period of renewed expansion. The legislature substantially increased the financial support for the Survey, which enabled Rothrock to add new staff members and increase the number and intensity of geologic investigations. In 1939, the Survey purchased a magnetometer and began a long-range magnetic survey of the State. World War II brought about a renewed need for studying the mineral resources of the State. Investigations of manganese deposits, bentonites, pegmatites, and oil and gas revealed much about the natural resources of South Dakota. In 1952, the Survey purchased its first electric logger, making possible the correlation of electric logs between bore holes, which contributed greatly to



the knowledge of the subsurface geology. The Survey was also able to purchase its own vehicles including jeeps and jeep-mounted auger drill rigs. With better equipment and added personnel, Rothrock could now organize a variety of geologic projects on a large scale. This was especially evident between 1943 and 1957, during which time the Survey pursued three extensive programs: studies for Missouri River development, geologic mapping of 15-minute quadrangles, and investigations of water reservoirs.



Jeep-mounted auger rig used for test drilling during mapping of a geologic quadrangle.

With the Geological Survey as an established institution, the sixth period of its history, 1957 to the present, brought about a continuation of similar projects. Upon Rothrock's retirement, Allen F. Agnew, State Geologist, 1957-63, became the first State Geologist who was not Chairman of the University's Geology Department. Striving for closer relations with federal, state, and local agencies, Agnew significantly increased the number and types of cooperative investigations. In 1959, a cooperative agreement was made with the United States Geological Survey to study the geology and water resources of individual counties. During this period, the Survey was also becoming more involved with locating rural and urban water supplies. In 1961, the legislature made possible the purchase of a large rotary drill rig which greatly enhanced

the capabilities of the Survey. Many other cooperative agreements were made during Agnew's term as State Geologist including work with the State's Water Resources Commission, topographic mapping with the United States Geological Survey; studies in highway geology with the State's Department of Highways; and sand and gravel studies for the State's Highway Commission. Agnew also implemented a reorganization of staff in order to facilitate the operation of Survey activities. The State Geologist became primarily an administrator, under which the staff was arranged according to specific responsibilities, such as Administrative Assistant, Engineering-Petroleum Geologist, Head of Ground Water Investigations, Highway Geologist, and so forth. As the administrative duties continued to grow, Agnew felt it necessary to establish the office of Assistant State Geologist, to which he appointed Merlin J. Tipton in 1962. Also, to give more efficiency in executing the duties concerned with gas and oil, a Western Field Office was established in Belle Fourche and later moved to Rapid City. During Agnew's term as State Geologist, the Science Hall, which housed the Survey, was condemned, and the Survey was moved temporarily to the fourth floor of the Student Union. In 1962 the Survey was moved to the new Science Center, where it remains to this day occupying the third and fourth floors.

On September 1, 1963, upon Agnew's resignation, Duncan J. McGregor was named State Geologist. During McGregor's term as State Geologist, 1963-81, the cooperative programs were continued. However, he broadened the educational objectives of the Survey by establishing an area of Educational Services, which included aspects promoting tourism. Through McGregor's term as State Geologist and that of his successor Merlin J. Tipton, 1981 to the present, the Survey has

progressed through a period of continued expansion. Generous funding appropriated by the legislature has made possible such things as: the purchase of several more rotary and auger drilling rigs with sophisticated coring capabilities, the addition of garages and storage facilities, the acquisition of x-ray diffraction and electric logging equipment, conversion to a computerized data base system, improvement of laboratory facilities, and the addition of personnel, full time and part time. Many more cooperative programs have been instituted including:

- ▶ Participation in a National Uranium Resource Evaluation,
- ▶ A hydrologic unit-studies program with the State Water Rights Commission and the United States Geological Survey,
- ▶ Water-supply studies with the United States Army Corps of Engineers,
- ▶ Water-quality studies with the United States Environmental Protection Agency,
- ▶ A study of the Big Sioux Basin's geology and water resources, with the United States Geological Survey and the East Dakota Water Development District, and,
- ▶ A study dealing with irrigation possibilities for central South Dakota, with the Bureau of Reclamation and the Central South Dakota Water Development District.

Under State Geologist Merlin J. Tipton, the Survey's hydrologic section is also presently involved in investigations to determine the hydrology of glacial till, and many other environmental studies, such as landfill siting, gasoline and hazardous-waste spills and low level nuclear waste disposal siting.

The South Dakota Geological Survey, which became a division of the State's Department of Water and



Survey drill crew using a rotary drill rig for test drilling during a county-wide investigation.

Natural Resources in 1974, has existed for scientific, economic and educational reasons and thereby has served both the sciences of geology and hydrology, and the citizens of the State. The Survey has continuously sought to outline the surface and subsurface rock formations and interpret their hydrology and geologic history. Concurrently, trained personnel, which today includes 32 full-time staff members, 22 of whom are geologists, hydrologists, or chemists, have fulfilled a responsibility to discover and characterize the natural resources of the State. For general knowledge and scientific utilization throughout its 95-year history, the Survey has made available the results of its field and laboratory investigations, and today it continues to provide information valuable to the scientific profession and the citizens of South Dakota.

## TENNESSEE

Tennessee Division of Geology, Department of Conservation, Tennessee Division of  
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### HISTORICAL SEQUENCE OF ORGANIZATIONAL NAME:

The First State Geological Survey, 1831-50  
The Second State Geological Survey, 1854-99  
The Third State Geological Survey, 1909-23  
The Tennessee Division of Geology, 1923-present

### NAMES AND TITLES OF ORGANIZATIONAL DIRECTORS AND DATES SERVED:

Gerard Troost, First State Geological Survey, 1831  
Abolishment of First Survey, 1850  
James H. Safford, Second Geological Survey, 1854  
Ending of Second Survey, 1899  
Beginning of Industrial Revolution, 1900  
Third Geological Survey, George H. Ashley, 1909  
A. H. Purdue, State Geologist, 1912  
L. C. Glenn, State Geologist, 1917  
Wilbur A. Nelson, State Geologist, 1918  
Department of Education Established, Geology Became a Division, 1923  
Harold D. Miser, State Geologist, 1926  
Walter F. Pond, State Geologist (Economic Geology Emphasized), 1927  
Conservation Department Formed, Geology Transferred to Conservation, 1937  
State Oil and Gas Board Established, 1943  
Harold B. Burwell, State Geologist, 1945  
Herman W. Ferguson, State Geologist, George Swingle Appointed, 1951  
William D. Hardeman, State Geologist, 1952  
Robert E. Hershey, State Geologist, 1969  
William T. Hill, State Geologist, 1985

### TENNESSEE DIVISION OF GEOLOGY

By William T. Hill

The Tennessee Division of Geology had its beginnings in 1831 when Dr. Gerard Troost, professor of geology, mineralogy, chemistry, and natural history at the old University of Nashville, delivered an address to the Tennessee General Assembly on the State's natural resources. The First State Geological Survey, original forerunner of the Tennessee Division of Geology, was established as a result of

the address, and Dr. Troost became the first State Geologist. Tennessee's establishment of a state geological survey was preceded only by those of North Carolina, South Carolina, and Massachusetts.

During Troost's tenure as State Geologist he prepared ten geologic reports for the Legislature, of which all but the first, second, and tenth were published. The first report, which contains descriptions of the more prominent geological features of the state, was read in the House of Representatives on September 18, 1832.

The First Geological Survey existed 19 years, until 1850, when the General Assembly was forced to abolish it because Dr. Troost became incapacitated by serious health problems. Four years later, in 1854, the Survey was reactivated as the Second Geological Survey, and Dr. James M. Safford, professor of chemistry, natural history, and geology at Cumberland University, accepted the position of State Geologist and Mineralogist.

Safford was eminently qualified for his new assignment as the second State Geologist of Tennessee. In 1851, before his appointment in 1854, he published his first report on Tennessee geology, entitled *The Silurian Basin of Middle Tennessee*. In 1853 he published two more reports, one entitled *General Topography of Middle Tennessee* and the other entitled *On the Parallelism of the Lower Silurian Groups of Middle Tennessee with Those of New York*. The latter paper, which he read at a meeting of the American Association for the Advancement of Science, received wide recognition from the scientific community.

In December 1856, 2 years after he became State Geologist, he presented a report to the 31st General Assembly of Tennessee on the geology of the state and included a geological map prepared with special reference to the location and development of the mineral and agricultural resources of the state.

Active geologic work was curtailed in 1860 by the Civil War, but Safford continued to occupy the position of State Geologist during the war years. After the war he resumed his previous work until his retirement in 1899. Although Safford carried the title of State Geologist until his death in 1907, for all practical purposes the Second Geological Survey ended with Safford's retirement in 1899.

By 1900 the United States was undergoing a revolution--an industrial revolution fueled by the power of

machines. Although the main industry makers were coal and iron, other mineral resources were increasingly needed. Tennessee's contribution to this industrialization was mainly in the mining of her natural resources--coal, iron and other mineral resources for which new uses were being discovered. New industries wanted to establish plants in the state. They needed to know where to find the coal and iron deposits. Clay was needed for ceramic products; phosphate and limestone for the chemical industries; limestone for the preparation of cement and lime. Good deposits of marble, zinc, gravel, chert, and crushed stone were needed for many operations. Because of the work done by the earlier geological surveys, many of Tennessee's mineral resources had been located and, through published reports and maps, made available to all interested parties.

Mining industries were on the move, and they needed this additional and more detailed natural resource information as soon as possible. Leonidas C. Glenn, a geology professor newly come to Vanderbilt University, began trying to convince state officials to reestablish the state geological survey so it could gather the needed information. He was joined in his efforts by Professor C. H. Gordon, of the University of Tennessee Geology Department, and with additional support from practical mining men and others in the state, the Tennessee General Assembly was persuaded to establish the Third Geological Survey. The Third Geological Survey was established under the Public Act passed on April 30, 1909, but was not made active until May 1, 1910.

The First Geological Survey was a one-man survey. Troost was paid \$250 for each of his first 2 years, and \$500 per year thereafter. Out of this money he paid his traveling and other field expenses. The Second Geological Survey was also a one-man survey. By 1909 the



need for geologic work was so great that one man could not meet it; therefore, the Third Geological Survey was established as a bureau authorized to employ, in addition to the State Geologist, associates, assistants, and a support staff.

George H. Ashley of the U.S. Geological Survey, an outstanding organizer and administrator, was offered the job on March 16, 1910. In his administrative report of 1910, Ashley listed the technical personnel employed by the Third Geological Survey and described their various duties. In 1911, the Third Geological Survey began publishing a magazine entitled *The Resources of Tennessee*, that had the following introduction:

There are over 2,000,000 people in Tennessee ... and only 3,000 copies of the Survey's publications are printed. It is realized that if the people of the State, and outside the State are to be benefited in any large measure from the work of the Survey, it must be through the cooperations of the newspapers, magazines, and technical journals. Therefore, the statements of the results of the Survey's work and reviews of its new publications are cast in the form suitable for use by publishers, in the hope that they will cooperate in extending the benefits of the Survey's studies by making liberal use of any or all of the matter in this journal.

*The Resources of Tennessee* was a monthly publication that has been described as a magazine devoted to the description, conservation, and development of the resources of Tennessee. The publication also served to shorten annual administrative reports.

In *The Resources of Tennessee* Ashley and members of his staff published reports on mineral resources such as bauxite, cement materials, chert, coal, gold, iron, lead, manganese, and oil and gas. Other topics discussed included the manufacture of sulfuric acid, road improvements, water power and navigable streams, and soils.

Ashley resigned as State Geologist on March 15, 1912, after serving 1 year

and 10 months, and returned to the U.S. Geological Survey.

On March 16, 1912, Dr. A. H. Purdue, formerly professor of geology at the University of Arkansas and State Geologist of Arkansas, accepted the assignment of State Geologist of Tennessee. While in Arkansas, Purdue had established an impressive reputation in geological investigations. Several of his important contributions to the geology of Arkansas were made in cooperation with the U.S. Geological Survey (USGS). He and Ashley had worked together for the USGS in 1892 and 1893.

Purdue continued Ashley's program and plan of organization with practically the same personnel. His staff in 1912 numbered 17.

One of the early additions to the staff was Paul C. Bowers, named chemist of the Survey in June 1913. Purdue believed that a full-time chemist was a necessity. In February 1914, he expanded the survey's interests by establishing a Division of Forestry under the direction of R. S. Maddox, professional forester.

Following the death of Purdue, in 1917, Dr. L. C. Glenn of Vanderbilt University generously offered his services in attending informally to the correspondence and personal inquiries of the Survey until more definite arrangements could be made. On January 10, 1918, the Geological Commission met and elected Glenn Acting State Geologist, to serve until a permanent successor to Purdue could be secured.

During Glenn's brief tenure, the first two numbers of Volume VIII of *The Resources of Tennessee* were published, including a posthumous article to Dr. Purdue on the manganese deposits of Bradley County.

On April 9, 1918, Wilbur A. Nelson was elected State Geologist. Nelson had been an Assistant Geologist with the Survey from 1911 to 1914.

Early in Nelson's tenure as State Geologist, the General Assembly directed the Survey to cease publication of *The Resources of Tennessee*. No reason for this action is given, but Nelson's habit of lecturing the members on their general responsibilities and proper course of action in his annual reports, published in *Resources*, probably had something to do with it. Later administrative reports to the Legislature had to be published as Bulletins, Nos. 24 (1921), 27 (1923), and 35 (1925), which, as the members of the General Assembly were no doubt aware, had much less circulation than *Resources*. The last issue of *The Resources of Tennessee* was Volume IX, No. 2, published in April 1919.

When the Administrative Reorganization Bill of 1923 was enacted into law, the Department of Education was established and the Third Geological Survey became a Division in the new Department. The Survey was no longer required to report to the General Assembly, but instead began reporting to the Commissioner of Education. The biennial report for the years 1923-24 was the last report to the General Assembly published in Bulletin form.

During Nelson's tenure there were 30 or more professionals working for the Survey, including geologists, engineers, physiographers, chemists, soil scientists, and foresters, and *The Resources of Tennessee*, a new edition of the state geologic map, and Bulletins 20 through 36 were published.

In 1925, after serving 7 years, Nelson resigned as State Geologist of Tennessee to become State Geologist of Virginia.

In 1926, Mr. H. D. Miser took leave of absence from the U.S. Geological Survey for a year to replace Nelson, who had already departed for Virginia, and to serve as Acting State Geologist of Tennessee. He had become acquainted with Tennessee geology during parts of 1913, 1914, and 1920, when he mapped

the geology of the Waynesboro 30-minute quadrangle as part of a cooperative project of the State and Federal surveys. The resulting report was published by the Tennessee Division of Geology in Bulletin 26, 1921.

Like Dr. Glenn, Miser was a caretaker State Geologist, and never intended to serve in more than an interim capacity. During his tenure very little money was available for publishing, all of which was needed to complete reports already in press when Nelson left. After serving a year as Acting State Geologist, Miser resigned and returned to the U.S. Geological Survey.

Walter F. Pond, Assistant State Geologist of Missouri, accepted the job of State Geologist of Tennessee in 1927. There were 10 geologists on Pond's staff.

During Pond's tenure as State Geologist economic geology was heavily emphasized. Bulletins 37 through 50 and 52 were published, which included a number of thorough, careful, comprehensive studies of the geology of various mineral resources in Tennessee, such as iron, phosphate, oil and gas, clay and manganese. Pond also started a new series of publications, the short, concise "Market Circulars." These were designed to answer general inquiries about various mineral commodities, and eleven were completed. Somewhat more comprehensive studies of a number of commodities were published in a short-lived second series of *The Resources of Tennessee (Occasional Papers)*. Work on oil and gas was reported in "Oil and Gas Charts" 1 through 4. A map of the Jefferson City zinc district was one of the last things published during his tenure. In 1933, a newly revised edition of the State Geologic Map, the 4th, was published. It was considered a major contribution to understanding the general geology and mineral commodities of the state.

A number of items of legislation passed during the Pond years added to

the responsibilities of the Survey. An act passed in 1932 required, for the first time, the casing of oil and gas wells, the plugging of abandoned wells, and the shutting in of subeconomic gas wells. While this act made no specific reference to the Division of Geology, its provisions obviously could not be implemented without drawing heavily on oil and gas data in the Survey's files.

The Administrative Reorganization Bill of 1937 codified the procedures of many government agencies, including the Division of Geology, and created the Conservation Department, to which the Division was transferred.

Finally, late in Pond's tenure, the Oil and Gas Regulatory Act of 1943 established a State Oil and Gas Board. The Commissioner of Conservation is *ex officio* Chairman of this Board, and the State Geologist is *ex officio* the State Oil and Gas Supervisor, charged with day-to-day implementation of the requirements of the act. The act also provided that the Board would not become active until oil production in the state reached a level of 50,000 barrels per day and maintained this level for 90 days. It was not necessary to activate the Board until 1968, but Pond and his successors had to be ready to do so at any time, so the systematic accumulation of well data that would allow intelligent decision making when the time came to activate the Board was continued and accelerated.

Perhaps the most interesting thing about Pond's tenure as State Geologist is that he inherited a Survey organized much as Ashley set it up in 1909, mostly staffed with part-time and cooperating geologists and a very small cadre of full-time professionals, and passed it on to his successor as an entity similar in most respects to the modern Survey.

After Pond left the Division in 1945, Harold B. Burwell was appointed State Geologist. Burwell had been with the Division since 1936. There were eight geologists on Burwell's staff.

During Burwell's tenure, he established collaborative publishing programs with the Tennessee Valley Authority and the U.S. Geological Survey. As a result of this relationship, a new series of topographic maps on a scale of 1 inch to 2,000 feet was begun by the Tennessee Valley Authority.

This was followed by a cooperative agreement on July 1, 1949, with the U.S. Geological Survey, in which maps on this same scale were prepared for the rest of Tennessee. These excellent contour maps serve as the basis of modern geologic research and mapping.

Burwell also continued and enlarged a cooperative program with the U.S. Geological Survey to study the surface-water resources of the state. Also, cooperative ground-water studies with the Federal Survey were started in 1947.

Burwell resigned in May 1951 to become an oil and gas consultant. He was succeeded by Herman W. Ferguson, a veteran of the Division since 1940.

Ferguson, who had spent several years mapping and doing research on the eastern part of Tennessee, recognized the desirability of having a representative of the Division in Knoxville. In 1951 he appointed George D. Swingle to supervise East Tennessee activities from an office in Knoxville. Swingle resigned in 1953 to join the staff of the University of Tennessee.

During his short term of office Ferguson supervised, among other activities of the Division, research on coal, oil and gas, nonmetallics, ground water, and stream gaugings. He served also as joint supervisor with the U.S. Geological Survey for the cooperative topographic mapping project.

In August 1952, Ferguson resigned to accept a job with the U.S. Steel Corporation.

William D. Hardeman, who had been with the Division continuously since 1946, was appointed State Geologist in 1952. During his 17 years

in office, the department expanded to include more than 40 professional staff members. This number included those based in the Nashville office, the Knoxville Branch staff, and consultants throughout the state. The office of the Division in Knoxville was officially recognized as the Knoxville Branch of the Division. In October 1954, Stuart W. Maher was put in charge of this office.

In 1953, Hardeman initiated a new series of publications entitled "Information Circulars." He followed this by publishing the most recent state geologic map, scaled at 1 inch to 4 miles (1:250,000). In 1955, another new series, "Reports of Investigation," was started.

In 1964, a new series of geologic quadrangle maps was started which included mineral resource summaries to accompany each geologic quadrangle map. In addition to outlining rock formations, these maps show information on occurrence, mining, reserves, exploration, and so forth, of mineral deposits and construction materials found in the quadrangle area. This series is still being published as newly mapped quadrangles are completed.

During Hardeman's regime, in 1968, the Oil and Gas Board published *Rules and Regulations* pertaining to oil and gas exploration.

This publication was totally revised and republished in 1972 and again in 1980.

On July 8, 1969, Hardeman resigned to become Chief of the Geologic Branch of the Tennessee Valley Authority.

Following Hardeman's resignation, Robert E. Hershey was appointed State Geologist. Hershey first worked full time with the Division from 1951 to 1953, leaving to serve stints with the U.S. Bureau of Mines and the Atomic Energy Commission. He returned January 1, 1958.

Hershey maintained a staff in Nashville and branches in Knoxville and Memphis.

Hershey established an Environmental Geology Section and began publishing a new series of bulletins and maps pertaining specifically to environmental geology. The oil and gas program expanded under Hershey's direction, and he was instrumental in establishing and maintaining contact with all mining operations in the state, as well as the oil and gas operations. The growth of the Division resulted in an increase in publications by the various sections of the Division, and Hershey also initiated publication of nontechnical bulletins, such as *Bulletins 73 and 74, Place Names of Tennessee* and *The Geologic History of Tennessee*, and a new series on the geology of Tennessee's state parks. These publications are very popular with the general public and help promote general awareness of the functions of the Division of Geology.

Hershey retired from the Survey in 1985 and was followed by Dr. William T. Hill, the present State Geologist. Hill spent most of his professional career working in private industry, retiring in 1984. In 1985, he accepted the position of State Geologist and as of this writing has served 2 years.

Since Hill has been in office, the survey has been reorganized, shifting from function-related groupings within the Division to a regional subdivision, and greater emphasis has been placed on geologic, environmental, and geologic hazards mapping and publishing. In 1986, the Division published twelve 7.5-minute geologic and mineral resource map packages, as compared to three or four in most recent years.

During Hill's 2 years, many changes have occurred in the Oil and Gas Board regulatory section in the areas of reorganization, new and updated equipment, upgraded inspector qualifications and salaries, and a lengthy task force



study of inspection and regulation policies, State laws and Board rules and regulations. The study resulted in sweeping changes in oil and gas laws, rules and regulations in 1986 and 1987.

Like most state surveys, the Tennessee Survey has to handle more and more data, faster and faster, on tight budgets. To resolve this problem the Survey is turning to computers and computer-supported equipment, such as plotters and digitizers.

Since 1831 the Tennessee Survey's interests and responsibilities have changed as the needs of the public have changed. At first, emphasis was on regional mapping of geology and locating and describing the State's natural resources, including minerals, water and even forests. Later, from when the industrial revolution reached

Tennessee in about 1900 to well into the 1950's and 1960's, emphasis was on economic geology and detailed geologic mapping. Now, because of the public's concern about the quality of life, engineering geology, environmental and hazard geology, and regulation of the extraction of natural resources are subjects that are becoming more and more part of the Survey's routine. The Tennessee Division of Geology's goals for the next several years are to work toward completing the geologic mapping of all 7.5-minute quadrangles, develop good communications with the geologic community, "computerize" the files, develop a data base for the coal and mineral industries, and establish an effective environmental/geologic hazards reporting program.

## TEXAS

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### HISTORICAL SEQUENCE OF ORGANIZATIONAL NAME:

Geological and Agricultural Survey of Texas, 1858-61 and 1866-67  
 Texas Geological Survey, 1873-75  
 Geological and Mineral Survey, 1888-94  
 University of Texas Mineral Survey, 1901-05  
 Bureau of Economic Geology, 1909-11  
 Bureau of Economic Geology and Technology, 1911-25  
 Bureau of Economic Geology, 1925-present

### NAMES AND TITLES OF ORGANIZATIONAL DIRECTORS AND DATES SERVED:

Benjamin F. Shumard, State Geologist, 1858-60  
 Francis Moore, Jr., State Geologist, 1860  
 Benjamin F. Shumard, State Geologist, 1860-61  
 Samuel B. Buckley, State Geologist, 1866-67  
 John W. Glenn, State Geologist, 1873-74  
 Samuel B. Buckley, State Geologist, 1874-75  
 Edwin T. Dumble, State Geologist, 1888-94  
 William B. Phillips, Director, 1901-05  
 William B. Phillips, Director, 1909-15  
 Johan A. Udden, Director, 1915-32  
 Elias H. Sellards, Director, 1932-45  
 John T. Lonsdale, Director, 1945-60  
 Peter T. Flawn, Director, 1960-70  
 William L. Fisher, Director, 1970-present

### TEXAS BUREAU OF ECONOMIC GEOLOGY

Mary Ellen Johansen, Editor

The Bureau of Economic Geology, the oldest and one of the largest research units at The University of Texas at Austin, has filled the role of state geological survey since 1909. It is one of the largest publishers of geological reports and maps in the world.

For most of its existence the Bureau has been a relatively small organization--staffed with a dozen or fewer professional scientists. In recent years, as the demands on all kinds of Texas resources have increased dramatically,

the Bureau has grown to a professional staff of approximately 100, including geologists, chemists, and biologists, and a support staff of about 115 in administration, computing, editing, cartography, word processing, curation, and rock analysis. But with changes in size, the Bureau's mission--to understand the state's geology and resources--remains the same.

The roots of the Bureau's mission are 130 years deep. Predecessors of the Bureau date to 1858, when the eighth Texas Legislature passed an act providing for a survey to help understand the young state's vast lands. This first survey, the Geological and Agricultural Survey of Texas, was

sustained by annual appropriations and was independent of any other institution. Benjamin F. Shumard was named State Geologist. In 1860 he became a victim of a political contest among state leaders, being suspended by Governor Sam Houston and replaced by Francis Moore, Jr., and then temporarily reinstated by the Legislature.

The Civil War brought the first survey's operations to a halt. During wartime a percussion cap factory occupied its laboratories and museum. No records survive; supposedly Shumard's first assistant, Samuel B. Buckley, "went north" with them. When the Survey was reestablished in 1866, Buckley returned to take charge despite Shumard's protests, but he was removed in 1867, and all remaining records disappeared in a political upheaval.

The second geological survey was created by the Legislature in 1870 but did not begin work until 1873. John W. Glenn was appointed State Geologist. He resigned in 1874 because of "disorders and a lack of appreciation of geologic work," and once again the successor was Buckley. Like the first survey, the second was a subject of political turmoil and lasted only until 1875, producing two reports of marginal value on Texas resources. Texas' third survey of the 19th century, the Geological and Mineral Survey, was established in 1888 by the twentieth Legislature as part of the Commission of Agriculture, Insurance, Statistics, and History. It operated for 6 years with state appropriations and an additional 5 years without funding; it was officially terminated in 1901. For a total appropriation of \$80,000, the third survey, directed by Edwin T. Dumble, performed an astonishing amount of work and laid the foundation of Texas geological research. His staff included W. H. von Streeruwitz, W. F. Cummins, and R. A. F. Penrose, Jr.; R. T. Hill worked for Dumble in cooperation with

the U.S. Geological Survey. Dumble divided the state into regions and assigned each a geologist. The annual reports of the survey include papers on the general geology of the several regions of the state, along with special papers on mineral commodities, including the fastest developing resource of the time--lignite. Despite its accomplishments, the Survey was the subject of a fight in the twenty-third Legislature and was denied funding by the Governor in 1893. Dumble remained in Austin, completing reports and living off fees charged for professional services, hoping that he would receive a budget from the next Legislature. But when funding for the Survey was reconsidered in 1895, the Governor again vetoed the budget.

Pressure to survey state lands continued however. Charges were made that valuable mineral lands were being sold for practically nothing. So in 1901 the twenty-seventh Legislature created the University of Texas Mineral Survey, beginning the transition from the 19th-century state agency surveys to a university-supported survey. The Legislature had already transferred the library, records, and collections of Dumble's Survey to the University of Texas in 1889. The Mineral Survey reported to the Board of Regents and was attached to the University but was not a part of it. William B. Phillips was appointed Director. The Survey had a specific mission--to survey only lands belonging to the public schools, the University, and asylums and to determine the mineral value of these lands. Phillips' staff included Johan A. Udden, B. F. Hill, Heinrich Ries, and G. B. Richardson. The Survey existed until 1905; it expended a total of \$25,000 and produced eight publications and maps on mineral districts, commodities, and problems of the state mining laws.

The full transition from a state agency geological survey to a university-administered geological re-

search organization came with the creation of the Bureau of Economic Geology in 1909 by the University of Texas Board of Regents. The Board recognized the usefulness of the Mineral Survey to the state and its practical role in providing scientific information to the public through the University. Phillips was made the Bureau's first director, a position he held until 1915. In 1911 the organization's name was changed to Bureau of Economic Geology and Technology. A mining engineer, Phillips stressed studies of the mineral resources of the Trans-Pecos region of Texas and investigations into the utilization of the lignite, coal, petroleum, and natural gas resources of the state. He also promoted research in engineering and industrial chemistry under the auspices of the Bureau. Following Phillips' resignation and the appointment of Johan Udden to Director in 1915, the Bureau was reorganized upon Udden's recommendation into three separate divisions: a Division of Economic Geology, a Division of Engineering, and a Division of Chemistry. These divisions became independent in 1925 and were together designated as the Division of the Conservation and Development of the Natural Resources of Texas, including (1) the Bureau of Economic Geology, (2) the Engineering Experiment Station, which became the Bureau of Engineering Research in 1926, and (3) the Industrial Chemistry Experiment Station, which became the Bureau of Industrial Chemistry in 1927. Later, these organized research bureaus of the University, together with the Bureau of Business Research, were loosely grouped as the Texas Commercial and Industrial Research Council, which met quarterly to promote industrial development through joint public symposia.

Udden had been hired by Phillips as the Bureau's first field geologist. At age 52 Udden left a professorship at Augustana College in Illinois for the

opportunity to do geological research in Texas. "The study of the geology of the Southwest has only begun," wrote Udden, "and still it has revealed so many new and unexpected things that I am firmly of the opinion that there will be interesting geologic work to do in Texas for a whole century to come."

Under Udden's direction, geological research at the University of Texas had its real beginning. For the first time the Bureau began work in stratigraphy and paleontology. Udden assembled a talented research staff, including the foremost reconnaissance geologist Charles L. Baker and the world-renowned German invertebrate specialist Emil Böse, who undertook the first thorough faunal research in Texas. In 1916 Udden brought to completion the first compendium of Texas geology, *Review of the Geology of Texas*, coauthored by Baker and Böse, which included the first geological map of the state. He also initiated a program of areal and stratigraphic geological investigations on the county level.

In large part owing to the leadership of Udden, in the first 23 years of its life the Bureau played a vital and versatile research role alongside the burgeoning exploration departments of the oil companies. Udden taught the leading oil company geologists of the early decades of the petroleum industry, and he pioneered the use of what were to become the basic exploration tools of the oil geologist: micropaleontology and detailed lithological interpretation of well samples. Part of Udden's genius was that he recognized early the need for basic geological information in any oil exploration program, and he foresaw the tremendous additions to the understanding of the stratigraphy and structure of rocks that would come from drilling.

Udden encouraged the oil companies to make accurate collections and descriptions of well samples and to contribute their records to a well sample



pool to be administered by the Bureau, a neutral agency. Today the Bureau's Core Research Center houses one of the largest public collections of subsurface geological materials in the country. Holdings include cores from more than 4,000 wells in addition to drill cuttings from more than 100,000 wells, most of which are donations from private sources.

Udden was also one of the first to recommend the use of the seismograph in oil exploration. Edgar W. Owen, the author of *Trek of the Oil Finders*, a history of petroleum exploration, told Bureau historian W. Keene Ferguson that "Udden's little paper [on the potential value of seismograph exploration tools] that he delivered to AAPG in 1920 was one of the real milestones of geological science." Another major effect of Udden's work with the Bureau was his 1919 AAPG paper on the potential producing formations in Texas. "All the way through he just gave the oil companies a whole new concept on the magnitude of the prospects in Texas at a time when Texas was doing damn little," related petroleum historian Owen.

A period of retrenchment in the Texas government in the early 1920's almost resulted in the elimination of the Bureau. The Governor wanted to cut the Bureau's appropriations because it was not engaged in teaching and therefore not considered to be an essential part of the University. Udden and others convinced the Governor otherwise, but the 1921-22 budget was down by more than one-third from the previous fiscal year. In 1925, the new state administration, elected on a platform of retrenchment, cut the Bureau's budget even further.

Udden gave up active directorship of the Bureau in 1925. Associate Director Elias H. Sellards assumed active directorship and in 1932 was appointed Director, a position he held until 1945. Sellards' first duties were to

attempt to offset the effects of the budget cuts. He was quite successful in soliciting contributions from geological societies and oil companies for funding Bureau publications. In addition to his concern with budgetary matters, Sellards also established a course in petroleum geology at the University. The lecturers in the pilot course, titled "Petroleum Production from Salt Domes of the Coastal Plain," were the leaders in Texas geological research. The course marked the beginning of the Department of Petroleum Engineering at the University.

When Sellards became Bureau Director in 1932 his staff included F. B. Plummer, Charles Baker, and W. S. Adkins. The latter two researchers and Sellards wrote the classic study *The Geology of Texas, Vol. I, Stratigraphy*. That publication is now in its eighth printing. During the depression years of the 1930's and the war years of the 1940's, Bureau geologists continued to focus their main research on stratigraphic investigations in support of oil exploration, conducting studies of the Tertiary formations of the Gulf Coast, Pennsylvanian and Permian strata of West and North-Central Texas, and the Ellenburger Group of West Texas. The Ellenburger study was coauthored by Virgil E. Barnes, who celebrated his fiftieth anniversary with the Bureau in 1985. Under Sellards, Bureau researchers also participated in mineral resource surveys funded by the Works Progress Administration (WPA). During a 1936 WPA mineral resource survey in Grimes County, Barnes first became interested in the black, glassy specimens called tektites. His subsequent research and review of the world tektite literature resulted in the 1940 publication of his now classic paper *North American Tektites*. Barnes was the first to conclude that tektites were not meteorites, as had been believed, but had earth-bound origins. The National Science Foundation began

supporting Barnes' tektite research in 1960, and in the ensuing years he visited tektite-strewn fields all over the world. His studies culminated in his definitive 1973 book *Tektites*.



Dr. Virgil E. Barnes celebrated his fiftieth anniversary with the Bureau of Economic Geology in 1985.

In the late 1930's Sellards steered the WPA surveys more into the area of vertebrate paleontological investigations. Sellards' own scientific interest was in early man, and his work resulted in a revival of scientific interest in the search for evidence of ancient human cultures in all of North America.

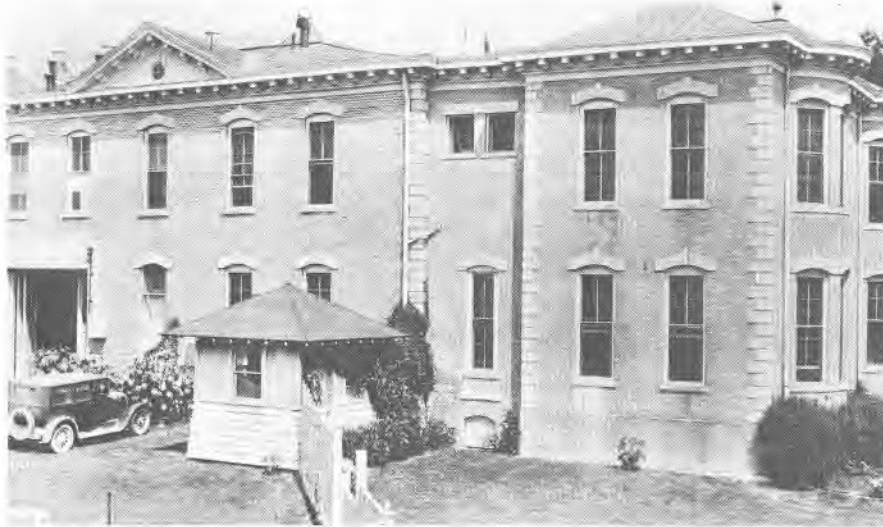
In 1945 John T. Lonsdale was named Bureau Director, a position he held until his death in 1960. Lonsdale assisted in the post-World War II industrial development of the state by initiating a program of surveying the state's mineral resources other than oil and gas. The Bureau's studies of the mineral resources of particular river drainage basins were intended to provide a basis for predicting future industrial growth and resultant demands on water resources. These mineral resource studies marked the entry of the Bureau into resource planning programs, which have since

received a significant part of the Bureau's energies. During Lonsdale's tenure Bureau staff also completed a tremendous amount of basic geological research.

In the 1960's, pollution became a vital concern of American society. Under the direction of Peter T. Flawn, who was named Director in 1960, land-use planning and resource management became important goals of geological research. Flawn recognized the need for long-term planning to reconcile the conflicts between conservation and resource management groups. In 1969 he initiated the *Environmental Geologic Atlas of the Texas Coastal Zone*, consisting of seven separate folios. Each folio consists of a basic Environmental Geologic Map, at a scale of 1:125,000, and a series of eight Special-Use Maps, at a scale of 1:250,000. The atlas was designed to provide a thorough inventory of natural and manmade resources of the Coastal Zone and to serve as a basic document in planning, development, and conservation of the Texas coast.

During the late 1960's geologists at the Bureau also became involved in the advancement of lithogenetic stratigraphy. Regional surface and subsurface studies in the Gulf Coast Basin and Permian Basin resulted in the concept of depositional systems, which led to the Bureau's prominence during the 1970's and 1980's in facies analysis. Ideas and methods developed at the Bureau have been applied widely in mineral and petroleum exploration, reservoir characterization, environmental geology, and the new field of seismic stratigraphy.

In 1970 Flawn assumed the position of Vice-President for Academic Affairs at The University of Texas at Austin. He later served as President of the University. William L. Fisher succeeded Flawn, becoming the sixth Bureau Director. Fisher is also Chairman of the Department of Geological Sciences at



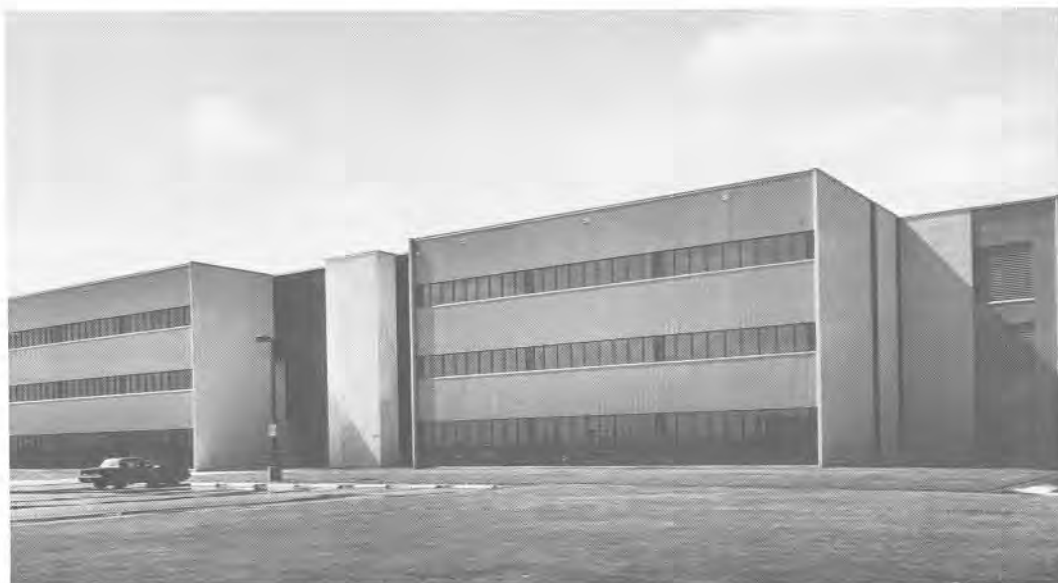
Little Campus building (circa 1928) housed the Bureau of Economic Geology's offices from 1928 to 1967.

The University of Texas at Austin, where he holds the Leonidas T. Barrow Chair in Mineral Resources. From 1975 to 1977 he served as Assistant Secretary for Energy and Minerals with the U.S. Department of the Interior. Under Fisher the Bureau's activity today has probably been equaled only by that of the Bureau during the emergence of the oil industry under Udden. However, the size and housing of the Bureau have changed tremendously from Udden's day to the present. In 1967 a staff of 50 professional and staff personnel moved from Little Campus to the newly built Geology Building on the University campus. In 1984, the year of the Bureau's seventy-fifth anniversary, a staff more than triple in size moved to a new three-building facility at Balcones Research Center, the University's research campus. The Bureau's facilities now consist of a three-story, 150,000-square-foot research and administration building; a two-story, 35,600-square-foot Core Research Center/Mineral Studies Laboratory; and a one and one-half story, 100,000-square-foot core repository.

Bureau of Economic Geology research is aimed chiefly at near- and intermediate-term concerns in the area of natural resources. Two primary concerns are the safe, secure disposal of waste products, especially those that are toxic or radioactive, in geologic formations and the means of realizing sufficient production of energy resources.

Assurance that hazardous waste disposal is safe and secure requires critical assessment and understanding of rock and soil composition, geochemistry, and especially the behavior and movement of formation waters. The Bureau's Land, Water, and Environmental Resources Investigations include studies of isolation of high- and low-level radioactive waste and toxic chemicals and assessment of potential water pollution in specific areas of the state.

The Bureau's Energy Resources Investigations involve studies of petroleum, gas, and coal. Through the years Bureau research on oil and gas trends has aided the discovery of these resources so critical to the state and its economy. Today and in coming years, as



The Bureau of Economic Geology's research and administration building, completed in 1984, is part of the Bureau's three-building complex located at Balcones Research Center, The University of Texas at Austin.

conventional production of oil and gas declines, Bureau research on Texas oil and gas focuses on geologic characterization of reservoirs so that more of the some 100 billion barrels of oil now considered unrecoverable can ultimately be recovered. In 1986 preparation of an atlas of major Texas gas reservoirs was initiated. The gas atlas will define the contribution of various types of reservoirs to current production and will group these reservoirs into genetically related plays, provide a baseline for future trends in reserve additions and reserve growth, and extend to gas some of the methodologies for resource analysis that were initiated with the *Atlas of Major Texas Oil Reservoirs*, a Bureau best seller since its publication in 1983. Current lignite research at the Bureau concerns the state's vast deep-basin deposits and their hydrogeology in anticipation of when these deep seams, through in situ gasification, will be an important source of gas energy for the state.

In addition to waste isolation and energy investigations, the Bureau

conducts extensive research projects in the areas of coastal studies and mineral resources. A significant part of the state's population and industrial base lies in the Coastal Zone, where dynamic natural processes such as shoreline erosion, land subsidence, flooding, and hurricanes continuously affect the environment and must be understood to avoid or reduce loss of life and property. Bureau reports on natural hazards of the zone, from erosion to subsidence to flooding, as well as maps and descriptions of land and environmental resources, supply the technical information necessary for living in harmony with these natural processes.

Hard minerals, many strategic and critical, have been mined intermittently in Central and Trans-Pecos Texas. Many of these mineralized areas hold resources of marginal concentration. Yet as prime deposits throughout the world are being exhausted, the marginal hard mineral districts in Texas assume potential. Future realization of the potential depends largely on detailed understanding of mineral origin and emplacement. The



work of the Bureau-administered Texas Mining and Mineral Resources Research Institute is dedicated to such understanding.

The products of public sector research of the Bureau are many, but the essential product is the communication of the results of its research in reports and maps. Since 1909 the Bureau has produced some 1,700 reports and maps on the geology and resources of Texas. Major reports of the Bureau are published in The University of Texas Publication series; its own series include Reports of Investigations, Geologic Quadrangle Maps, Geologic Atlas Sheets, Environmental Geologic Atlases, Guidebooks, Handbooks, Geological Circulars, Mineral Resource Circulars, and Special Publications. Bureau reports have covered, in varying degree, nearly every aspect of Texas geology and resources. Long-term mapping projects include the "Geologic Map of Texas," which will replace the U.S. Geological Survey's Texas map, published in 1937 and out of print for many years. The Bureau's "Geologic Atlas of Texas," a series of 38 separate

map sheets, was completed at the end of 1986. With the publication of the last sheet in the series, the atlas project has shifted from new mapping to revising maps that have gone out of print. Virgil Barnes has served as director of the project since it began in 1961. Publications are sold for a nominal price to recover printing costs. To date, approximately 1.66 million reports and maps have been distributed worldwide by sales to individuals, to other public agencies, and to private organizations as aids to the discovery and development of the state's vast energy and mineral resources, as well as the utilization of its diverse land resources.

The continued perfection of the geologic and resource model of Texas will not be the sole determinant in our state's future success in winning its resources and living with the natural processes, but it will be, as it has been in the past, a fundamental and critical determinant. Future Bureau research will continue to be dedicated to that perfection for the benefit of the state and its citizens.

## UTAH

Utah Geological and Mineral Survey, Utah Department of Natural Resources,  
606 Black Hawk Way, Salt Lake City, UT 84108-1280. Phone 801-581-6831.

### HISTORICAL SEQUENCE OF ORGANIZATIONAL NAME:

Utah Geological and Mineralogical Survey, 1931  
Utah Geological and Mineralogical Survey placed in the Utah State Department  
of Publicity and Industrial Development, 1941  
Utah Geological and Mineralogical Survey, State School of Mines and Mineral  
Industries, University of Utah, 1949  
Utah Geological and Mineralogical Survey, Department of Natural Resources,  
1973

### NAMES AND TITLES OF ORGANIZATIONAL DIRECTORS AND DATES SERVED:

No Director, 1931-41  
Arthur L. Crawford, Senior Investigator, 1941-44; Director and Commissioner,  
1946-49; Director, 1949-61  
William P. Hewitt, Director and State Geologist, 1961-74  
Donald T. McMillan, Director and State Geologist, 1974-81  
Genevieve Atwood, Director and State Geologist, 1981-present

### HISTORY OF THE UTAH GEOLOGICAL AND MINERAL SURVEY\*

Compiled by Martha R. Smith

Utah, located in three physiographic provinces, is rich in natural resources and geologic expressions. Our unique location furnishes us with a wide array of energy, metallic, nonmetallic, scenic and water resources along with a challenging spectrum of geological hazards. The Utah Geological and Mineral Survey (UGMS) observes, monitors and inventories these resources and hazards through its Economic Section, Mapping Section, Applied Section, Information Section and the Administrative Section.

Pioneers settled Utah in 1847 but mining did not become an important resource until 1863 when placer and

lead-silver veins were discovered in Bingham Canyon. By the end of the 19th century, mineral production was an important part of Utah's economy. In his comprehensive *Ore Deposits of Utah* (U.S. Geological Survey Professional Paper 111 {USGS}), B. S. Butler reported that the total value of mineral production in the state had risen from \$6 million in 1880 to almost \$100 million in 1917.

Although a formal state geological survey was slow to evolve, the role of a survey was filled by the combined efforts of the USGS, the University of Deseret (now the University of Utah) and private enterprises. In the 1870's, J. W. Powell, U.S. Geological Geographic Territorial Survey, explored portions of the state and F. V. Hayden provided the first photographs and illustrations of our dramatic scenery and geology. As part of the 100th

\*Portions of this report were extracted from UGMS Circular 77.

Meridian Survey, G. K. Gilbert published USGS Monograph No. 1 on Lake Bonneville in 1890. Four years later, a Department of Mines was formed at the renamed University of Utah, and Dr. James E. Talmage became the first professor of geology. The early geologic studies focused on stratigraphy and paleontology rather than economic works.

In 1896, Utah's statehood was established and 100,000 acres were allotted to establish and maintain a School of Mines. Eight years later, the State Legislature established the Utah Engineering Experiment Station as part of the State School of Mines. Over the next 18 years, the Experiment Station published 17 bulletins on engineering topics related to the use of natural resources.

In 1919, the Board of Regents founded the "University Geological and Resource Survey of Utah" under Dr. Fredrick J. Pack, Deseret Professor of Geology and head of the department since 1907. No funds were provided for this survey.

In 1919, Dr. Lyon, Director of the joint U.S. Bureau of Mines Intermountain Experimental Station-Utah Engineering Experiment Station, introduced a bill to the state legislature proposing the formation of the "Utah Geological and Mineralogical Survey." Rivalries among local geologists prevented passage of the proposal until 1931 when the first Utah Geological and Mineralogical Survey was formed with an appointed nonsalaried Advisory Board and no operational funds.

In 1941, the state government was reorganized, and the Utah Geological and Mineralogical Survey (UGMS), together with the Utah State Parks Commission, the Utah State Planning Board, and several other agencies, was placed in the newly created Utah State Department of Publicity and Industrial Development (UPID). Arthur L. Crawford was hired by UPID as a senior

investigator for mineral studies and editor of geologic reports.

In 1946, Arthur L. Crawford was appointed by Governor Maw as a Commissioner of the UPID and given responsibility for Raw Materials and Research. One of Crawford's earliest efforts as commissioner was to obtain support for an investigation of the oil and gas possibilities of Utah. By the end of 1949, *The Oil and Gas Possibilities of Utah* came off the press just as Utah's first oil field, the Ashley Valley Field, was discovered.

#### **ARTHUR L. CRAWFORD: 1949-61**

Another reorganization of state government took place in 1949, and the Utah Department of Publicity and Industrial Development was abolished. The UGMS was salvaged by transferring it to the State School of Mines and Mineral Industries of the University of Utah and by providing a \$25,000 appropriation for the 1949-51 biennium. Arthur L. Crawford was appointed its first Director.

Under Director Crawford, the financially struggling Survey built its source of revenue by soliciting manuscripts for publication and sale from professors and graduate students. During his term, the UGMS issued over 200 publications and began a library of samples for geologic research.

#### **WILLIAM P. HEWITT: 1961-74**

In 1961, the UGMS advisory board named Dr. William P. Hewitt Director, with Arthur L. Crawford as Assistant Director (until his retirement in 1964). Survey policies began focusing on economic activities and the UGMS experienced a 15-year period of growth. New programs instigated by Dr. Hewitt were mineral appraisals of state-owned lands and state-selected in lieu lands, detailed geologic studies of mining districts and coal deposits, oil impregnated sandstone studies, oil and gas



Arthur L. Crawford  
UGMS Director, 1949-61



William P. Hewitt  
UGMS Director, 1961-74

fields studies, and economic studies of the Great Salt Lake.

Dr. Hewitt's survey also concerned itself with potential geologic hazards in Utah. A new section of Urban and Engineering Geology was created. Environmental issues were investigated as early as 1966 and 1 year later the waste disposal problem was first addressed.

Milestones accomplished during Hewitt's directorship include increasing the volume of UGMS publications, awarding of the first federal grant, and successfully supporting legal efforts to procure state ownership of the Great Salt Lake.

In 1973, legislation dictated the transfer of UGMS from the University of Utah to the Department of Natural Resources, officially named the Survey Director as State Geologist, and shortened the name to Utah Geological and Mineral Survey.

#### **DONALD T. McMILLAN: 1974-81**

William P. Hewitt retired in 1974 and was succeeded by Donald T. McMillan with Howard Ritzma serving as Assistant Director. Under McMillan's guidance, there was a steady increase in the Survey's cooperatively funded activities. Grants were obtained to study low-temperature geothermal resources along the Wasatch Front, coal resources of Utah, and methane contents of Utah's coals. In addition, the first U.S. Geological Survey Earthquake Hazard Reduction Program grant was awarded. In 1977, the legislature charged the Survey with responsibility for assessing earthquake risks throughout the state.

In conjunction with the USGS and the Bureau of Land Management, the UGMS started a computerized listing of all known mineral deposits in the state. Survey geologists began field checking





Donald T. McMillan  
UGMS Director, 1974-81

data included in the Computerized Resource Information Bank (CRIB).

The survey, during McMillan's term, continued to produce UGMS publications, printed a biannual report, an Energy Resource Map, a new Geologic Map of Utah and Garfield and Box Elder County studies.

**GENEVIEVE ATWOOD:  
1981-PRESENT**

Donald T. McMillan retired in 1981 and was succeeded by Genevieve Atwood. In 1982, Director Atwood guided the Survey into a productive geologic mapping program. This ongoing project combines efforts of USGS, UGMS, students, and other contractors and produces 15 new 7.5-minute quadrangles per year.

Under the direction of Genevieve Atwood, the UGMS developed, in conjunction with the USGS, a State funded earthquake program. The flooding of 1983 encouraged broadening the program to include risk delineation along the Wasatch Front. Survey staff



Genevieve Atwood  
UGMS Director, 1981-present

investigated surface ruptures, frequencies of past faulting events, magnitude of events potential consequences of earthquakes and response readiness. The UGMS also began preparing a series of geological hazards maps for the purpose of aiding home buyers, real estate developers, school districts, and hospitals.

Under Ms. Atwood's direction, the Information Program focuses on informing the public of Utah's resources and various hazards. Projects instigated by the information section include computer availability of technical and nontechnical data, brochures delineating the economic geology of each of Utah's 29 counties and proposals for geologic projects with outside contractors.

The Economic Program continues to work on the CRIB program with the intention of making all the information available by computer. A new program to open communications and exchanges with private industry began in 1988. Ongoing projects include a Great Salt

Lake salines program, a core sample library, an extensive coal program and mining district mapping.

Political and economic highlights of Director Atwood's years include the 1979-85 Paradox Basin Study (geologic characterization study for proposed high level nuclear waste), the 1979-87 super collider investigations, the 1982-present Great Salt Lake level fluctuation studies, ongoing earthquake studies and challenges associated with the mineral economy downturn.

Under Genevieve Atwood's guidance, the UGMS is striving to improve services and communications with Utah's industries, developers, researchers, and the general public. Continued geologic mapping delineation of geologic hazards, computerization and increased availability of technical and nontechnical information, and increased quantity and quality of economic projects are all important to UGMS's future.

## VERMONT

Office of the State Geologist, Agency of Natural Resources, 103 South Main Street,  
Center Building, Waterbury, VT 05676. Phone 802-244-5164.

### HISTORICAL SEQUENCE OF ORGANIZATIONAL NAME:

State Geologist, 1844-48  
State Naturalist, 1853-56  
State Geologist<sup>1</sup> and Curator of the Cabinet<sup>2</sup>, 1856-1947  
State Geologist, 1947-76  
Office of the State Geologist, 1976-present

### NAMES AND TITLES OF ORGANIZATIONAL DIRECTORS AND DATES SERVED:

Charles Baker Adams, State Geologist, 1845-48  
Zadock Thompson, State Naturalist, 1853-56  
Augustus Young, State Naturalist, 1856  
Edward Hitchcock, State Geologist & Curator of the Cabinet, 1856-61  
Albert D. Hager, State Geologist & Curator of the Cabinet, 1864-70  
Hiram A. Cutting, State Geologist & Curator of the Cabinet, 1870-86  
George W. Perry, State Geologist & Curator of the Cabinet, 1886-98  
George H. Perkins, State Geologist and Curator of the Cabinet, 1898-1933  
Elbridge C. Jacobs, State Geologist and Curator of the Cabinet, 1933-47  
Charles G. Doll, State Geologist, 1947-76  
Charles A. Ratté, State Geologist, 1976-present

<sup>1</sup> The name "Vermont Geological Survey" was first used unofficially in the State Geologist's report of 1911-12 and continues more or less unofficially.

<sup>2</sup> A joint resolution of the 1848 legislature provided "That all collections . . . amassed by the State Geologist . . . be deposited in the State House . . ." The first cabinet was prepared in 1856 with A. D. Hager (assistant to the State Geologist) acting as the first curator [5, p.1-2]. The rock collection was rendered worthless in the great flood of 1927 [1, p. 24].

### HISTORY OF THE VERMONT GEOLOGICAL SURVEYS AND STATE GEOLOGISTS

#### A BEGINNING

A bill authorizing the Governor of Vermont to appoint a State Geologist was signed on October 28, 1844. Governor William Slade announced his appointment, Charles Baker Adams, professor of Chemistry and Natural History at Middlebury College, effective March 1, 1845 [1, p. 3].

The duty of the State Geologist was stated as follows:

to commence and prosecute a thorough geological and mineralogical survey of the

state, embracing therein a full and scientific examination and description of its rocks, soils, metals and minerals; make careful and complete assays and analyses of the same . . .

Thus, a position of State Geologist and a duty to conduct a geological survey were clearly established by legislation. A state geological organization known as the Vermont Geological Survey has never been legally authorized. Since the subject of organization name is suggested in the title of this document it perhaps should be noted here that the first reference to the "Vermont Geological Survey" is in the 1911-12 report of the Vermont State

Geologist, George H. Perkins (State Geologist, 1898-1933). The term has been in general use since then and appears on geological publications originating from the State Geologist's Office. The "Office of the State Geologist" is the current (unofficial) organizational name. The position and title of Curator of the Cabinet (a natural history collection and display formerly housed in the Capitol in Montpelier) was held by the State Geologist until 1947. The title is now obsolete. The devastating flood of November 1927 destroyed "The Cabinet" and rendered the specimens worthless. Most of the rocks and minerals of any value were given to Professor Charles H. Richardson of Syracuse University [1, p. 24]. Thus the State Geologist's "Cabinet" is no longer in existence. A few rock samples were found in a state of disarray in the storeroom at the University of Vermont in 1976 when the Office of the State Geologist was moved to Montpelier. The new State Geologist at the time, Charles A. Ratté, donated these samples to the Fairbanks Museum in St. Johnsbury.

#### **Charles B. Adams: 1845-48**

Adams' (State Geologist 1845-48) appointment expired in February 1848. Three annual reports (1845 {The first report ever issued on Vermont Geology [6, p. 3]}, 1846, and 1847) were published but he had not completed the "survey." Adams had accepted (1847) a professorship at Amherst (MA) College [4, p. 8]. In 1848 the Legislature failed to make an additional appropriation to complete a final report and the survey ceased.

#### **Zadock Thompson: 1853-56**

In 1853, a democratic governor was elected. Governor John S. Robinson supported the survey and declared the state could afford it and that agriculture would benefit. House Bill



Charles Baker Adams (1814-53), first State Geologist (1845-48), Burr Professor of Chemistry and Natural History at Middlebury College (1838-47) and a leading American conchologist. From the State Geologist's Report (1946).

271 passed and Zadock Thompson was appointed State Naturalist (1853-56) [1, p. 8]. Thompson worked with enthusiasm; however, his health failed and he died in 1856. The survey and final report remained incomplete. Thompson's major accomplishment, *History of Vermont* (1842), preceded his appointment as State Naturalist. No annual reports on the Geology of Vermont were published during Thompson's tenure.

#### **Augustus Young: 1856**

Governor Stephen Royce appointed Augustus Young of St. Albans as Thompson's successor on February 29, 1856, to hold office until the next session of the General Assembly [1, p. 8]. Young presented his "Preliminary Report" for the new Governor R. Fletcher in September. Mr. Young died in 1856 [6, p. 7].





Zadock Thompson (1796-1856), State Naturalist, 1853-56, while assistant to the State Geologist, 1845-47, made special studies of Vermont mountain heights and Chittenden County trap dikes. His preliminary estimates appeared in his 1842 *History of Vermont*, p. 8. Portrait from an engraving by F. C. Buttre in the Wilbur Collection, UVM.



Edward Hitchcock (1793-1864), State Geologist, 1856-61, and President of Amherst College, 1844-54, produced with his sons the first detailed study of Vermont geology, whose bedrock map served for a century. From the State Geologist's Report (1946). No picture of Augustus Young (1785-1857), his predecessor for 7 months of 1856, has been found.

## A COMPLETION

### Edward Hitchcock: 1856-61

The first report on the Geology of Vermont, including the first state geological map, plates, wood cuts and an extensive two volume text, was published in 1861. The survey was conducted and completed by Edward Hitchcock (State Geologist, 1856-61) with the aid of his sons Edward and Charles, and Albert D. Hager. For the first four state geologists (Charles Adams, 1845-48; Zadock Thompson, State Naturalist, 1853-56; Augustus Young, 1856; Edward Hitchcock, 1856-61), this "final" report was a monumental accomplishment. It did, however, bring to an end all survey activities [1, p.11].

## A HIATUS

The only public responsibility (for the State Geologist) which the Vermont

legislature saw for the period 1861 to 1898 was to "keep" the State Cabinet and to give someone the title of State Geologist and Curator of the Cabinet as a point of reference [1, p. 11].

### Albert D. Hager: 1864-70

On November 22, 1864, Albert D. Hager accepted the appointment as State Geologist "to encourage the further development of" Vermont's underground resources. However, the legislature provided no compensation for the position and when, in 1870, the Missouri Bureau of Mines invited Hager to continue their state geological survey on salary, he left Vermont for good [1, p. 15]. (Reports are conflicting, Perkins [6, p. 12] indicates Hager accepted a position with the Iowa Survey.)

There is no evidence that Hager kept records or contributed beyond his early involvement with the Hitchcock



Albert David Hager (1817-88), assistant to Hitchcock, Vermont State Geologist (1864-70), Missouri State Geologist (1870-71). Chicago Historical Society.

survey and the publishing of the first report on the Geology of Vermont.

#### **Hiram A. Cutting: 1870-86**

Hiram Adolphus Cutting became State Geologist in 1870. His main intent while in office was to continue the geological survey. However, with no funds appropriated to the office, he was unable to report any progress. He resigned on March 3, 1886, due to poor health [6, p. 12].

#### **George W. Perry: 1886-98**

George William Perry of Rutland, a popular lecturer, nature lover and clergyman was appointed State Geologist in November 1886 by Governor Ebenezer J. Ormsbee. Perry was provided an annual budget of \$150.00 to assemble and publish data on the mineral and stone industries of Vermont. For the first time a systematic statistical look at Vermont's

mineral resources was called for and partly achieved. At this time no talc (presently Vermont's most productive and economically valuable mineral resource) had been discovered; however, Perry predicted it would be. He also noted that J. Seward Webb was drilling for natural gas at Shelburne (probably the first exploration for hydrocarbons in Vermont) with not much success [1, p. 18].

In 1896 Governor Urban A. Woodbury's retiring message stated "... I think that he (Perry) has accomplished as much as any person could with the limited means at his disposal, I believe that the value of his work is not worth to the State what it costs" [1, p. 18]. Perry resigned in 1898 [3, p. 18]. He had collected considerable information on the state's mineral industries (marble, granite, slate, soapstone, copper) which was the source material for the 1898 State Geologist's (Perkins) report on the marble, slate and granite industries of Vermont [1, p. 19-20].

### **RENEWED SURVEY**

#### **George H. Perkins: 1898-1933**

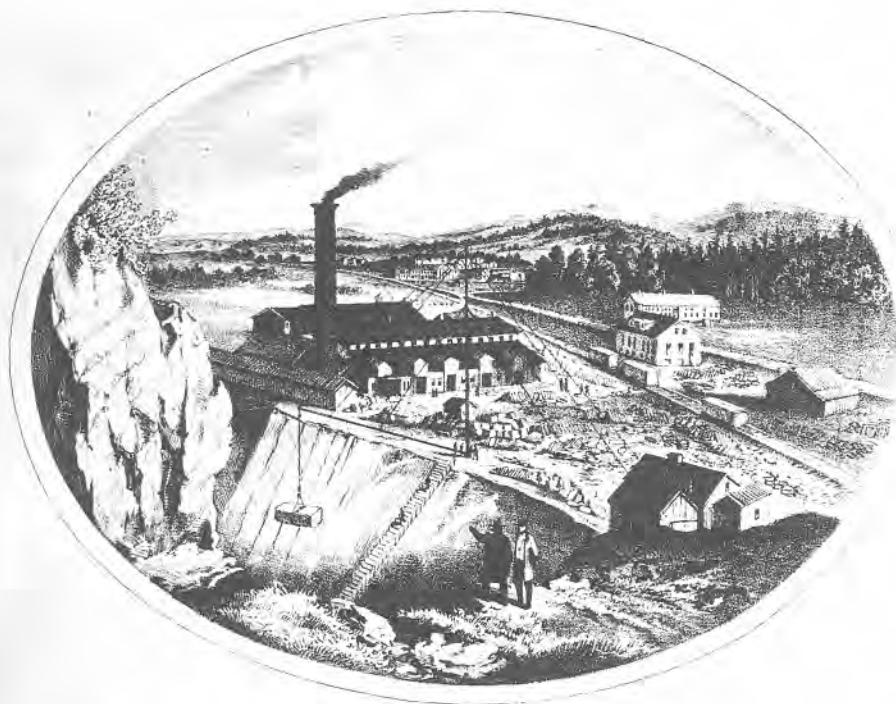
George Henry Perkins, the first professional geologist since Hitchcock to hold the office, was appointed by Governor Josiah Grout on September 7, 1898. Perkins was reappointed each biennium until he died in office on September 12, 1933, at the age of 89 [1, p. 19].

Perkins produced eighteen biennial reports. These *Reports of the Vermont State Geologist* were devoted to reporting on the state's mineral resource potential. In addition, and for the first time in the history of the geological survey process, Perkins encouraged geological scientists from nearby colleges, universities, etc., to conduct their investigations in Vermont. Thus, he was able during his tenure to amass a considerable catalog

of geological information relating to the State of Vermont [2, p. 39]. In the 1911-12 report, Perkins started listing these contributors as "Staff of the Vermont Geological Survey;" thus, the unofficial organization "The Vermont Geological Survey" was born. The first regularly scheduled reports and publications on Vermont geology were the hallmark of Perkins' leadership. Over 115 publications on the geology of Vermont towns, counties, its fossils, physiography, topography, water resources, etc., are included in Perkins' biennial reports. Also, included in his reports were 150 accounts of the state's mineral

industries and mineral resources ranging from the dominant industries of marble, granite, and slate to the metals of copper, iron, gold, lead, silver, and platinum. Accounts of the flourishing asbestos, clay (kaolin), talc and soapstone industries are included as well as mention of coal (lignite), manganese, ocher, graphite, garnet, mica, feldspar, peat, and mineral springs.

Perkins' imposing volume of over 300 pages on Vermont's marble industry climaxed his career shortly before his death (in office) in 1933 [1, p. 24].



Sheldons & Slason's Marble Quarry  
West Rutland

The second largest marble business in 1860, Sheldons & Slason (pronounced Slawson) was in the late 1850's, when the Hitchcocks visited them, hiring 160 men and using many horses and oxen for teaming and powering the derricks which hoisted 70,000 cubic feet of blocks out of the quarry in 1859. A 70 horsepower steam sawmill converted these blocks into \$130,000 worth of inch-thick slabs according to the 1860 manuscript census of manufacturing, and produced the perpetual plume from its smokestack shown in this lithograph, Plate xxxvi in Hitchcock's *Geology of Vermont*, drawn by H. F. Walling; lithographed by Ferdinand Meyer.



Hiram Adolphus Cutting (1832-92), State Geologist, 1870-86, M.D., A.M., Ph.D., &c., a one-man extension service and walking encyclopedia about nature in Vermont. From Norwich University Archives.



George Henry Perkins (1844-1933), State Geologist, 1898-1933, about 10 years before his first appointment. UVM Archives, gift of Geraldine Andrews.

#### Elbridge C. Jacobs: 1933-47

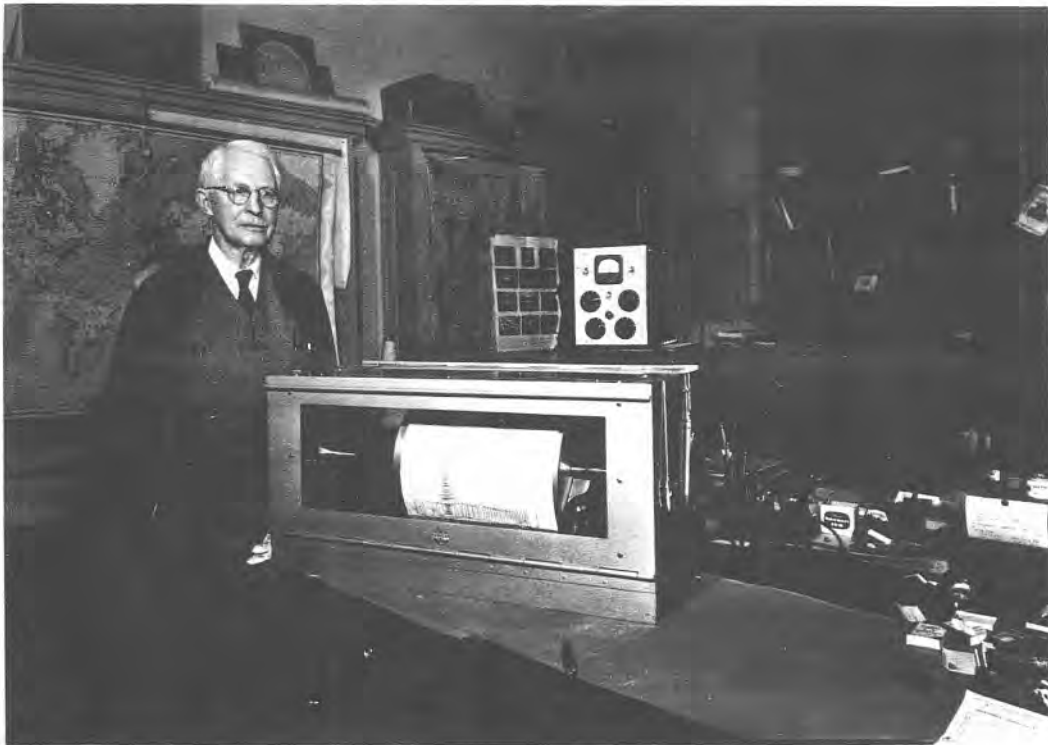
On September 23, 1933, Elbridge C. Jacobs was appointed State Geologist by Governor Stanley C. Wilson. Jacobs was a well qualified Professor of Geology at the University of Vermont and had been considered by Perkins as an Assistant State Geologist. The Office of the State Geologist had been associated with the University for 35 years, and thus, it was appropriate to continue this connection with Jacobs' appointment.

The position of State Geologist continued, as before, as a part-time job. The total budget in 1933 was \$1,200. These funds were used primarily to publish the biennial report and provided for the small salary and expenses of the State Geologist. Larger appropriations in 1945 (\$2,000) and 1946 (\$4,000) made it possible to seriously embark on a real mapping program of Vermont's bedrock geology. This program had started earlier (1943-44) with the mapping of the Strafford quadrangle by Professor Charles G. Doll (University of Vermont). Jacobs' plan was to complete the quadrangles along the Canadian



George William Perry (1846-1928), State Geologist, 1886-98, Universalist minister and founder of Eagle Camp, South Hero. Perry Family Archives, courtesy of Helen Perry Smith. Taken about 1895.





Elbridge Churchill Jacobs (1873-1957), State Geologist, 1933-47, with his seismograph, in his basement office, Robert Hull Fleming Museum, 1940's. UVM Archives.

border so as to continue the extension (to the south) of bedrock formations which had already been mapped and described by the Canadian Geological Survey.

During his 14-year tenure, Jacobs published 7 biennial reports. Although these reports were devoted largely to an accounting of the state's mineral industries, considerable effort was made to publish reports on the state's geology through the contributions of the scientists and authors who were working on the geology of Vermont at the time. Perhaps the most prolific and influential geologist of the Jacobs' era and later was Dr. Wallace M. Cady of the U.S. Geological Survey.

Two important occurrences of Jacobs' time that influenced the State Geologist's program were the State of Vermont/U.S. Geological Survey cooperative topographic mapping

program that provided good base maps for the geological scientist, and the re-opening of the Vermont copper mines in 1942 that reemphasized the value of having up-to-date information on the state's geologic and mineral resources. Jacobs' most renowned publication, *Physical Features of Vermont*, was prepared after his retirement in 1947. Its popularity has required several printings.

## MODERN GEOLOGICAL SURVEYS

### Charles G. Doll: 1947-76

The tenure of Dr. Charles G. Doll, State Geologist from 1947 to 1976, has been the most productive period in the history of geological surveys of Vermont. Doll had the strong support of Governors Ernest W. Gibson and Joseph B. Johnson. The timing of his tour of office also coincided with a surge in the

interest to expand the copper industry in the state. Soon after taking office, Doll was awarded a \$15,000 grant by the Vermont Copper Company to conduct a mineral survey. In addition, the George A. Ellis (former president of the Vermont Copper Company) fund provided \$85,000 to the University of Vermont for minerals research. On July 8, 1947, Doll outlined his long-range program for bedrock and surficial mapping of the state to a committee meeting on the use of the Ellis Fund. The new survey would produce in a decade a new bedrock geology map and the first surficial geology map of the state. Studies in environment geology would be conducted and special reports prepared [1, p. 28].

Progress was slow in the first 8 years. Only six mapping projects were completed and reports published. Governor Johnson wanted to accelerate the program. Financial support for the survey went to \$43,200 in 1955-57 and to \$92,000 in 1957-59. The new Centennial Geologic Map of Vermont was published in 1961 just 100 years after the publication of the Hitchcock map and the first survey report on the "Geology of Vermont." The first Surficial Geologic Map of Vermont was published in 1970. By 1975, seven environmental reports had been completed and six were published. Doll's work was not completed but a magnificent accomplishment had been attained.

A significant result of Charles Doll's accomplishments was the establishment of a publications framework for making information on Vermont geology readily available to the public. A major Bulletin Series was established for publishing significant new mapping of Vermont bedrock and surficial geology. An Economic Geology Series was to see eight reports published during his term of office. The Geology for Environmental Planning Series, mentioned earlier, and the

Geology of State Parks continue to be popular publications. Other series initiated under Doll were the Special Bulletin, the Special Publication, and Studies in Vermont Geology each covering geologic topics and categories of special interest and coverage.

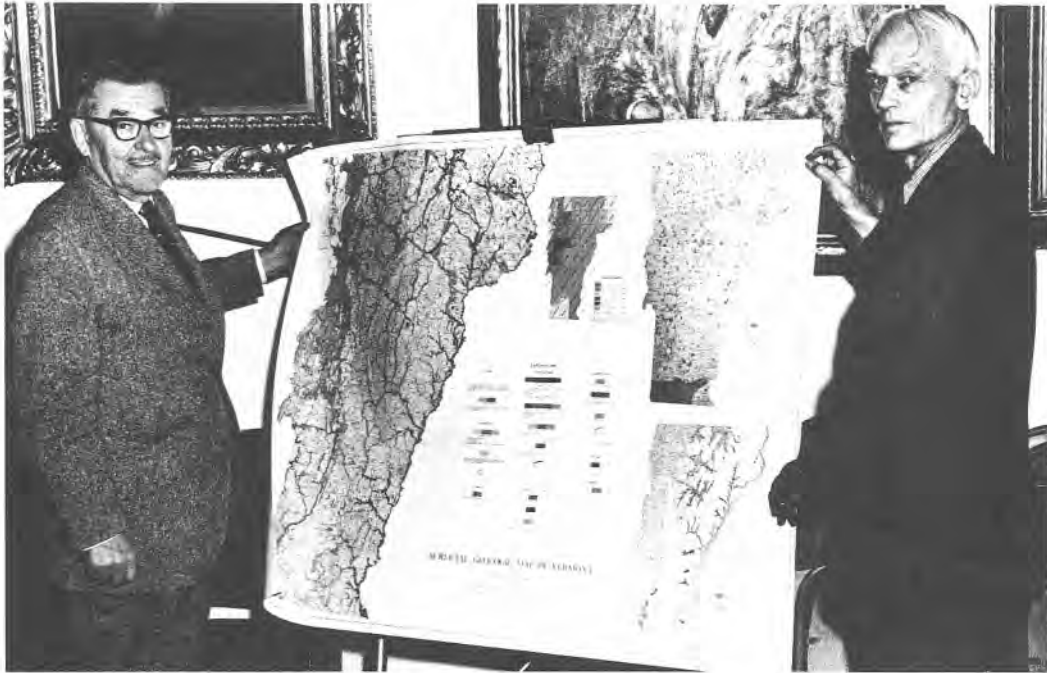
Although Charles Doll's original goal calling for completion of the studies in environmental geology was not met, his perseverance in the fulfillment of the second major survey of Vermont's basic geologic framework developed a substantial and highly useful geologic information base that has served Vermont well.

Dr. Charles G. Doll retired in 1976.

#### **Charles A. Ratté: 1976-Present**

In 1970, Departments of the Vermont State Government were reorganized into super agencies for purposes of better interaction and communication. The natural resources departments were organized under the Agency of Environmental Conservation (now the Agency of Natural Resources). The State Geologist continued to maintain an office at the University of Vermont in Burlington. In 1976 at the request of the Secretary of the Agency of Environmental Conservation a new State Geologist, Dr. Charles A. Ratté, was appointed by Governor Thomas Salmon and the office was moved to the State capital in Montpelier and placed within the Planning Division of the Agency. The State Geologist was asked to determine how best he could serve the needs of this agency and other branches of state government as well as the public and private sector, and to determine under what authority he could best serve within this agency. For the first time the position of State Geologist became a full-time appointment.

The State Geologist presently functions as a division director and reports directly to the Agency Secretary.



Governor Deane C. Davis (1900 - ) and Charles G. Doll with Surficial Geologic Map of Vermont, at the State Capitol, March 24, 1970. Vermont Department of Highways photo by Woody Grimes.

The primary function of the State Geologist is to maintain an up-to-date geological information base and to provide this information to the users through regular publications and information services.

Ratté recognized immediately that the needs for a detailed geological information base capable of answering the critical environmental questions of the day could not be met without outside help. He has sought to enter into cooperative and jointly funded agreements with the Federal Department of Interior (Geological Survey and Bureau of Mines). Programs having mutual national and state goals have been and continue to be successfully conducted.

The State Geologist has developed and maintains a complete bibliography of Vermont geology; has entered into cooperative programs with the U.S. Geological Survey to conduct geological mapping, slope stability studies, and

topographical mapping; has established an information service which includes a publication and sales capability; and has developed a public education program of talks and lectures on Vermont geology.

Ratté's prime objectives are:

1. To develop and seek passage of legislation that firmly establishes a State Geological Organization with clearly defined duties and responsibilities, and to build a budget and staff that make it possible to function in a highly professional fashion;
2. To establish a program that provides for a continuous "geological survey" that recognizes and fulfills the needs of both the public and private sector;
3. To encourage research and modernization of geological thought particularly as it applies to a better understanding of Vermont geology, while at the same time developing a capability for the practical application

of geological information to help solve the problems related to the wise use and protection of Vermont's natural resources.

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## VIRGINIA

Division of Mineral Resources, Department of Mines, Minerals and Energy,  
Natural Resources Building, P. O. Box 3667, Charlottesville, VA 22903.  
Phone 804-293-5121.

### HISTORICAL SEQUENCE OF ORGANIZATIONAL NAME:

Geological Survey of Virginia, 1835-43  
Virginia Geological Survey, 1908-54  
Division of Geology, 1954-57  
Division of Mineral Resources, 1957-present

### NAMES AND TITLES OF ORGANIZATIONAL DIRECTORS AND DATES SERVED:

William Barton Rogers, 1835-43	William Mahone McGill, 1947-57
Thomas Leonard Watson, 1908-24	James Lewis Calver, 1957-78
Wilbur Armistead Nelson, 1925-28	Robert Calvin Milici, 1979-present
Arthur Charles Bevan, 1929-47	

### VIRGINIA DIVISION OF MINERAL RESOURCES

By Bruce Hobbs

### ONE HUNDRED AND FIFTY YEARS OF DIVISION HISTORY

1835-42

Virginia had the fifth legislatively formed state survey in the United States. During the 1834-35 session of the General Assembly, William Barton Rogers persuasively addressed the House of Delegates on the necessity of a geological survey. On March 6, 1835, "An Act to authorize a Geological Reconnaissance of the State, with a View to the Chemical Composition of its Soils, Minerals and Mineral Waters" was passed, and shortly thereafter Rogers was appointed to direct the survey that was placed under the responsibility of the Board of Public Works. In August of that year he was elected to the chair of Natural Philosophy at the University of Virginia. Accordingly, he moved to Charlottesville to fill his appointment as Director.

In the remaining 9 months of that year he collected and interpreted information on Virginia's "general geological features." Included in this survey were determinations of the "chemical composition of . . . soils, minerals, and mineral waters." The compilation was to be used to justify legislative support for "a more complete examination" of the State. Despite academic responsibilities to the University and field work done using primitive modes of transportation, he accomplished the task. He submitted a lengthy *Report of the Geological Reconnaissance of the State of Virginia* to the House of Delegates in January 1836. One-third of the report was given over to discussion of various marls. The remaining two-thirds included information on such mineral resources as limestones, sandstones, granites, slates, soapstone, coal, ores of iron, copper, gold, and other materials having economic potential. The Legislature was sufficiently impressed to enact the continuation of the geological and mineral survey of the State.

Rogers vigorously set about amassing geological and mineralogical

information to compile a comprehensive report for the Board of Public Works. He served both the Board and the University. His field seasons were limited by academic responsibilities, and general progress was affected by scarcity of funds, a staff limited to no more than four geologists at times and student disorders. Regardless of these difficulties he managed to submit six annual reports to the Board on further investigations and appraisals of marl, magnesium and hydraulic limestone, diatomaceous earth (infusorial earth), sand and gravel, coal, natural coke, iron ore and other materials. Thermal springs were also studied. Stratigraphic contributions included numbering of rock formational units using the known geologic periods of that time (no Ordovician, Permian, etc.), using stratigraphic names correlative with those in Pennsylvania and New York, and recognition of similar fossils occurring in Virginia and Great Britain. The geology in England did to some extent influence his choice of stratigraphic nomenclature. His reports were among the first works to contain descriptions of igneous and metamorphic rocks in the State. He and his brother, Henry, the State Geologist of Pennsylvania and later New Jersey, made the first major structural synthesis of the Appalachian chain in their respective states. They recognized inverted folds and reverse faults, as well as emplacement of igneous rocks derived from "subcrustal" viscous materials.

In March 1841 when Rogers learned that the survey was to be discontinued January 1, 1842, he wrote Judge J. F. May requesting support for extension. May responded that if the legislative bill had not been offered in the manner it had, there would be an immediate repeal of the enabling act. Rogers temporarily accepted the mandate. Accordingly, the sixth annual report for the year 1841 was brief. It was

primarily a plea to extend and fund the survey until April 1843. Unfortunately on February 3, 1841, Rogers had provided assurance of the "... completion of our exploration and revisionary labours in the field, by the termination of the next campaign. . ." He used military terms, corps and campaign, for the field seasons. The need for future work was referred to, but not dwelled on. Possibly, this report influenced the Legislature--in any event, they agreed to extend the survey until April 1842. Rogers continued with the University of Virginia until his resignation in 1853. One year later efforts were made again to preserve the survey's mineral collection and to publish the final report. These efforts failed.

Except for the effort of Rogers' wife, Emma, the demise of State support would have relegated a considerable amount of his work, including a geological map of Virginia, to obscurity. Although the obligation to provide annual reports to the Board of Public Works and the Legislature was achieved, funds for publication of much of the survey's results were meager. Fortunately Emma Rogers, his wife of 33 years, unceasingly worked to collect and compile her husband's reports, papers, and letters during the 2 years succeeding his death in 1882. Geologists today are indebted for her insight to preserve through publication in 1884 his scientific endeavors and in 1896 a historical account of the Rogers' "dynasty." The first comprehensive geological map of Virginia for that time was published. A long delayed obligation to the public was discharged.

### Renewed Efforts

The need for continued geologic investigations into Virginia's mineral wealth was now established. In 1904 the Virginia Agricultural and Mechanical College and Polytechnic Institute at Blacksburg, Virginia (now VPI & SU),

initiated a faculty position to be filled by an experienced geologist. They procured the services of Thomas L. Watson, who was to engage in a geological survey of the State. The survey was partially supported by funds secured from an agreement struck between the State Board of Agriculture and the College Board of Visitors. Even though funding was terminated by both groups in 1906, Watson completed his important studies on lead and zinc deposits. He was invited in 1907 to accept the chair of economic geology at the University of Virginia.

Even though the State Board of Agriculture withdrew its support, a move to acquire funds for the College through the Senate seemed in all likelihood assured of success. The Agriculture Board was to be included in this new effort but was inadvertently left out. As a result, the bill failed. A minor factor not related to these difficulties had developed. At this time the College suffered from a lack of credibility because of its sale of diseased livestock, which could have brought about general disfavor within the Legislature. P. B. Barringer, who was then President of the College was determined to regain responsibility of the geological survey. About this time Senator G. T. Rison had introduced a bill into the General Assembly which would reestablish the geological survey at the University.

Some 30 years earlier the University had begun to rebuild its geology staff and facilities, thus putting it into strong contention with the College, which just did not have comparable qualifications at that time. Although Barringer had the loyalty of the students and some faculty, he created animosity with the Legislature, which contributed to loss of support. It should be remembered that the original survey had been soundly based in Charlottesville 72 years previously. Further, the University clearly pointed

out that there was no real conflict--both institutions should pursue geological surveys. The Rison Bill gave equal representation on the State Geological Commission to both the University and the College. In the University's opinion the State geological survey was a separate and distinct entity, the work of which was too great a burden for a single educational institution to undertake.

The Rison Bill was enacted into law February 25, 1908. It provided for the establishment of a State Geological Commission, which had direction over a State geological survey that was to be located at the University of Virginia. The five-member Commission was to select a geologist of established reputation as Director of the survey. Objects and duties of the survey that are set forth in the act of 1908 form the basis for the responsibilities of the present day Division of Mineral Resources.

#### 1908-24

By the time Thomas Leonard Watson was appointed Director of the survey in September 1908, he had completed a comprehensive volume on the *Mineral Resources of Virginia*. This work was compiled in celebration of the Jamestown Exposition, which was a commemoration of the 300th Anniversary of the settling of the United States in 1607. It took 15 months to accumulate, prepare, and have printed all the mineral resource information available. The volume, a monument to early achievements in economic geology, is still used today as an important reference. Even though he reported on a considerable range of earth-related subjects, his primary interests were in economic geology, mineralogy, and petrography. During his tenure as Director, he and his staff published reports on titanium, manganese, gold and tin deposits, clay and apatite materials, cement

resources, and water resources. The first reports on coal resources in southwestern Virginia were published. A regional report on the physiography and geology of the Coastal Plain in Virginia was issued. Watson served unstintingly as Director for 16 years until his death in 1924.

The General Assembly continued the State Geological Survey as a Bureau under the direction of the State Geological Commission, as evidenced by its inclusion in the 1919 Code of Virginia. Shortly after Watson's death, Albert W. Giles was appointed Acting Director until September 1925. During Giles' brief term, Governor E. L. Trinkle authorized the initiation of a surface-water study in Virginia in cooperation with the U.S. Geological Survey.

It was in the mid-1920's that Governor Harry F. Byrd gave momentum and approval to form a commission that would guide Virginia's interests in development of her mineral and water resources, as well as her forestry, scenic and recreational assets. The General Assembly approved on March 17, 1926, the establishment of the broadly based State Commission on Conservation and Development. Heretofore, guidance in matters of geology, forestry and water power was given by the five member State Geological Commission. The newly devised seven member State Commission on Conservation and Development was vested with all rights, powers, and duties previously vested by law in the Water Power and Development Commission, the State Geological Commission, the State Geological Survey, the office of the State Geologist and the office of the State Forester. This reconstitution, organizational adjustment, and campaign to establish the Shenandoah National Park/Skyline Drive consumed much of the Commission's attention. The State Geological Survey, caught up

in the expressed need to develop Virginia's natural wonders and resources, was technically left on a directionless course between the two commissions.

#### 1925-28

Wilbur Armistead Nelson had been appointed to succeed T. L. Watson as Director of the Survey. He assumed responsibilities of the position in September 1925. The first several months were a familiarization period for him. A good deal of the time was spent in coordinating current work as well as making numerous field visits. Nelson composed a lengthy report on the purpose, activities and accomplishments of the Survey through June 1926. Interestingly, the roster of personnel included the Survey's first female geologist, Anna I. Jonas. Where the previous Commission was principally concerned with mineral resources, the interest of the new Commission was necessarily diluted by scenic and recreational aspects of State development.

In November 1926, the new Commission "took over" the State Geological Survey. The Commission and its Executive Secretary exercised a tight centralized control and the Executive Secretary assumed general administrative direction of the Survey. Up until then the Survey was an administratively autonomous unit, when Rogers and Watson were State Geologists. Nelson strived to encourage a balance between these two extremes. Under the new arrangement the Commission received "second-hand" knowledge of Survey activities and requests that were stamped with the overprint of the Secretary's opinion. Survey personnel had more of an opportunity to recognize needs from direct contact with the public and industry. The Commission approved all printing, but only after the Secretary made a critical evaluation of the



manuscripts presented for their consideration. Quite correctly they desired a product that was to be concise and readable. Difficulties arose over the mass of technical data incorporated in some reports and the way in which the reports were formatted. Nelson stayed at odds with the Secretary over printing, as well as over, indirect communications from the Commission. In September 1927 the Commission decided that both the State Geologist and the State Forester should be employed full time. It was realized that persons in these positions could not serve "two masters." This directive required each of the incumbents to sever their faculty status with the University. Considering the Survey's past history, Nelson thought otherwise. He may not have been aware of the growing procedural demands of administrative responsibilities being wrought by the State. Finally, in November Nelson's general denial of contact with the various commissioners and indefinite instructions caused him to write the Chairman asking for clarification of his duties. Different members of the Commission were involving themselves in the Survey work. Although recognizing their vested authority, Nelson felt compelled to submit suggestions to overhaul the organizational structure. With no response to this effort, he presented a resolution outlining procedural relationships between the Commission and its divisions in mid-1928. Ironically, the resolution was unanimously accepted by the Commission--too late. Nelson resigned his position as State Geologist to continue his unharassed faculty association with the University.

During his brief 3 years as Director of the State Geological Survey, Nelson was fully responsive to requests of the Commission and maintained a steady flow of periodic reports on the Survey's progress and accomplishments. The most significant contribution was the

revision of earlier maps for the most comprehensive 1:500,000 scale geologic map of the State up to that time. This 1928 edition was the general base for geological information over a 35-year period. Also published was information on oil, gas, gold and water resources. The first study of sediments in Virginia's Triassic basins was released. Investigations were chiefly in economic geology and included such materials as sand, gravel, limestone, shale, clay, peat, coal, iron ore, kyanite, granite and soapstone. Major projects on thermal springs and the stratigraphy and structure of the Appalachian Valley were initiated. Regional geologic mapping continued throughout the State. At the same time the Survey maintained its topographic mapping, water power and stream gauging programs.

The Commission persuaded Nelson to remain Director while they selected his successor. He did so for about 3 months until the University began its fall session. Finding a replacement was more difficult than the Commission had anticipated. Linwood H. Warwick was Chief Clerk and had joined the Survey shortly after Watson was made Director. Graciously, he accepted the responsibility of Acting Head in order that the Survey might continue to operate until the Commission could complete its task of selection.

#### 1929-47

Arthur Charles Bevan became State Geologist in June 1929. A more clearly defined administrative relationship between the Commission and Survey was established, a legacy from the former State Geologist. Bevan energetically took hold of the task of planning and directing survey work. Early on he carefully accumulated a small technical staff of geologists, all of whom had completed their formal education and had extensive geological experience in Virginia. This staff was

augmented with part-time assistance from geologists and students who were employed mostly during the field seasons. A program was developed whereby some of the Survey work was achieved by a 50/50 cooperative funding base with U.S. Geological Survey personnel. Bevan designed the Survey work and field investigations around developing basic information through geologic mapping and studies of economic resources for which the industrial community had the most need. With unerring insight he placed emphasis on inventorying occurrence, character and distribution of Virginia's fuel and mineral resources. Bevan was indeed following the precepts of the 1908 Rison Bill that was the keystone of the Survey's enabling act. It is interesting to note that Morris M. Leighton, State Geologist of Illinois, who was retiring as President of the Association of American State Geologists, delivered a closing address in February 1934 that incorporated many of the same precepts. This address, herein called the "Leighton Doctrine," is a profound guide for the assurance public benefit and advancement through sound development of its mineral wealth. Leighton stressed the vested obligation to all surveys that they must "... secure and make available scientific and economic information on the mineral resources of the State, with a view to promoting the development of the State's mineral resources and the welfare and happiness of the citizens of the State. . . ." Further he emphasized, "... It is one thing for a State to be backward because of meagerness of resources, it is quite another thing for it to be backward because of ignorance. . . ."

In March 1937 the name of State Commission on Conservation and Development was changed to the Virginia Conservation Commission. Seemingly, Bevan enjoyed a good

working relationship with the Commission. He later wrote that Governor Harry F. Byrd clearly recognized the need for full-time attention to conservation and development of the State's natural resources. The Commission had provided a highly competent full-time Executive Director to manage this task. The wisdom of such actions was "indicated by progress," without political interference, which was made by development of the State's resources.

In the last years of Bevan's tenure as State Geologist, World War II began and culminated in victory for the American allies. However, the stability that manifested itself under his guidance was shattered. In 1947 all the technical staff except the Assistant State Geologist resigned from the Survey for more promising opportunities. Under the circumstance of salary rates and research conditions, it was impossible to replace them with geologists of adequate professional training and field experience. Two years previously the State Geologist and State Forester united to seek a new building to replace the quite inadequate facilities and working conditions with which they had to struggle. The attempt failed. Bevan resigned September 1947 to accept a "unique" research and administrative position with the Illinois Geological Survey.

During the 18 years that Bevan served as State Geologist, the Virginia Geological Survey and the U.S. Geological Survey cooperatively produced the first 1:250,000 scale geologic map of the Appalachian Valley. Extensive studies on limestone and dolomite deposits and ground-water resources were begun. The Survey hosted the Virginia section of the 16th International Geological Congress that met in Washington, D.C. in 1933. The first successful gas well in Virginia was drilled in Scott County. Coal was mined locally in the Midlothian area near

Richmond. There was particular interest in caves and commercial caverns. Requests for information on mineral resources potential in part guided the selection of various projects. Of interest to industry and the public were fuel resources of coal, gas, oil and peat; deposits of sand, gravel, glass sand, limestone, dolomite, marble, marl, travertine, gypsum, phosphates, barite, pyrite and ocher; occurrences of fuller's earth, kaolin, diatomaceous earth, bauxite, bentonite and fireclay; Piedmont and Blue Ridge deposits of granite, pegmatite, feldspar, mica, unakite, kyanite, beryl, vermiculite, staurolite, talc, soapstone and asbestos; and rock materials containing aluminum, copper, gold, iron, lead, manganese, nickel, tin, titanium, zinc and zirconium.

With the advent of World War II, the mineral industry had to step up production to meet the demand for raw materials. Energy resources were the number one target. Coal, oil and gas were premium commodities--this was the time of gasoline rationing. Mica was highly sought after for use in electrical components, and bauxite was mined as a source of aluminum for light-weight metal construction. Virginia's abundant limestone resources were tapped for raw materials used as flux in smelting of steel, as agricultural lime for fertilizer in food production and as rock wool in the manufacture of insulation. Manganese, tungsten, vanadium and titanium were sought to make various alloys of steel. Titanium at that time was used in arc welding and as a pigment of paint. Zinc was used in the manufacture of brass, rubber and galvanized iron. Clays and crushed stone were needed for construction of factories and housing. Through use of raw materials in national defense, the public was beginning to appreciate the need for mineral resources. This was one more demand of society that

increased the scope for the need of geologists.

#### 1947-57

William Mahone McGill, a mining engineer, was promoted to State Geologist in September 1947. By then he had worked for the Survey some 18 years, and he inherited an organization that was in disarray. The demand for service by industry and the public was being compromised by wholly inadequate salaries and facilities. Bevan had noted that, considering available salaries and research conditions, experienced geologists were difficult to find.

The Department of Conservation and Development was reorganized in 1948. The "Duke Commission," under the direction of Charles J. Duke, Jr., submitted a report with suggested changes to improve efficiency and lower costs of operation to Governor William M. Tuck. It was recommended that the newly designated Division of Geology be expanded to investigate those mineral resources for which there were insufficient data--this included ground water. Because the Duke Commission considered the Division primarily a scientific research unit of the Department, it suggested securing assistance from in-state and out-of-state college faculties on cooperative arrangements. This action would mitigate difficulty in filling vacant positions.

The problem of inadequate office and laboratory space was solved in 1949. Governor Tuck agreed to provide funds for construction of a building on the University of Virginia grounds to house the Division of Geology. Both the University and the Commission accepted this generous offer. The Natural Resources Building was completed, and the Division staff occupied the new quarters by January 1950. McGill continued to have difficulty in filling position vacancies

with experienced geologists. Investigations and field conferences were regularly reported to the Director for the next 3 years. In the beginning of the 1953-54 fiscal year, McGill departed from the usual submittal. His report was an explanation of the Division's functions and duties being pursued. For several months the Director worked on a Departmental reorganization that included review of the Division of Water Resources. At the time the head of that Division was on both State and Federal payrolls and thus subject to conflicts of interest. Prior to the Director's study, the Division of Geology was responsible for ground-water investigations. Gradually, it too became caught up in the maelstrom of reorganization. The Duke Commission had pointed out that the Division was primarily a scientific research unit. In contrast, the Director had a strong belief that the State should be involved directly with establishing mineral industries in Virginia. Actually both of these capabilities were requisite to the success of a geological survey. The Director wished to establish a Division of Mineral Resources, headed by a Commissioner and assisted by four geologists experienced in mineral economy. In addition to his mineral resources functions, the Commissioner would have charge of the Division of Geology. The Department began peripherally to involve itself in the Division of Geology's operation. For example, although rock sample sets had been given away free, the Division was now required to charge a reasonable fee to partially defray preparation costs. During mid-1956 Marcellus A. Stow, Head of the Department of Geology at Washington and Lee University, Lexington, Virginia, was retained as a consultant to assist in the reorganization. Approval for this action was obtained from the Governor and the Division of Personnel. McGill was faced with the dilemma of eminently losing

the ground-water activities assigned to the Division of Geology, as well as sharing some and being directed in other geological responsibilities by a new Commissioner of Mineral Resources. He retired from his position effective April 1957.

McGill had particular interests in oil and gas development, manganese ore deposits, and production of topographic maps. He established the nontechnical quarterly publication *Virginia Minerals* in October 1954. He was involved in the revision of the State's oil and gas laws and had acquired responsibility for the Oil and Gas Inspector and the associated Board in January 1957. From his reports, a great deal of time was spent with Division clients, particularly in field conferences. McGill seemingly carried on operations as they had been done in Bevan's day. Ground-water and fuel resources, ores of zinc, copper, manganese and iron, and occurrences of limestone, dolomite, shale, clay and granite received the greatest attention because of client interest. McGill published six reports that were in press when Bevan resigned. Curiously though, only eight Division reports that were begun during the time he was State Geologist were published. They contained information on ground water, oil and gas, and iron, titanium and zinc resources.

#### 1957-78

James Lewis Calver became Commissioner of the Division of Mineral Resources and State Geologist in May 1957. He inherited the Division at what was possibly the nadir of its administration. By formal training he was a geologist with a background in business administration and experience in geology and survey operations. Shortly after his arrival as Commissioner, a new Director was appointed to head the Department--he was an engineer with a background in government administration. Calver



rebuilt the Division imparting a much needed stability. For the first several years technical and office records were put in order, procedures established and the organizational structure of the Division was developed. At the same time responses to public and industrial requests were met and geologic and mineral resource investigations provided. New techniques of analyses both in the field and laboratory were utilized. Although stream gauging had been left to other government agencies, oil and gas inspection to the State Department of Labor and Industry, ground-water activities were to remain as a Division responsibility. Included in these activities was an agreement with the U.S. National Park Service to perform a study of the geology and ground-water resources of the Shenandoah National Park. Later through an efficiency study, the Division lost this responsibility and ground-water activities were transferred to the Division of Water Resources in 1969. Two years later these duties and functions were passed on to the State Water Control Board. Nonetheless, the commitment to complete the studies in the Shenandoah National Park was fulfilled. In the mid-1970's, the Division published its first environmental map, thus beginning its involvement in depicting geologic factors that affected land utilization and land-use planning.

The Department placed emphasis on conservation of natural resources and all matters of economic development. As recorded in the Acts of Assembly for 1958, its name was altered to the Department of Conservation and Economic Development. At the same time the Division had its name changed to the present Division of Mineral Resources. Over the years Calver built a staff that could adequately address the needs and problems within the scope of geologic and mineral resources investigations

and interpretations. It was his perceptive guidance that led the Division to progress as a strong viable organization. He retired in June 1978.

During his 21-year tenure of association with the Division of Mineral Resources, Calver and his staff made many beneficial contributions to the Commonwealth of Virginia. He had a particular interest in the topographic mapping program. In 1962 map coverage for about 90 percent of the State was inadequate or nonexistent. Over a period of 10 years and in cooperation with the U.S. Geological Survey, Virginia was depicted with adequate 1:24,000 scale topographic quadrangle maps. In 1972 a follow-up revision program was initiated. Also, the first orthophotoquads and slope, county and orthophoto maps were published. The 1928 edition of the State geologic map was revised in 1963 and preparation of 1:24,000 scale geologic quadrangle maps was initiated. Over 10 percent of the State's 40,000 square miles was examined and illustrated on these published maps. Geophysical mapping was initiated, and State coverage was completed with maps depicting magnetic and gravity characteristics of strata and structures. Partial aeroradioactivity map coverage of the State was completed. The Division installed a seismic station that operates on a 24-hour, 7-day a week basis to record earthquake activity.

In the area of economic development the State crossed over the \$1 billion threshold of annual value in mineral production. Major commodity studies on clays and shales, silica resources, limestones/dolomites and base- and precious-metal deposits were continued. Laboratory analyses by the U.S. Bureau of Mines were initiated in conjunction with the evaluation of clays and shales. Periodic visitation to quarries and mines were started, and the Division's first detailed 1:500,000 scale mineral industries map of the State was

published. Oil and gas records were systematized. In the area of energy resources, the Division became involved in the Outer Continental Shelf Program of a 31 petroleum company consortium to study the possible development of offshore oil. The modern regional study of coal resources in southwestern Virginia was completed. Samples were collected and analyzed--resulting data was entered into the National Coal Data Resources system.

The specter of inadequate funding began gradually to have effect on the Division in the late 1970's. Earlier double digit inflation initiated a slow down in the national economy. State appropriations were reduced. For the last 6 months in 1978, C. R. Bruce Hobbs, Jr., then Assistant State Geologist, was asked to serve as Acting State Geologist until a new State Geologist could be selected.

#### 1979-Present

Robert Calvin Milici became the seventh State Geologist when he assumed Division responsibilities in January 1979. He moved immediately to initiate a coal program. Because of a mutual interest in energy resources, cooperative contracts were entered into with the U.S. Geological Survey and U.S. Bureau of Mines. This was a revival of arrangements that were terminated earlier by legislative action. In the previous agreements State funds were transferred to the U.S. Geological Survey. In the new agreements, however, the State is only furnishing in-kind-services. A field office was established in Abingdon and two field stations were set up--one at the College of William and Mary and one at Virginia Polytechnic Institute and State University. These locations provide the needed access to all "corners" of the State and allow greater efficiency and economy in operation.

In 1983, the Division was plunged into a situation wholly beyond its

control. The State's mine safety program was called into question because of recent mine accidents. A remedy to the situation lay in the unification of those State units that were involved in mining and energy activities. Adjunct to such action was the opportunity to reduce administrative duplication. In 1984, the General Assembly passed legislation to reorganize the Department of Conservation and Economic Development. This Department became the Department of Conservation and Historic Resources and a new Department of Mines, Minerals and Energy was created. The Divisions of Mineral Resources, Mines and Quarries, Mined Land Reclamation, and Energy were consolidated into the new Department effective January 1, 1985. This is the fourth time the Division has been caught up in the throes of reorganization. Even though the intervals are becoming greater, there is the ever present attempt to create a Natural Resource unit in the State.

In the 6 years Milici has been Commissioner of Mineral Resources and State Geologist, the Division has made many contributions to the economic development and quality of life in the State. Chief among these is the coal program in part supported by federal contract. Several phases of a coal resources project were completed and studies on coalbed methane reported. The investigation of coal on federal lands was published, as well as a bibliography of coal in Virginia. Coal sample data continues to flow into the National Coal Resources Data system. A singular contribution to safety is the completion of a guide to coal mine roof falls as related to miner training. Stratigraphic, structural and lineament studies for oil exploration and county oil and gas maps were published. Publications of geologic quadrangle maps continued at an approximate rate of three maps per year. Karst maps were

completed and distributed. A new industrial minerals and mineral resources map was released. New information on high-silica resources and clay materials was published and the ever-popular subject, gold, received detailed attention. In fact, one gold publication was reprinted within about 4 years of its first release. With more involvement in public concerns, the Division assisted in the review of potential uranium mining and milling. An agreement was made with the U.S. Geological Survey to enter data on mineral resources into the Computerized Resources Information Base (CRIB) system. Now called Mineral Resources Data System (MRDS), this data base currently provides instant access to records of over a thousand occurrences and deposits of metallic and industrial minerals in Virginia. With a steadily rising population and greater demands by society for environmental protection, Division personnel have become increasingly involved in reviews of environmental impact statements and in providing geological assistance to localities, as they address a multitude of land-use problems. The State Minerals Management Plan was a significant step forward in clearing the way for orderly mineral development on State lands.

### LOOKING FORWARD

As it has been for so many years, the major effort of the Division of Mineral Resources will be directed toward geologic mapping. Geologic maps, which are essential to man's understanding of the earth and development of its mineral resources, are of primary importance in the continuing development of the earth's surface by the ever-growing human population. They are an essential element of the information needed to make prudent decisions concerning the wide variety of land use and man's activities--construction, waste disposal,

development and protection of water resources as well as exploitation of its mineral wealth. Natural hazards--earthquakes, volcanoes, landslides, floods, radon--become increasingly more difficult to avoid and have an increasingly greater potential to affect more and more people and property.

The technology of geologic mapping is improving as the result of the continuing development of remote sensing techniques. The geological relationships of mapped elements become more clear as geophysical tools better enable the geologist to look "into" and understand the earth. Map preparation is becoming increasingly automated, reflecting the progressive development of computer sciences.

The quality of geologic maps depends to a considerable degree on the availability of suitable topographic maps at all scales. A mapping program, to be effective, must/should be capable of producing a variety of accurate up-to-date maps, from those depicting the broad geologic relationships of entire states or geologic regions, to intermediate-scale maps of counties or localities and to the detailed 7.5 minute map series. Specialty maps of mines and prospects at a scale of 1 inch equals 400 feet, although not a common product of state geological surveys, are an essential source of information as they are released by industry.

The future of the Division of Mineral Resources, thus, will be driven by the needs of Virginians to construct, interpret, distribute, and maintain the geological data base for the Commonwealth. The maps made today will provide the basic information needed to address the concerns and problems of tomorrow.

## WASHINGTON

Division of Geology and Earth Resources, Department of Natural Resources,  
Olympia, WA 98504. Phone 206-459-6372.

### HISTORICAL SEQUENCE OF ORGANIZATIONAL NAME:

- State Mining Bureau at Tacoma (inactive from 1893-1900 due to lack of appropriations), 1890-1900
- Washington Geological Survey at University of Washington, Seattle, 1901-20
- Department of Conservation and Development, Division of Geology at Washington State College, Pullman, 1920-45
- Department of Conservation and Development, Division of Mines and Geology (name changed to Department of Conservation in 1957) at Olympia, 1945-68
- Department of Natural Resources, Division of Mines and Geology at Olympia, 1968-73
- Department of Natural Resources, Division of Geology and Earth Resources at Olympia; field office opened at Eastern Washington University at Cheney in 1980 and moved to Spokane in 1982, 1973-present

### NAMES AND TITLES OF ORGANIZATIONAL DIRECTORS AND DATES SERVED:

George A. Bethune, 1890-92  
Henry Landes, 1901-20  
Solon Shedd, 1920-25  
Harold E. Culver, 1925-45

Sheldon L. Glover, 1945-57  
Marshall T. Huntting, 1957-71  
Vaughn E. Livingston, Jr., 1971-82  
Raymond Lasmanis, 1982-present

### HISTORY OF WASHINGTON STATE GEOLOGIC DIVISIONS

By Raymond Lasmanis  
State Geologist

This report, written for the American Association of State Geologists, is an expansion of a historical article by Huntting (1971).<sup>1</sup>

Washington became a state in 1889, and on February 28, 1890, the first State Legislature established a State Mining Bureau. It appointed George A. Bethune to the position of State Geologist. The sum of \$3,300 was appropriated for 1 year to cover his salary, travel expenses, rent, laboratory equipment, and chemicals. Bethune served until 1892 and issued two reports.<sup>2</sup> The first deals mainly with metal mining districts but also gives some information about coal and coal

mines; in the second report he states that during the session of the State Legislature convened in January 1891, a bill was passed whereby money was appropriated for preliminary work necessary to the commencement of a geological survey of the state. An unfortunate omission in the language of the bill caused the state supreme court to declare it illegal, therefore null and void. Consequently, the State Mining Bureau became inactive after 1892 because of a lack of appropriations.

The character of the times and the duties of the State Geologist can be gleaned from a quotation from Bethune's first annual report:

I speedily found my field of labor to be an extensive one, it becoming apparent that I must needs to revive a lapsing interest in our mines and in mining development generally, visit all sections where mineral was known to be existent, and many in



which prospectors believed it to exist and desired the advice and direction of myself, as State Geologist, regarding what course to pursue in the premises.

During the past year, or rather that part of it intervening between the date of my formal taking of office and the present time, I have visited, inspected, and now report upon every mining district, every mine of promise or prospective worth, every industrial and commercial enterprise born of the mineral development of the country, and all geological formations indicative of the existence of merchantable metal in Washington, as far as is known.

It is interesting to note that the enabling legislation of February 28, 1890, directed the state geologist to establish an assay laboratory. Listed in Section 6 of the bill is a schedule of analytical fees. For instance, the cost of a gold and silver assay was set by law at \$2.00. After deducting the cost of chemicals, one-half of the remaining monies was retained for operation of the laboratory and the other half paid into the state treasury.

As the state's industrial base developed, demand for natural resources increased substantially. Mining of coal, industrial minerals, and metals flourished. A demonstrated need for a state agency knowledgeable in natural resource subjects led to the establishment of the Washington Geological Survey in 1901. The legislature appropriated \$5,000 per annum to cover the Survey's activities. Soil and hydrologic surveys were added to the duties of the State Geologist. The State Geologist reported to a Board of Geological Survey chaired by the Governor. During the first meeting of the Board in 1901, a staffing plan was approved which specified that faculty of the University of Washington would serve on the survey. Staff was to receive no salary other than a small per diem allowance. Professor Henry Landes was appointed State Geologist.

The first publication of the Washington Geological Survey was released in 1902<sup>(3)</sup> and contained six

parts as follows: Part 1, Creation of a state geological survey and an outline of the geology of Washington; Part 2, The metalliferous resources of Washington, except iron; Part 3, The non-metalliferous resources of Washington, except coal; Part 4, The iron ores of Washington; Part 5, The water resources of Washington--potable and mineral water, artesian water, and water power; and Part 6, Bibliography of the literature referring to the geology of Washington.

The second report of the Survey was published in 1903<sup>(4)</sup> and consisted of two parts: Part 1, The building and ornamental stones of Washington; Part 2, Coal deposits of Washington.



Topographic survey team near Granite Point, Whitman County, Washington, April 1923.  
Photo by Arthur J. Kralowec.

Examination of minutes of the Board of Geological Survey from 1909-21 shows a very active state geological survey with broad responsibilities. Close financial and programmatic ties were established with the U.S. Geological Survey. For instance, the Report of the State Geologist dated November 2, 1910, lists completion of five 15-minute topographic quadrangle maps and hydrographic monitoring at 50 stations as well as completion of water-power surveys of 11 rivers. Both the topographic and hydrographic surveys were conducted with a 50/50 state-federal funding formula. The 1910 report also tabulates geologic surveys of



Dr. W. A. G. Bennett with petrographic instruments, September 1948.



Division library, September 1948.

coal fields, logged-off lands, metal mining districts, and cement materials. There was a separate budget for a survey of road construction materials.

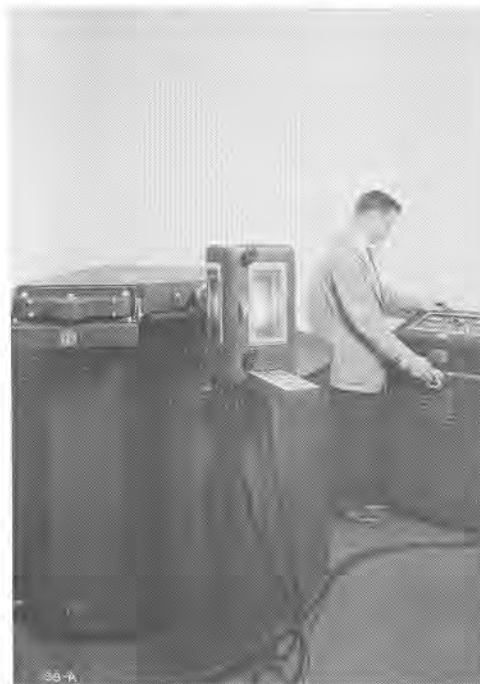
In the December 11, 1920, Report of the State Geologist to the Board of Geological Survey, State Geologist Henry Landes recommended to the legislature that a geologic map of the state be prepared. He noted that the most persistent single inquiry to the survey was in regard to a geologic map of the state. However, it was not until 1936, under the leadership of Harold E. Culver, Supervisor, that the first preliminary geologic map of the state was published at a scale of 1:500,000. The geology was generalized with only 19 units depicted on the map. The next statewide geologic map, with considerably more detail, was published in 1961 while Marshall T. Huntting was supervisor. Geologic units now numbered 87, but the scale remained at 1:500,000.

The original title of the state's geological survey and its responsibilities have been changed from time to time with changes in the state government at Olympia. For instance, topographic and hydrologic surveys are no longer a responsibility of the State Geologist. The state geologists and the titles of the organization are listed at the beginning of this account.

In 1934 during the Great Depression, a program was established to stimulate employment by developing the state's mineral industry. A Mineral Resource Division, with J. D. Hull as Supervisor, was established within the Department of Conservation and Development. In 1935, a Division of Mines and Mining was established to replace the Mineral Resource Division and Thomas B. Hill was named Supervisor. Both divisions' headquarters were located in Olympia. Funding was made available through the Works Progress Administration (WPA) to employ 150 geologists, mining

engineers, metallurgists, and prospectors to characterize the mineral deposits of the state. Special emphasis was placed on marketing strategies. The program was titled Economic Statewide Mineral Survey of Washington State. The division existed through the end of World War II, when it was combined with the Division of Geology.

The reports generated by the WPA-funded programs formed a strong foundation for mineral development in the state. Information contained in the field and laboratory reports was used as a base for numerous division publications. The reference files are still utilized by economic geologists.



Grant M. Valentine with spectrograph and D.C. arc rectifier unit, September 1948.

In today's complex society, the Division of Geology and Earth Resources has assumed other responsibilities besides the traditional geologic and economic mineral-resource functions. The division has regulatory responsibility to administer the State

Surface-Mined Land Reclamation Act, the Oil and Gas Conservation Act, the Geothermal Resources Act, and the Underground Natural Gas Storage Act. The present-day State Geologist also serves as the State Oil and Gas Supervisor.

Currently, the cornerstone of the division's geologic program is the production of a state geologic map. A greater base of knowledge and the need for detailed information has necessitated the use of 1:250,000 scale for the map. It will take 9 years to produce the four geologic map quadrants of the state. Geology will be depicted on the maps by a total of approximately 300 individual units with accompanying explanatory materials and charts. The first product, the southwest quadrant of the state, was published in December 1987.

Increasing population pressures and the desire for a better environment will serve as the impetus for the division to provide additional services in environmental geology. Programs will be aimed at reducing environmental damage from mass wasting and mitigating losses from earthquakes, debris flows, and landslides.

## REFERENCES

1. The Washington State Geologists, by Marshall T. Huntting, Supervisor, *Journal of the West*, Vol. X, No. 1, January 1971.
2. Mines and Minerals of Washington, Annual Report of George A. Bethune, first state geologist (Tacoma: January, 1891); and Mines and Minerals of Washington, Second Annual Report, George A. Bethune, State Geologist (Olympia: O.C. White, State Printer, 1892).
3. Washington Geological Survey, by Henry Landes, State Geologist. Vol. I Annual Report for 1901. (Olympia: State Printer, 1902).
4. Washington Geological Survey, by Henry Landes, State Geologist. Vol. II Annual Report for 1902. (Tacoma: Pioneer Bindery and Printing Co., 1903).



## WEST VIRGINIA

West Virginia Geological and Economic Survey, Mont Chateau Research Center,  
P.O. Box 879, Morgantown, WV 26507-0879. Phone 304-594-2331.

### NAMES AND TITLES OF ORGANIZATIONAL DIRECTORS AND DATES SERVED:

Israel Charles White, 1897-1927  
David B. Reger (Acting), 1927-29  
Cassius McCarl Lemley, 1929-30  
Rietz C. Tucker (Acting), 1930

James D. Sisler, 1930-34  
Paul H. Price, 1934-69  
Rietz C. Tucker (Acting), 1943-45  
Robert B. Erwin, 1969-Present

### HISTORY OF THE WEST VIRGINIA GEOLOGICAL AND ECONOMIC SURVEY

#### THE FOUR ERAS

The history of the West Virginia Geological and Economic Survey can be viewed in four distinct eras:

1. The Formative Years (early 1800's-1897).
2. The I. C. White Years (1897-1927).
3. The Paul H. Price Years (1934-69).
4. The Robert B. Erwin Years (1969-present).

Each era was characterized by a distinctive dynamic leadership, and each era saw a quantum leap in the West Virginia Survey's research, technology, and contribution to the Mountain State's economic prosperity.

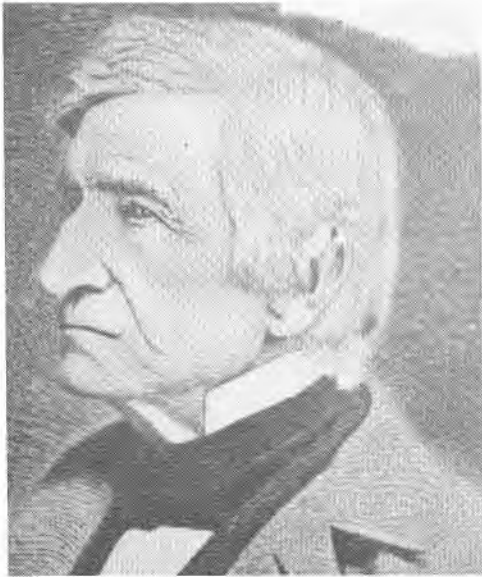
#### THE FORMATIVE YEARS: EARLY 1800's-1897

The history of geology in West Virginia began early in the 19th century when Thomas Jefferson and other naturalists described prehistoric animal bones in a cave in the eastern panhandle, not far from the Nation's capital, but formal scientific investigation of our geology and natural resources did not begin until 1835. The General Assembly of Virginia passed an act on March 6 of that year providing for "A geological reconnaissance of the

State, with a view to the chemical composition of soils, minerals, and mineral waters of the State of Virginia." (At that time, western Virginia was 28 years away from Statehood, and was still part of the Commonwealth of Virginia. It would become the independent State of West Virginia during the Civil War, in 1863.)

The first survey continued for 6 years, under William Barton Rogers. As Virginia's State Geologist, he made an annual *Report of Progress of the Geological Survey* to the General Assembly. These reports contained plentiful information about the geology of western Virginia, particularly of the Kanawha River valley. Rogers also recorded analyses of the coals from mines he visited in the present-day counties of Fayette, Grant, Harrison, Kanawha, Mineral, Monongalia, Preston, and Taylor.

The very first geologic map showing the area that would become West Virginia, the "Hotchkiss Map," was published about 1841. In 1836, S. P. Hildreth of Marietta, Ohio, published an article on the bituminous coals of the Ohio Valley, which included a detailed account of the geology of the Monongahela River valley. In this article Hildreth pointed out the importance of coal deposits in that area. These initial efforts comprised the total of professional geologic activities in western Virginia.



William B. Rogers,  
Virginia's First State Geologist

In 1864, one year after West Virginia was granted Statehood, Arthur Ingram Boreman, the first Governor, urged the Legislature to authorize the appointment of a State Geologist. Another famous West Virginian, H. Joseph Diss Debar, presented the Governor's suggestion as House Bill 22. The bill was postponed because the embryonic State treasury was committed to public enterprises of greater urgency.

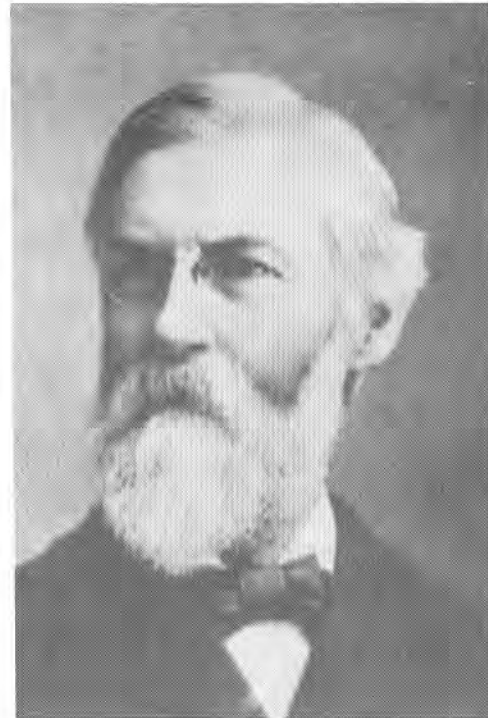
Unabashed, Governor Boreman vigorously reiterated in subsequent sessions that "the resources of our State should be made known by means of a Geological Survey..."

#### West Virginia University's Role

About the time that Governor Boreman was promoting a State Survey, he also sounded a warning about the future of higher education in West Virginia. The time had come to use land granted to the State by the Federal government under the Morrill Act to establish an agricultural and engineering college. The Agricultural College of West Virginia began in 1867, and the following year its name was

changed to West Virginia University. It was established in Morgantown, Monongalia County, in northern West Virginia, where it remains today.

During the very first year of classes, Samuel G. Stevens, Professor of the Natural Sciences Department, gave a course in geology and mineralogy to students in their junior year. Professor Stevens was assisted in succeeding years by John James Stevenson, distinguished geologist from New York. It was Stevenson's mastery of his subject, his personal magnetism, and his interest in people that induced a student named Israel C. White to focus upon geology after he gave up the study of medicine. White would later become the first State Geologist of West Virginia, would become internationally known, and would attribute his geological success to Stevenson.



John J. Stevenson,  
West Virginia University Geology Professor

From that time on, the efforts of the University's Department of Geology

toward creating a State Geological Survey make it impossible to separate the histories of the two.

### Advocating a Geological Survey

In December 1869, Professor Stevenson addressed the second meeting of the West Virginia Historical Society (of which he was founder), advocating a State geological survey. Noting that West Virginia and Virginia were the only states not conducting geological investigations, he said:

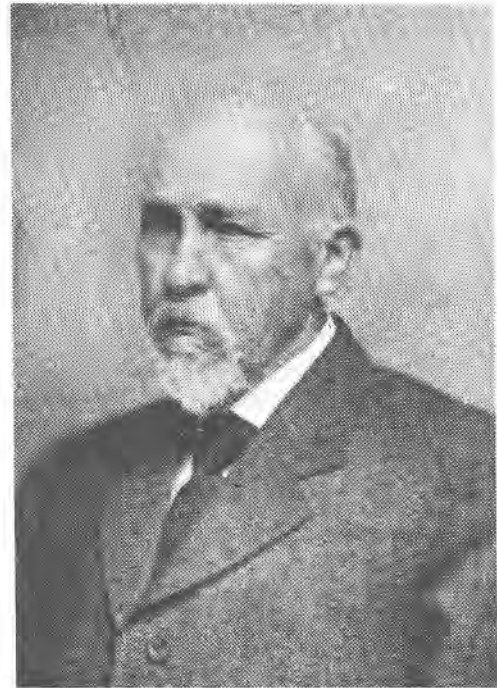
Experience has shown but one way in which to open up the resources of a country, and this is a Geological Survey . . . That steps looking to a Geological Survey of this State should be taken immediately no thoughtful man can for a moment doubt . . . The State lies on the border of the great Appalachian field, rich in coal, iron, and other minerals . . . but the extent of these deposits is not positively ascertained . . . Many of the mining enterprises initiated in this State have failed through insufficient knowledge respecting the geological structure of the country, while many others owe their failure to want of proper outlet for their products. At the time when West Virginia had long been a settled country, Indiana, Missouri, and Iowa were a vast wilderness . . . Now those States rank among the chief in the Nation, while West Virginia, so far from advancing, has been going backwards. The excellent surveys of those States opened up their resources, published them to the world, and so induced a steady flow of emigrants to them. . . . Having as its chief object the advancement of the State's interest, this society can do nothing better at this meeting than to prepare, on behalf of the society, a memorial on this subject, to be presented to the Legislature at its coming session.

In February 1870, *The Geological Survey of West Virginia--Its Importance and Necessity* was delivered to the West Virginia Legislature. During that session, a petition from the historical society requested appointment of a State Geologist.

The 1876 Centennial International Exhibition in Philadelphia became the final impetus for creating a geological survey. Governor John J. Jacob, faced

with appointing a Board of Centennial Managers to gather materials for the Exhibition, requested the prompt establishment of a State Survey in 1875.

Mathew Fontaine Maury, Jr., son of a distinguished Washington and Lee professor, was appointed to direct the preparation of exhibits, and William M. Fontaine, Professor of Geology at West Virginia University, was appointed assistant. After the Exhibition, Maury and Fontaine collaborated on a book, *Resources of West Virginia*, the first of its kind for the Mountain State.



William M. Fontaine,  
Professor of Geology, 1872-79

From 1867 until 1897, geological investigations were conducted primarily by the West Virginia University Department of Geology. The major contributors were Stevenson, White (Department Chairman from 1880 to 1888), Samuel B. Brown (Chairman from 1894 to 1926), and William M. Fontaine (Professor from 1872 to 1879). The growth and prestige of the Geology



Samuel B. Brown,  
West Virginia University Geology Professor

Department was reportedly a deciding factor when the Legislature of 1897 would finally establish a State Geological Survey.

In 1880 the *University Daily* described the Department of Geology:

We can say from a personal knowledge and without boasting that its study [geology] can be pursued here with better advantage than at any other college or university in the United States. Special attention is given to this subject by the instructor . . . and the student is taught in the field to examine, study, and describe all classes of rocks with which he may meet. . . . This work is done on Saturdays, so that it does not interfere with the regular routine of study.

The West Virginia House of Delegates in 1882 appropriated \$5,000 for a Geological Survey--a vote that was afterwards reconsidered. White, in a letter to State Senator William Dawson, commented, "\$5,000.00 is not a sufficient appropriation to start a Geological Survey on any basis that will be of enduring usefulness."

### Creating the Geological Survey

Finally, on February 26, 1897, the Legislature passed "An Act to establish a State Geological and Economic Survey and to make provisions for the preparation and publication of reports and maps to illustrate the natural resources of the State, together with the necessary investigations preparatory thereto."

The Act established a Commission, which first met in Wheeling on September 23, 1897. The members were George W. Atkinson (Governor), M. A. Kendal (State Treasurer), Jerome H. Raymond (President of West Virginia University), and James H. Stewart (Director of the Agricultural Experiment Station). They accepted free office space from the University in Morgantown and appointed Dr. I. C. White as State Geologist, with Samuel B. Brown as part-time assistant. Soon Dr. White initiated an inventory of the resources of West Virginia.

### THE I. C. WHITE YEARS: 1897-1927

#### Israel Charles White

I. C. White was born on a primitive farm in Monongalia County, northern West Virginia, on November 1, 1848. When West Virginia University opened in 1867, he was a member of the entering class. He received an A.B. degree in 1872 and an A.M. in 1875. In 1877, at the age of 29, he had become head of the Department of Geology and Natural History at West Virginia University. His Ph.D. was awarded by the University of Arkansas in 1880. Honorary degrees included an L.L.D. from West Virginia University in 1919, and a D.Sc. from the University of Pittsburgh in 1921.

With the Second Geological Survey of Pennsylvania from 1873 to 1884, he served as Assistant Geologist and published eight reports. With the United States Geological Survey from 1884 to 1888, he was an Assistant





Israel Charles White,  
First Director, 1897-1927

Geologist. He served West Virginia University during 1877 to 1892.

Dr. White served for many years as geological consultant for the Baltimore and Ohio Railroad and for Hope Natural Gas Company. During 1904-06, he surveyed the coal and oil resources of Brazil for the Brazilian government. He held high offices in several scientific and civic organizations, and in 1908 was selected by President Theodore Roosevelt to discuss "The Waste of Our Fuel Resources" at the first White House Conference of State Governors. Excerpts from this treatise will be quoted as long as there are geologists.

I. C. White is noted for his practical application of the "anticlinal theory," which is based on the roles played by gravity and geological structure in segregating oil and gas into commercial pools. By applying the theory's principles to potential oil and gas fields in West Virginia and Pennsylvania, he was able to prove the practicability of

the theory and operated a successful petroleum business.

#### Accomplishments Under I. C. White

Under I. C. White's leadership, the fledgling West Virginia Geological and Economic Survey rose from a meager beginning to achieve international fame, accomplishing many remarkable tasks. They are too numerous to list, but here are highlights:

- ▶ Established true meridians in every county (with USGS).
- ▶ Completed 15-minute topographic quadrangles of the entire State (with USGS). West Virginia was the first state to accomplish this feat, the last map being issued in 1931.
- ▶ Established and maintained gages on all principle rivers of the State (with USGS).
- ▶ Described and mapped the soils of 48 of West Virginia's 55 counties (with U.S. Bureau of Soils).
- ▶ Published two general volumes on oil and gas, three on coal, and one each on clays, limestones and cements, iron ores, salt and sandstones, forestry and wood industries, and on living and fossil flora.
- ▶ Published 25 volumes describing the geology and mineral resources of 51 counties, including topographic and structural geologic maps. These volumes represent the painstaking work of dedicated men such as David B. Reger, Ray V. Hennen, Charles E. Krebs, Paul H. Price, and George P. Grimsley. To this day these remain valuable references to the Mountain State's geology.
- ▶ Published two general geological maps of the State.

The publications, totaling **over 22,000 pages** of scientific data, stand as a monument to the ideals of I. C. White.



Ray V. Hennen, early geologist with the West Virginia Geological Survey



George P. Grimsley, early geologist with the West Virginia Geological Survey

This geologic record perhaps excelled that for any similar area in the world. The information paved the way for the State's attainment of an enviable position in geologic research and industrial importance.

Before his death in 1927, White was able to say that West Virginia had risen to **fourth** place in the Nation in the value of her mineral production, and to **first** place in the production of bituminous coal. One of West Virginia's most energetic scientists and colorful personalities had firmly established a Geological Survey for the Mountain State.

#### **THE TRANSITION YEARS: 1927-34**

After I. C. White's death, David B. Reger, Assistant Geologist, was placed in charge, remaining until the appointment of Cassius McCarl Lemley as State Geologist by the Commission in December 1929. Mr. Lemley died only 3

months later, at which time Rietz C. Tucker, Assistant Geologist, was given the office of Acting State Geologist. Four months later, the Commission appointed James D. Sisler as Superintendent of the Survey. He served 4 years, and resigned in October 1934.

During this period the Survey labored but was in turmoil from the confusion of administration changes. Adding to this confusion was the need to physically regroup the Survey. For years the offices had been scattered about West Virginia University--partly on I. C. White's property, in Mechanical Hall, and in the Agricultural Experiment Station. The University Library basement warehoused salable publications.

In 1927, the geologic staff moved from Mechanical Hall to the new Chemistry building. In 1928, the valuable I. C. White Library, willed



David B. Reger,  
Geologist in Charge, 1927-29



Rietz C. Tucker,  
Acting State Geologist, 1930 and 1943-45



Cassius McCarl Lemley,  
State Geologist, 1929-30

jointly to the University Department of Geology and to the Geological Survey, was moved. Contracts were let for equipping a chemistry laboratory, and the survey chemist moved from the Experiment Station to the new

quarters, thus completing the physical consolidation.

The cooperative soil-mapping program had progressed rapidly, and by 1930 only Randolph and Greenbrier Counties remained to be completed. In this work, the United States Bureau of Soils provided a scientist, and the West Virginia Geological and Economic Survey amortized field expenses.

The 15-minute topographic mapping program had been completed in 1924, but several of the earlier quadrangles were found to need revision, both in culture and topography. This work was financed 50/50 with the U.S. Geological Survey. By July 1930, 53 quadrangles were completed. In 1932, the first complete geologic map of the State was published by Superintendent Sisler.

Mr. Sisler's first biennial report (July 1931 to June 1933) reveals the effects of the Great Depression. Budget cuts halted the cooperative soil survey, stream gaging, and topographic mapping programs. All field studies stopped. This severe cut in the Survey's budget was necessary, but it stopped the



James D. Sisler,  
State Geologist, 1930-34

growth of the storehouse of natural-resource knowledge created by the Survey. This storehouse would be tapped heavily by New Deal agencies such as the Work Projects Administration, Public Works Administration, and the Civilian Conservation Corps.

#### THE PAUL H. PRICE YEARS: 1934-69

##### Paul Holland Price

Dr. Price was appointed Acting State Geologist following the resignation of Mr. Sisler. On May 27, 1935, he became Director and State Geologist. Under Price's leadership, the Survey flourished again. He immediately hired technical personnel to replenish the ranks depleted by the Depression. Soon after his appointment, he set out to improve the Survey's facilities, which were inadequate for effective work. As a result of these efforts, in 1942 the Survey and the Geology Department at West Virginia University moved into the newly built Mineral Industries Building, later



Paul H. Price,  
Director, 1934-69

renamed White Hall in honor of Dr. White.

#### The Thirties and Forties

Cooperative soils mapping and stream gaging resumed in 1935. 1936 saw release of the volume *Springs of West Virginia*, published in part to promote tourism. Its announcement stated that springs were located "for the most part in areas that have few other mineral resources such as coal, oil, and gas but invariably are in areas with scenic background and recreational environment."

The annual report for 1936 contained the first mention of the deeper drilling program for oil and gas that would greatly benefit the State. This same year saw Price contracting with Ward's Natural Science Establishment for a large, plaster-of-Paris relief map of West Virginia. Copies of this wall-mounted model were ultimately secured for the West Virginia Departments of Conservation and Agriculture, for two utilities (Monongahela West Penn; Appalachian Electric and Power), for West Virginia University, and for



the Governor's reception room in the Capitol. Some can be seen to this day.

The close ties between West Virginia University and the Survey were further cemented by their joint hiring of a Geologist in 1936 and by the appointment of Price as Professor and Head of the Geology Department in 1938.

Between 1937 and 1955, Alvah J. W. Headlee and others published several volumes giving chemical analyses of various samples of petroleum, natural gases, brines, coals, etc. This provided data that to some extent remain the basis for today's figures and statistics.

In addition to research dealing with the State's natural resources, the Survey also carried out an intensive mapping program. Among the West Virginia maps published under Price were a new geologic map, shaded relief map, base map, mineral resources and mineral industries map, three editions of an oil-and-gas map, a limestone map, and nearly 300 topographic maps under a cooperative program with the U.S. Geological Survey.

To study the ground-water resources of the State, Price initiated in 1941 a cooperative program between the West Virginia Geological Survey and the U.S. Geological Survey. Studies under this program included systematic examination of the State's river basins.

### Other Achievements

Other attainments under Price were as follows:

- ▶ His election to the Presidency of the Association of American State Geologists.
- ▶ Preparation of the oil and gas display at the New York World's Fair.
- ▶ Study of variations in coal-ash fusibility.
- ▶ Cooperative surface-water measurement with the Water

Resources Division of the U.S. Geological Survey.

- ▶ Complete review of the limestone resources of the State.
- ▶ Publication of statewide summaries of the stratigraphy and economic geology of the Silurian and Devonian periods.
- ▶ Publication of natural-gas analyses. This greatly stimulated the stripping of liquid hydrocarbons such as butane, and influenced establishment of a synthetic rubber plant at the community of Institute near West Virginia's capital city of Charleston.
- ▶ Publication of several volumes of deep-well records.
- ▶ Identification of extensive rock-salt deposits along the Ohio River (this led directly to location of several chemical plants).

### World War II

During World War II, Price volunteered his services, and Rietz C. Tucker again became Acting State Geologist. Although the staff was at a minimum during the war years, two important studies were completed. One concerned desulfurization of natural gas from deep sands, and the other was the finalization of plans for extensive cooperative ground-water projects. A clay laboratory was established, but the Survey coal laboratory closed because the Federal government built a similar laboratory in Morgantown.

Price returned from wartime duties to the Directorship in 1945. His primary concern was personnel; the higher standard of living that evolved during the war made it extremely difficult to employ capable individuals at Survey salaries.

### The Post-War Years

In 1949, construction of an annex building began. A volume describing some 400 caverns of the Mountain State

was released. A special focus on coal commenced when Aureal T. Cross accepted a joint position with the Survey and the University Geology Department.

In 1950, the Survey was instrumental in forming the West Virginia Secondary Recovery Study Group. This group spearheaded three major achievements: (1) secondary recovery of oil that otherwise would be lost, (2) legislation to permit repressuring of oil-bearing strata by water flooding, and (3) research by Dr. Alvah J. W. Headlee, Survey Chemist, on phase behavior in low-pressure oil reserves (this resulted in the revitalization of petroleum wells).

Oscar L. Haight, a petroleum geologist with experience in South America, came to the Survey in 1952. During his 16 years with the Survey, he prepared many structural maps and publications on oil and gas, most important of which were 12 maps and bulletins describing oil and gas possibilities by county.

### The Sixties

The prosperity of the Nation and of West Virginia were reflected in the Survey's burgeoning activities during this decade. The three most outstanding developments were:

- ▶ A new topographic mapping cooperative program with the USGS, to complete mapping of the entire State in 7.5-minute quadrangles.
- ▶ Geologic consulting for the National Radio Astronomy Observatory at Green Bank in Pocahontas County. The Survey prepared a geologic report to aid in site selection in cooperation with the National Science Foundation and Associated Universities, Inc.
- ▶ Advising other State agencies concerning possible locations for emergency underground manu-

facturing/storage facilities in West Virginia.

The decade saw increasing specialization of the staff into the areas of coal, petroleum, economic geology, laboratory analysis, and archeology. Highlights in some of these areas follow.

**Coal**--The Survey issued a series of publications that anticipated the need for geologic information on bolting for coal mine-roof support. Also published was research that identified the strategic element germanium in some coals, in greater amounts than in existing commercial sources.

**Petroleum**--The Survey published the results of the first well drilled to the base of the Paleozoic in West Virginia. Nine oil and gas maps were released summarizing the stratigraphy, structure, producing horizons, and drilling in the State. A study was conducted of geologic factors affecting natural-gas production in specific areas. Intensive analysis of West Virginia's crude oils was conducted; this work isolated and defined the properties of several hundred different hydrocarbons, data of inestimable value in refining operations. A core drill was acquired for stratigraphic studies.

**Economic Geology**--A comprehensive report on the Ohio River Valley was published, describing the economic resources and geology of this major drainage basin. Cooperative studies were performed with various engineering organizations in preparing plans for a north-south turnpike in the State.

**Fundamental Geology**--Survey Geologists prepared two additional systemic volumes detailing the statewide geology of the Cambrian and Ordovician periods.

**Archeology**--An archeologist was added to the staff in 1960, to preserve scientific data on prehistoric sites.

**Geologic Data**--In the mid-1960's, limited computer-processing of data began. This was the kernel from which today's computerized Survey has grown.

**Publications**--Numerous general-information bulletins were issued on coal, oil and gas, fossil plants, geomorphic history of the New-Kanawha River system, and state park bulletins. Collections of common rocks and minerals were sent to every high school in the State. This work in the aggregate included 21 hardbound volumes, 19 bulletins, 21 reports of investigations, and several dozen maps, educational circulars, and journal articles.

### Mapping with Students

A far-sighted Survey policy was the hiring of West Virginia University geology students to do both routine and specialized tasks. This ensured the students of funds for their education, provided practical experience in geology, and furnished the Survey with assistants for its programs.

Significantly, major contributions have been prepared in this way in the form of master's or doctoral theses. In 1962, a systematic geological mapping program was initiated using graduate students, members of the Geology Department faculty, and Survey personnel. In this program, students would map the geology of specific quadrangles for their theses and for the Survey. The Survey would contribute the field expenses of the student and the salary/expenses of supervising Survey personnel in exchange for publication and distribution rights.

### THE ROBERT B. ERWIN YEARS: 1969-PRESENT

#### Robert Bruce Erwin

When Price retired in 1969, Dr. Robert B. Erwin replaced him. Erwin holds a B.A. from the University of Vermont, an M.S. from Brown University, and a Ph.D. from Cornell. He served as a geologist with the Vermont Geological Survey and Texaco and taught geology at St. Lawrence

University. He is Past President of the Association of American State Geologists, a Fellow of the Geological Society of America, member of the American Association of Petroleum Geologists and the American Institute of Professional Geologists, and Professor of Geology at West Virginia University and Marshall University.



Robert B. Erwin,  
Director, 1969-present

### The Seventies and Eighties

The hallmark of the Erwin years has been the computerization of the enormous volume of geologic data collected over the decades. Computerization began in the mid-1960's when a specialized consulting group was formed within the Survey to use the mainframe at West Virginia University. In the late 1970's a computer system was purchased to handle the burgeoning needs of both data storage and research programs. Today, the Survey's Geologic Data Section operates from its own building, the Mont Chateau Data Center, augmented with numerous personal computers used by staff geologists.

Application of geologic information had long been restricted to mineral extraction. But in the 1970's, geology increasingly became part of land-use planning, water-resource management, building construction, planning of transportation and utilities, and waste disposal. Consequently, during the 1970's the Survey's activities broadened and deepened, with detailed statewide coal studies, land-use mapping, remote sensing, sophisticated analytical capabilities, and computerized data processing.

With these expanding duties, the Survey outgrew its quarters in White Hall on the West Virginia University campus, and in 1978 moved to the Mont Chateau Research Center on Cheat Lake, east of Morgantown, allowing most of the staff to be gathered under a single roof. This Center is the Survey's own separate facility. Office space is provided for the USGS Water Resources Division Subdistrict Office.

The Survey's activities have been divided into several programs, described below.

**Coal Resources Program**--To address growing environmental, health, safety, and economic problems of the coal industry, information is required on physical and chemical properties of West Virginia's coals and associated rocks. To address this need, the Coal Resources and Pollution Potential Program was initiated in 1973. This group has exhaustively studied the State's 62 minable seams and the 7,000-foot thickness of Carboniferous rocks in which they occur.

The Survey's computerized coal-resources information system, tied with the National Coal Resources Data System, enables prompt response to coal-related questions from government, industry, and the public.

**Coal-Quality Program**--This program provides coal petrology, geological evaluation of coal property, and coal-quality information (sulfur, ash, Btu,

etc.) on coal seams statewide. Fundamental research has included assembly of a large library of coal samples (about 5,000), a petrologic study of West Virginia's minable seams, and a study of trace-element occurrence.

Six coal-geology bulletins were published in the 1970's dealing with coal occurrence and mining in West Virginia, the suitability of the State's coals in coal-conversion processes, and specific coal analyses. Published maps included a large display map showing the original extent of all 62 minable seams in the State, a generalized geologic map of the State's coal fields, and a map showing coal rank and fixed carbon. A directory, *Mines in West Virginia*, is also issued periodically.

**Oil and Gas Program**--As a repository for statewide records on 50,000 oil-and-gas wells, well-location maps, geophysical logs, well cores, and well samples, the Survey has at hand a huge data base, with much of the data computerized. This data base continually provides oil-and-gas information to industry and the public.

For nearly 20 years, the Survey has disseminated research information through the annual Appalachian Petroleum Geology Symposium, and through publications. Major publications have included:

- ▶ Statewide maps (1:250,000), such as *Deep Well and Structural Geologic Map*, *Oil and Gas Fields Map*, *Pipeline Map*, *Aeromagnetic Map*, and *Gravity, Magnetics, and Structure of the Allegheny Plateau/Western Valley and Ridge in West Virginia and Adjacent States*.
- ▶ Statewide maps (1:500,000), including structural geologic maps contoured on the Greenbrier Limestone, the Newburg sand, and the top of the Ordovician.
- ▶ Statewide Silurian reports on stratigraphy, paleontology, depo-



sitional environments, and petroleum production for the McKenzie, Newburg, and Tonoloway Formations.

- ▶ County reports and maps (1:62,500).

#### **Economic Geology Program--**

This program is concerned with evaluation and development of West Virginia's nonfuel mineral resources (shale, clay, sandstone, and limestone) and with geographic matters.

The program compiles statistical data on mineral production, fossil-fuel extraction, and location and status of mining operations, published in the annual *Mineral Producers and Processors Directory* of over 1,200 Mountain State firms.

In geography, development of a statewide gazetteer of place names was completed in 1986. The Survey also edited all 495 7.5-minute topographic maps that cover the State and researched the tax-district boundary lines on each map so that they could be certified as correct. These certified maps are now the legal basis for determining the position of county and tax-district boundary lines, and for settling boundary disputes.

**Environmental Geology Program--**To help alleviate (and forestall) the State's environmental problems, the Survey established this program in 1971. Emphasis was on providing an authoritative basis for planning and land use. Seven environmental geology bulletins were released, focusing on sanitary-landfill sites and written in nontechnical language. Research encompassed geologic mapping, a study of mine-spoil potentials, water quality, and geologic hazards.

By entering these new areas, the Survey increased its contribution to the protection and management of the environment. In 1973 we began to use data and maps from new aerial and satellite surveys. At that time a land-use mapping project for the State was

initiated, using color-infrared photos. In cooperation with the U.S. Geological Survey's Land Use Data Analysis program, the Survey produced the first Statewide maps delineating land-use patterns.

During 1978 the West Virginia Cartographic Information Center was created in cooperation with the U.S. Geological Survey's National Cartographic Information Center. The Survey also began to participate in the National Water Use Data System, a cooperative project funded in part by the USGS. Water-use data are published annually.

Under contract with the Appalachian Regional Commission, the Survey completed a study of landslides and slide-prone areas around ten urban regions of West Virginia and published a report accompanied by 37 7.5-minute quadrangles.

**Analytical Program--**This program provides elemental and mineralogical analysis of rocks and water-quality analysis. The laboratory is considered among the best in the State, with equipment for X-ray diffraction, spectroscopy, and X-radiography. This equipment has allowed the Survey to perform in-depth studies of West Virginia's water, coal, limestone, and rocks.

Drainage-basin studies have been conducted to define the relation of water quality to human activities and to basic geology. Acid mine drainage studies have led to an ongoing investigation of how the acid forms. Coal analyses have become a major portion of analytical activities, and limestone resources are being chemically studied. We are now building a data base to facilitate finding the best limestone types for industry and road building.

The Analytical Program has developed a support role for graduate research projects at West Virginia University. This support includes analysis, interpretation of analytical

data, and professional consultation on complex analytical problems.

### Other Achievements

Under Erwin's resourceful management, the Survey has expanded dramatically in scope, staff, technology, and productivity.

Computerization has steadily progressed, now routinely aiding research, data handling, public service, publishing, and administration. The staff has more than doubled from the Price years. External funding via contracts, cooperative agreements, and grants has contributed greatly, especially to work in coal and oil and gas. Several landmark publications have recently been released:

- ▶ The hardbound *West Virginia Gazetteer of Physical and Cultural Place Names*, an 840-page volume listing nearly 31,000 names from topographic maps and other sources, accompanied by three 1:500,000-scale maps of the State (shaded relief, 7.5-minute grid, and UTM grid).
- ▶ Fiftieth Anniversary edition of *Springs of West Virginia*, a 500-page volume describing nearly 1,200 Mountain State springs.
- ▶ *West Virginia Mineral Resources Map*, a 1:500,000-scale presentation including regional stratigraphic columns.

- ▶ *Bouguer Gravity Map of West Virginia*, 1:250,000-scale, two-sheets.
- ▶ *Transportation Map of West Virginia*, showing all major highway, rail, water, and air facilities.

Major research continues in Devonian shale gas potentials, statistical methods for gas exploration, coal availability, coal-quality mapping, geologic mapping of 7.5-minute quadrangles, industrial limestone sourcing, and cooperative ground-water studies and mapping.

### THE FUTURE

Looking to the future, the Survey will have a large share in the difficult task of meeting the Nation's requirements for energy, mineral, and water resources. West Virginia's economic progress will depend not only on the critical assessment and wise use of resources but on effective environmental planning and safeguards.

The Survey's unofficial motto is "Geology Underlies It All." In West Virginia that is both figuratively and literally true today. The Survey looks forward to a very busy time during the remainder of this century, as it strives to meet the needs of West Virginia, her people, and her industries. The Survey and its staff will continue to welcome the opportunities and challenges that are presented.

## WISCONSIN

Wisconsin Geological and Natural History Survey, University of Wisconsin-  
Extension, 3817 Mineral Point Road, Madison, WI 53705.  
Phone 608-262-1705.

### HISTORICAL SEQUENCE OF ORGANIZATIONAL NAME:

State Geological Survey, 1853-56  
Geological and Agricultural Survey, 1857-62  
Survey of the Lead District, 1870-72  
Complete Geological, Mineralogical and Agricultural Survey, 1873-82  
Geological and Natural History Survey, 1897-present

### NAMES AND TITLES OF ORGANIZATIONAL DIRECTORS AND DATES SERVED:

Edward Daniels, State Geologist, 1853-54  
J. G. Percival, State Geologist, 1854-56  
Edward Daniels, Ezra Carr, James Hall, Joint Commissioners, 1857-62  
John Murrish, Commissioner, 1870-72  
Increase A. Lapham, State Geologist, 1873-74  
O. W. Wight, State Geologist, 1875  
T. C. Chamberlin, Chief Geologist, 1876-82  
E. A. Birge, Superintendent, 1897-1900; Director and Superintendent, 1900-19  
William O. Hotchkiss, State Geologist, 1908-19; State Geologist, Director and  
Superintendent, 1919-25  
Ernest F. Bean, Acting State Geologist, Director and Superintendent, 1925-26;  
State Geologist, Director and Superintendent, 1926-31; State Geologist, 1931-52  
George F. Hanson, Acting State Geologist, 1952-53; Director and State Geologist,  
1953-72  
Meredith E. Ostrom, Director and State Geologist, 1972-present

### WISCONSIN GEOLOGICAL AND NATURAL HISTORY SURVEY

By M. E. Ostrom

#### HISTORICAL DEVELOPMENT

The origin and history of state geological surveys reflect people's changing attitudes and concerns for resource development and environmental management (Ostrom, 1984).

Wisconsin's geological surveys trace their origin to public concern for economic development as expressed in an editorial in the *Madison Argus* on October 10, 1848, which urged that the geology of the state be investigated.

It is a credit to the editor of the *Argus* that in the year of Wisconsin's

statehood he recognized the potential value of a geological survey. Prior to 1850 the science of geology was in its infancy and there had been few geological surveys of the region. At that time the need for geological surveys was voiced principally by miners, who understood the value of geologic maps and scientific information in their search for minerals. Two surveys were commissioned in Wisconsin prior to 1850; both were in the southwest lead region. These two surveys, along with a limited investigation by G. W. Featherstonhaugh in 1835 and an extensive and detailed investigation employing more than 140 men by David Dale Owen in 1839, failed to satisfy the

needs of miners, who considered the reports of limited use. The Wisconsin Territorial Select Committee agreed with the miners and in 1840 concluded that little information of practical value was contained in the Owen report. This unfortunate conclusion can be attributed to administrative bungling, which transformed an elaborate and complete report with maps and illustrations into a printed "abridged and mutilated form, minus many important maps, and in insufficient quantity" (Lake, 1962, p. 43).

Interest in creating a geological survey continued during the period of early statehood from 1848 to 1853. However, in 1852 proposals to establish a State Geological Survey to Congress and to the State Legislature failed under the continued pressure of lack of funds. Then, as now, without the incentive afforded by scientific information, entrepreneurs were reluctant to invest venture capital. Thus, lead mining and production declined and the economic development sought by Governor Henry Dodge and the Territorial Assembly was stalled for want of geologic information. Thus, very early in its history Wisconsin developed a sense of the need for and the role of a Geological Survey supported by government.

#### **THE FIRST SURVEY: EDWARD DANIELS, 1853-54**

On March 25, 1853, the Legislature created Wisconsin's first State Geological Survey with an annual appropriation of \$2,500 for 4 years. The Survey's enabling act carried the seed of future legislative discontent because of the misconception that a state geologist and one assistant could "... complete a geological and mineralogical survey of the entire state ..." (Lake, 1962, p. 127) in 4 years. There was no appreciation of the difficulty and man-hours required to conduct such surveys or that the accuracy and detail of geologic maps

and reports is dependent on availability of basic information such as rock outcrops, rock cores, and cuttings from wells and exploration drill holes, and on concepts and technologies available at the time of their preparation. It was not understood that geological surveying involves extensive field study, laboratory analysis, and research. Nor was it recognized that geological surveying is a continuing process of integrating and evaluating new information, concepts, and technologies with the old as a basis to provide accurate and timely interpretative maps and reports for resource and environmental decision-making and policy-setting.

Governor Leonard J. Farwell appointed Edward Daniels as Wisconsin's first State Geologist. Daniels was a "Political Apothecary," a "Professor in the College at Waukesha," and a "Lecturer on Kansas Affairs" (Bean, 1937, p. 204). His political interests and inclinations likely contributed to his early departure from office, for with the election of a new Governor, Daniels was removed from office.

In the Survey's first year Daniels spent a considerable amount of time mapping in the lead region of southwest Wisconsin and produced the Wisconsin Geological Survey's first annual report (1854, 84 pages) dealing principally with this region. In the report he recognized the importance of mineral production statistics and mineral specimens to his work and he urged that these be sent to the Survey. Daniels observed that the lead mines were in transition, that near-surface deposits had been mostly worked out, that lead ore likely occurs in deeper rock formations, and that future mining would be forced to greater depths that would require more detailed scientific information if the industry was to continue.



Daniels' report was received favorably by the Legislature and a special committee recommended that the state survey be continued. However, on June 30, 1854, Governor William A. Barstow ousted Daniels despite a special legislative committee's objections and its declaration (1855) that "the removal is unjust to his character and reputation as a man of science." The majority observed that "... the survey could not function if every change in party controlling the governorship was followed by a change in the head of the survey."

The dismissal of Daniels concluded the first chapter in the history of the Survey. It was a prelude to "a decade of very stormy relations between the geological survey and the Legislature, which tended to distract from the more central issue which confronted the Legislature concerning the state's mineral wealth..." (Lake, 1962 p. 128), that is, making broad policy decisions.

#### **THE SECOND SURVEY: J. G. PERCIVAL, 1854-56**

James Gates Percival, generally referred to by his contemporaries as "Old Stonebreaker," was appointed to complete the remainder of Daniels' term as State Geologist by Governor Barstow in August 1854 (fig. 1). Percival appears to have been a peculiar choice for this appointment. Noted as a "ragged Ishmaelite," Percival "devoted himself to intellectual pursuits so diligently and intently that he neglected his dress, his living habits, and his money matters" (Lake, 1962, p. 129). However, he was a learned man who graduated from Yale College, wrote poetry in 13 languages, assisted Noah Webster with his dictionary, worked as geologist for the American Mining Company, taught chemistry at West Point, and had been in charge of geology for the Connecticut Geological and Mineralogical Survey.

Two reports of about 100 pages each, in both English and French editions, were issued during Percival's tenure, which ended after only 21 months due to his sudden death May 2, 1856. During the remaining 4 months of Percival's term, Wisconsin had no State Geologist. Percival's reports were extremely prosy and dealt with detailed descriptions of various geologic formations but did not directly address the question of the location of mineral deposits; therefore, both miners and legislators were dissatisfied. Debate following Percival's death centered mainly on the hiring, firing, and performance of State Geologists. The Governor was blamed for Percival's poor treatment and for underpayment of the position. Such debate detracted from more fundamental issues which were given only limited attention, such as:

- ▶ Was the state government acquiring reliable and realistic data on the mineral resources available for the growth of Wisconsin's economy?
- ▶ What was the proper balance between the honest search for reliable information and the desires of particular interests to influence that search for private gain?
- ▶ What use should be made of law to regulate and foster the healthy growth of the state's mineral potential? (Lake, 1962, p. 132)

#### **THE THIRD SURVEY: HALL, DANIELS, AND CARR, 1857-62**

Enabling legislation creating Wisconsin's third Survey, a Geological and Agricultural Survey, was passed by the Legislature on March 3, 1857, with an annual appropriation of \$6,000 for 6 years. In the Geological Survey's annual report, shortly before his death, Percival admonished the Legislature that the Survey should have a single leader to assure the "systematic unity which such

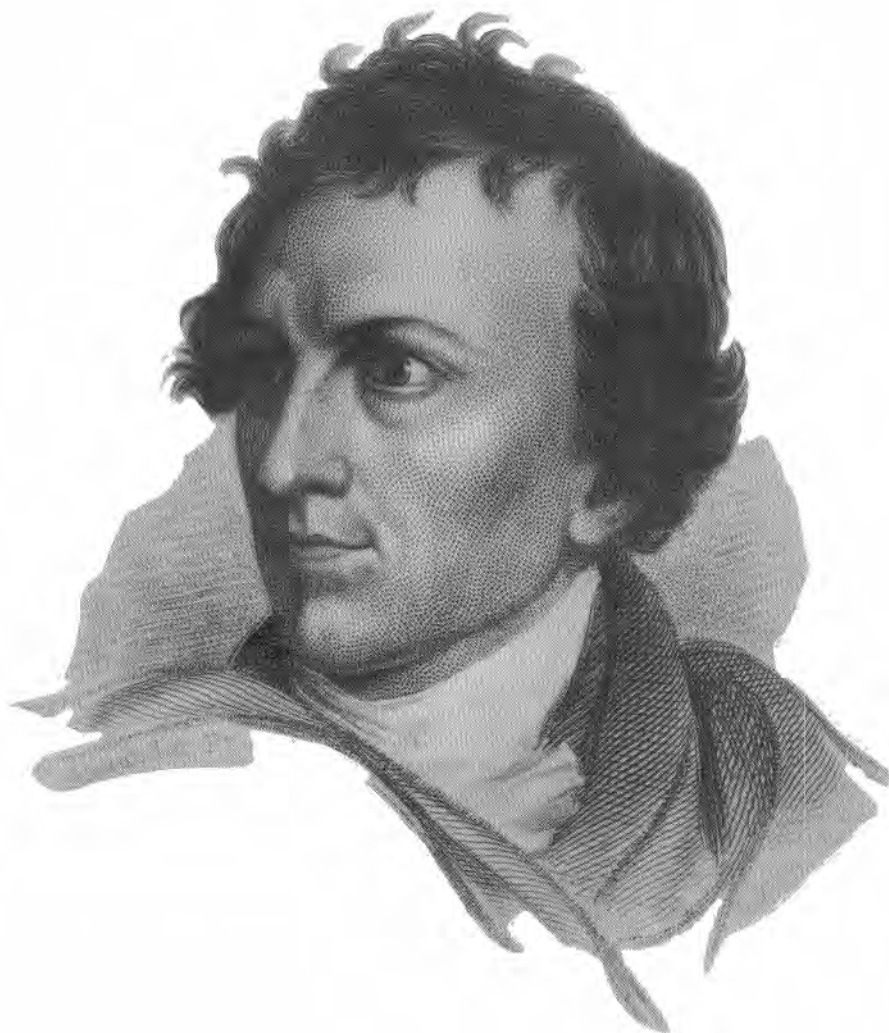


Figure 1.--"Old Stonebreaker," James Gates Percival, Wisconsin's second State Geologist (1854-56), a man of letters and science.

can best give the whole." However, his advice was ignored and the Legislature proceeded to create a situation primed for discord by placing it under the joint supervision of a commission consisting of Edward Daniels (former head of Wisconsin's first geological survey), James Hall (former State Geologist of New York and Iowa), and Ezra Carr (Hall's assistant at the New York Survey) (Bean, 1937). There was no clear-cut leadership in the Survey; each of the appointees had strong personalities. They clashed over leadership, budget, programs, and the character and quality of work and reports.

During this period, the Governor supported the Survey; the Legislature introduced bills calling for its abolishment several times. Except for a report on the lead district (one of four reports produced by this Survey), the Legislature was dissatisfied with the Survey's work. The Survey was not producing reports as fast nor were they as optimistic about mineral potential as anticipated. The Legislature's dissatisfaction with the Survey led to their repeal of the authorization act, thus abolishing the Survey in 1862.

Wisconsin had no Geological Survey for the next 8 years (1862-70). In 1869, in his annual message, Governor Lucius Fairchild restated the need expressed by past Governors and Legislatures that Wisconsin needed "a thorough geological survey." As in the past, the emphasis in this message was on the need for geologic knowledge as a basis for attracting capital investment to develop the state's mineral and agricultural resources.

#### **THE FOURTH SURVEY: JOHN MURRISH, 1870-72**

In 1870, in response to continued concern for decline in lead production and to Governor Fairchild's pleas, the Legislature approved an act "to provide for the survey of the lead district,

making maps, and collecting statistics and specimens from same." John Murrish, an experienced geologist from the Cornwall District, England, was appointed Commissioner. Contrary to expectations, his report (65 pages, published in 1871) was noncommittal on the question of deeper ores and, thus, satisfied neither miners nor the Legislature. He refused to overstate his findings; as his predecessors had done, he stated facts, not speculations. In spite of the Legislature's dissatisfaction, and the fact that several bills to abolish the Survey were introduced, Murrish remained as Survey Director for one more year and began the first studies of iron ore possibilities in central Wisconsin and especially near Baraboo in Sauk County and Black River Falls in Jackson County. He collected specimens of iron ore from these areas but, because he lacked more specific information, he refused to predict the presence of ore deposits. Nonetheless, the prospect for expanded mineral wealth suggested by his specimens was incentive enough for the Governor and Legislature to move toward an enlarged survey effort.

#### **THE FIFTH SURVEY: LAPHAM-WIGHT-CHAMBERLIN, 1873-82**

In 1873 the Legislature passed a law creating Wisconsin's fifth Survey, a "complete geological, mineralogical and agricultural survey of the state." The work was to begin in the far northwest in Ashland and Douglas Counties and to be completed in 4 years. On April 10, 1873, Governor Washburn appointed Increase A. Lapham to head the Survey with four subordinates: Roland D. Irving, T. C. Chamberlin, Moses Strong, and W. W. Daniels. Space was provided to the Survey by the University of Wisconsin, thus establishing a bond which would prove mutually beneficial. This survey was constituted with a significantly expanded capability. Over

the ensuing 9 years there would be more than 25 scientists--including geologists, mineralogists, chemists, biologists, and an ethnologist--involved in conducting basic resource surveys in Wisconsin. This was the most extensive survey of the state yet conducted and led to products (maps and reports) that were generally well received. The quality of the products led to an extension of the Survey to March 31, 1879.

Lapham died in 1875 and was replaced by O. W. Wight. There appear to have been political overtones to this appointment as expressed by Irving in a letter to Hall in 1875, which stated:

Our geological survey has gone the fate of its predecessors--or rather a worse one. The governor has appointed a disreputable politician to Dr. Lapham's position, leaving the survey still unorganized. We had accomplished an immense amount of work... It is probable that none of it will ever see the light... Wisconsin has most certainly had ill luck with its surveys (Bean, 1937, p. 213).

Fortunately, Irving's fears proved premature as Wight resigned in 1875 shortly after Governor Taylor was replaced by Governor Ludington. Wight was succeeded in February 1876 by T. C. Chamberlin (fig. 2), and the survey came to be known as the Chamberlin Survey. Chamberlin, a founder of the Wisconsin Academy of Sciences, Arts, and Letters in 1870, was a graduate of Beloit College (A.B. 1866, A.M. 1869) and taught there from 1873 to 1886. While at Beloit he was appointed Assistant State Geologist in 1873 and began his extensive work on glacial geology.

The results of the Chamberlin Survey were published in a four-volume set entitled *Geology of Wisconsin*. The set constituted a major advance in understanding the broad framework of Wisconsin's geology in the context of that time. However, Chamberlin (1878) understood the limitations of this work and stated that "The work will not be,

and in the vein of the extent of the field, its wilderness, and its inherent difficulties, could not be exhaustive, with the facilities at our command." For the first time--and thanks principally to Chamberlin's efforts--the seeds for understanding the function of a geological survey were planted, for he made it clear that "a survey is valuable as a continuing service, not only in addressing the frontier of geological knowledge but in serving as advisor to citizens and to municipalities" (Bean, 1937, p. 213).

Publication of Volume IV of *Geology of Wisconsin* in 1882 concluded the Chamberlin Survey. After completion of this work Chamberlin accepted a position as head of the Glacial Division of the U.S. Geological Survey. In 1887 he became President of the University of Wisconsin, a post he held until 1892 (Bailey, 1981, p. 25).

#### A PERIOD OF NO SURVEY

The 15-year period from 1882 to 1897 is marked by the absence of a Geological Survey in Wisconsin. The fact that the Survey was allowed to lapse in spite of Chamberlin's statement that Surveys are valuable as a "continuing service" can probably be attributed to the thoroughness and success of his survey, rather than to dissatisfaction with the products. Clearly, his advice went unheeded. The lapse was quite likely a reflection of a perception on the part of legislators that the survey was complete and that attention and money could be directed toward other concerns.

Another factor that likely contributed to the lapse of a Geological Survey in Wisconsin was the change in public attitudes regarding resources and social and environmental issues. During the early and mid-19th century the principal public attitude favored exploitation of resources as an incentive to encourage westward migration and settlement. Thus, Wisconsin's Geo-





Figure 2.--Thomas Crowder Chamberlin headed Wisconsin's fifth Survey (1873-79) which produced a four-volume set entitled *Geology of Wisconsin*, a major advance in understanding the broad framework of Wisconsin's geology. Photoprint courtesy of State Historical Society of Wisconsin. Portrait photo by C. Parker. WHi(X3)33074.

logical Surveys were commissioned in the hope their findings would lead to locating and developing mineral deposits. This attitude began to change toward the end of the century as the public slowly awakened to social and environmental problems caused by un-harnessed development. For example, the first social adjustments to mining in Wisconsin were introduced in the last half of the 19th century and "consisted principally in efforts to provide protection and compensation for mining-related injury and disease." The State Board of Health and the Bureau of Labor and Industrial Statistics were created "during this period in response to concern for worker health and safety" (Ostrom, 1983). The Legislature in 1893 also passed a law prohibiting the polluting of streams with "sawdust, lime, or other deleterious substances" (Lake, 1962). Thereafter, mineral development was recognized as a legitimate business but one that should be required to pay its share of the cost of government. Public attitude shifted toward believing that corporations have a responsibility for resource and environmental protection and public welfare. In addition, the state passed an *ad valorem* tax on minerals, thus removing the tax-free status of mining companies.

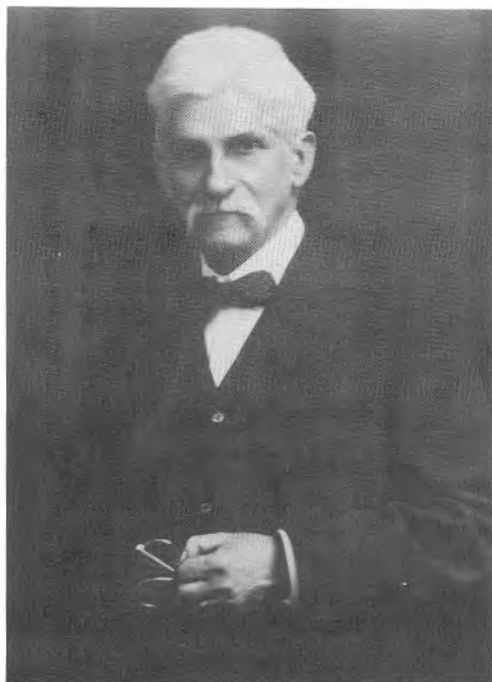
#### **THE SIXTH SURVEY: THE GEOLOGICAL AND NATURAL HISTORY SURVEY, 1897-Present**

The shift in public attitude toward greater social and environmental concern was reflected in creation of the Geological and Natural History Survey which "had the assignment to assist all segments of society in the important gathering, analysis, storage, and presentation of reliable facts about the state's resources" (Ostrom, 1983, p. 34).

The Geological and Natural History Survey was established principally through the efforts of the Wisconsin Academy of Sciences, Arts, and Letters.

Under the direction of Dr. Charles R. Van Hise--President of the Academy, Chairman of the University of Wisconsin Department of Mineralogy and Geology (1898 to 1903), President of the University of Wisconsin from 1903 to his death in 1918, and a founding member of the Geological Society of America in 1888--a motion was presented to the Academy that a committee be formed to draft a proposal to establish such a survey. In 1893 a bill was drafted by an Academy committee consisting of C. R. Van Hise (Chairman), C. R. Burnes, E. A. Birge, G. L. Collie, and A. J. Rogers. The bill was recommended to the Legislature in 1894 and finally approved in 1897. The newly created Wisconsin Geological and Natural History Survey (WGNHS) was placed under the authority of a board consisting of the Governor, the State Superintendent of Public Instruction, the President of the State University, the President of the Commission of Fisheries, and the President of the Wisconsin Academy of Sciences, Arts, and Letters. Its assignments were to conduct a geological survey of the state (especially iron ores, building stones, and road building materials); study the state's soils, animal life and fish, and plants (with special emphasis upon trees and conservation); complete the topographic mapping of the state; and prepare educational materials. Van Hise was appointed consultant geologist with the new survey--a position he held until 1903 when he became President of the University of Wisconsin and *ex officio* President of the Survey's Governing Board.

The Geological and Natural History Survey has been the most enduring of Wisconsin's surveys to the extent that it has lasted for 91 years and survived five directors (fig. 3). During its initial period of growth and expansion--the period from 1897 through 1931 which included the 1929 stock market crash and the shift of the Survey to the



A



B

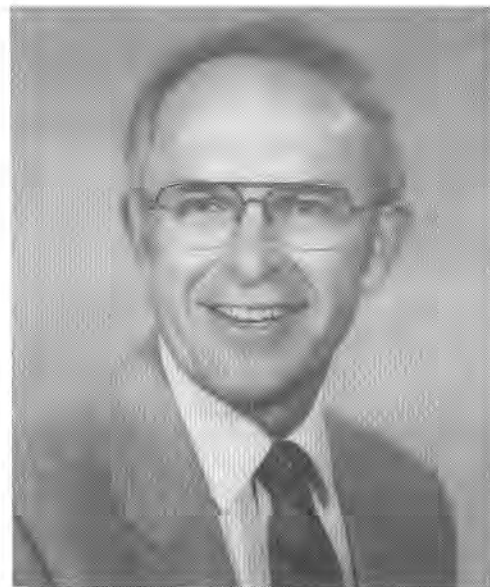


C

Figure 3.--Wisconsin's sixth Survey, the Geological and Natural History Survey, has survived five directors: A - Edward A. Birge (1897-1919), B - William O. Hotchkiss (1919-25), C - Ernest F. Bean (1925-52), D - George F. Hanson (1953-72), and E - Meredith E. Ostrom (1972-present).



D



E

Figure 3.--Wisconsin's sixth Survey - Continued

university--Dean E. A. Birge, William O. Hotchkiss, and Ernest F. Bean each served separate terms as leader of the Survey.

Birge was appointed Superintendent of the WGNHS in 1897. A renowned scientist and dean of the College of Letters and Science, Birge would eventually follow in the footsteps of Van Hise to become President of the University of Wisconsin in 1919. Birge was born in Germany in 1851; he received his early education in science at Leipzig and subsequently attended Harvard College and Williams College. Prior to his tenure as State Geologist, Birge taught at the University of Wisconsin. Considering himself a zoologist, his principal instructional areas were in biology and included physiology, embryology, histology, and bacteriology. Possibly because of this he was affectionately known as "Dr. Bug" to his students. Birge is also credited with inaugurating Wisconsin's first pre-med curriculum. A thorough and accomplished scientist, Birge stressed

the unfolding nature of scientific research in which each piece of new information leads to new questions and the need for additional research to provide answers. Harry L. Russell (1940, p. 13), Dean of the College of Agriculture, described Birge as belonging "to the group that views the world from the mountain top rather than from the canyon depth."

Birge guided the WGNHS during its infancy and, with his cohort Chancey Juday, continued pioneering work in lake biology begun in 1894. This work led to the development of the science of limnology, a word that first appeared in 1895. Under his influence, new WGNHS programs were developed in water powers and underground and surface water supplies (1905), road materials and highway surveying (1907), soil surveying (1909), and topographic mapping (1911), in addition to its programs in building stones, geology, geography, lake survey and biology, and forestry and biology. Birge served the Survey as Superintendent from 1897 to



1900 and as Director and Superintendent from 1900 to 1919 (fig. 4). In 1919 Birge resigned to become President of the University of Wisconsin and William O. Hotchkiss was appointed his successor.

A Wisconsin native, Hotchkiss earned bachelor, master, and doctorate degrees at the University of Wisconsin in science and engineering, completing the Ph.D. in 1916. His early professional work beginning in 1902 was in minerals exploration in Minnesota and in Ontario, Canada. He began work with the WGNHS in 1906 and was placed in charge of economic geology. In 1909 he was appointed State Geologist under Birge. When Birge left to become President of the University in 1919, leadership responsibilities in the Survey were consolidated and Hotchkiss became State Geologist, Director, and Superintendent.

During Hotchkiss' tenure, the work of the Survey's Highway Division begun in 1907 to carry on experimental and advisory projects in relation to highways and bridges (fig. 5) lead to creation of the State Highway Commission in 1911. Hotchkiss was the author of numerous Survey publications including *Rural Highways of Wisconsin*, *Limestone Road Materials of Wisconsin*, and *Geological and Road Map of Wisconsin*. He also served on many state and federal committees and was a member of many geological societies and President of the Association of American State Geologists.

Hotchkiss (1925, p. 12) stressed the adage that "a problem clearly perceived and stated is half solved." In Hotchkiss' view, Wisconsin's greatest resource is its people; its other resources of soils, minerals, forests, climate, and water power are the materials for improving



Figure 4.--State geologist William O. Hotchkiss leading a 1920 field party in serious discussion in the shade of scrub oak and pine near Baraboo (photograph by F. T. Thwaites). (E. O. Ulrich, Hotchkiss, Gilbert M. Smith, and Ernest F. Bean).



Figure 5.--Survey staff member William O. Blanchard and wife with the "Cage," the first motorized field vehicle of the Geological and Natural History Survey investigating the "bridgehead" south of the village of Lone Rock for road materials (1920; photograph by F. T. Thwaites).

and maintaining a high quality of life (Hotchkiss, 1924, p. 4). He understood the separate but related roles of industry and academia and emphasized the need for industry and the university to work together to identify and clearly define problems and to resolve them. His philosophy carried over into the planning and conduct of WGNHS programs, which reflected the needs of government, industry and the general public. Hotchkiss resigned in 1925 to

accept the position of President of the Michigan School of Mines.

Ernest F. Bean succeeded Hotchkiss. He was appointed Acting State Geologist, Director and Superintendent in 1925 and to full responsibility in 1926. Bean earned a B.A. degree from the University of Wisconsin in 1909 and an M.A. degree in 1911. From 1911 to 1915 he taught courses in regional and physical geography and economic geography. For

two summers Bean was a member of an Alaskan glacial expedition organized by the National Geographic Society. He began work with the WGNHS in the summer of 1909. In 1913 he was placed in charge of the Survey's field parties, which conducted geologic field reconnaissance and magnetic surveys on a township basis for mineral land classification in northern Wisconsin. In 1919 he was appointed Assistant State Geologist by Hotchkiss and continued his work with the mineral land classification program. In addition, in cooperation with the Highway Department, Bean developed a Road Materials Survey program to locate aggregate and other materials for highway construction. Bean endeared himself to students, faculty, and industry because of his warmth and sincerity. He retired in 1952 after 26 years with the Survey, the longest tenure of any of Wisconsin's State Geologists.

Bean assumed leadership of the Survey at a time of increasing budgets and responsibilities. Through no fault of his own, and no thanks to the Great Depression and attendant political turmoil, he presided over the only significant budget and program cut in the Geological and Natural History Survey's history. These cuts, which reduced the Survey's budget from \$99,485 in 1928 to \$7,500 by 1935, seriously damaged the Survey's capabilities and the production of information needed by both the state and federal governments, as well as the private sector, during the critical years of World War II.

In the pre-1931 period the Survey's broad responsibilities were clearly defined and incorporated under the headings of geological survey (which included water resources investigations), mineral land classification, mine valuation, lead and zinc district, natural history, soil survey, and highways (up to 1911). In

this period the Survey's budget allocation grew from \$8,550 to \$99,485 and its permanent full-time staff from 6 to as many as 32. The principal achievements of this period are indicated by the Survey's publications. They included completion of detailed geological surveys for a large area of central and northwestern Wisconsin and publication of results in over 90 reports and maps.

The Depression that followed the stock market crash of 1929 led to a severe belt-tightening in Wisconsin through executive and legislative evaluations of various state agencies. The WGNHS came under special scrutiny of Governor Robert M. LaFollette, Jr. In spite of advice to the contrary, the Governor proposed that the Survey be transferred to the University of Wisconsin, that its budget appropriation be eliminated and that responsibility for funding be with the University. University of Wisconsin President Glenn Frank, Dr. E. A. Birge, former Survey Director, Prof. C. K. Leith, head of the Geology Department, E. F. Bean, Director of the Survey, and Dean Chris L. Christiansen of the College of Agriculture all strongly urged that the Survey's budget be appropriated; but the Governor contended that the fund would be an unnecessary jackpot for the Geology Department of the University. In his view the Survey duplicated the work and responsibility of the University of Wisconsin Geology Department, and therefore, the university administration should have responsibility for its budgeting and support. This argument did not recognize the very distinct difference between the teaching function of the Geology Department and the resource survey, research, inventory, and service functions of the WGNHS.

Thus, in 1931, the WGNHS budget appropriation was cut to \$10,000 and it was transferred to the University of

Wisconsin. Its funding continued to be a line item in the state budget, but the University was given responsibility for Survey programs and budgeting. The Survey retained an additional \$15,000 earmarked for road materials surveys done in cooperation with the State Highway Commission. By fiscal year 1935 the Survey's annual budget had shrunk to \$7,500, reflecting the University's and the Legislature's almost complete disregard for the importance of geologic, hydrologic, soils, and mineral information for making decisions and setting policy on issues involving land and water resources and the environment. Professor C. K. Leith's admonition in 1931 that vetoing the Survey's appropriation and assigning budget and administrative responsibility to the University would "cause irreparable damage if the work is halted for two years" (Wisconsin State Journal, May 1, 1931) proved to be true. In fact, the Survey was ignored until 1943 when, in the midst of World War II, the critical need for minerals drew focus on the importance of the Survey's programs. The need for lead and zinc led in 1943 to a doubling of the Survey's budget to \$15,250--its first budget increase since 1927.

After 1945 the Survey's budget and capabilities increased, albeit at an unsteady pace. In 1945 the Survey received appropriations of \$15,000 each to resume its work in topographic mapping and soils survey, and in 1946 an appropriation of \$15,000 for ground-water research was added. Thus, with the help of various University faculty, Bean succeeded in at least partially restoring the Survey's capabilities in the areas of geology and mine valuation (1943), soils and topographic mapping (1945), water resources with emphasis on ground-water research (1946), and mineral resources (1949). He managed to increase the Survey's program and budget from an historic low of under

\$8,000 (1934-43), which provided for his salary and approximately \$1,000 for secretarial and minor technical help, to more than \$82,000. In addition, he made some progress toward restoring the Survey's pre-1931 programs except for mineral land classification and natural history.

The principal publications during Bean's tenure were a reprinting of the state geologic map at a scale of 1:1,000,000 in 1949 and several cooperative water resources and geology reports published by the U.S. Geological Survey. Bean retired in 1952.

George Fulford Hanson succeeded Bean as State Geologist in 1953. Hanson was born in Schenectady, New York. He received his primary education in England and attended Oxford University, where he enrolled in medicine. From 1937-43 he attended Union College in Schenectady, where he received a Bachelor's degree. He served as an officer in the U.S. Merchant Marine during World War II and from 1946-50 was an instructor at Union College while beginning his graduate training at Harvard. He transferred to graduate school at the University of Wisconsin and completed a Master's degree in 1952. In 1953, after serving as Acting State Geologist for 1 year, Hanson succeeded Bean.

Hanson inherited a Survey with a small staff, restricted quarters, limited budget, and antiquated equipment. Bean had succeeded in gaining the attention of State and University officials to the extent that some of the Survey's programs had been restarted. Hanson's task was one of building Survey programs to a viable program level. Under his direction the Survey's total budget increased nearly fivefold and its staff grew to four full-time geologists, eight part-time geologists/soil scientists, four technicians, and three secretaries plus other federal agency staff employed in cooperative programs. Hanson organized the Survey into



survey/research programs in environmental geology, mineral resources, topographic mapping, geologic mapping and stratigraphy, water resources, and soil survey. Each program contained the traditional basic survey activities of data collection and storage, research and analysis, and publication/outreach/service. The need for increased space was met by the Survey's move in 1966 from University-owned space to non-University owned rental quarters in a converted apartment building.

Hanson placed particular emphasis on the basic need for accurate and reliable topographic maps. He was also deeply concerned with ground-water issues, including pollution, effect of withdrawals on availability, and human impact through indiscriminate land use. His concern led to expansion of the Survey's programs in both of these areas. Under Hanson's influence and direction, the cooperative topographic mapping program with the U.S. Geological Survey focused on completion of the 1:24,000 scale 7.5-minute series. His efforts expanded the program to include the advice and financial support of the Wisconsin Departments of Transportation (1960) and Natural Resources (1974). Under the expanded program the state's share increased from \$15,000 per year to \$206,000; this amount was matched by the U.S. Geological Survey for an annual program total of \$412,000. The 7.5-minute topographic map series was completed in 1986.

The ground-water program, begun at a level of \$15,000 per year in 1946 under Bean, grew by small increments under Hanson from \$16,500 in 1953 to \$34,700 in 1966. Working through the Natural Resources Council of State Agencies and with the strong support of Senator Clifford Krueger, Chairman of the Senate Natural Resources Committee, Hanson and others were successful in gaining support for passage in 1966 of an annual

appropriation of \$300,000 for ground-water research and study. The funds were distributed among various agencies with responsibility for water resources; \$115,000 was allotted to the Survey.

Hanson continued the pattern of growth restarted by Bean and saw the Survey's budget increase from slightly over \$82,000 in 1953 to \$365,325 when he retired in 1972. Under his direction the Survey's programs in geology, soils, and ground water increased dramatically, and its efforts in topographic mapping were substantially aided by the cooperation and contribution of the Departments of Transportation and Natural Resources. During Hanson's tenure, over 100 reports and maps were published by the Survey. Chief among these were ground-water and geologic reports published by the U.S. Geological Survey under cooperative programs, and information circulars and bulletins published by the WGNHS.

With the restructuring and integration of the statewide University System in 1964, the Survey was transferred from its administrative location in the University of Wisconsin-Madison to the University of Wisconsin-Extension, where it was assigned at a divisional level. The move reflected the perception in the University that the Survey's mission and programs more closely resembled the outreach activities of UW-Extension than the traditional instructional functions of UW-Madison; however, the Survey retained its research functions. Subsequently, in 1967, the WGNHS lost its divisional status in UW-Extension and was made a department in the Division of Economic and Environmental Development. Following this, WGNHS staff were extended the privilege of inclusion in the University faculty subject to the same requirements as other faculty.

Meredith E. "Buzz" Ostrom was appointed Director and State Geologist

to succeed Hanson in July 1972. Ostrom received his Bachelor's degree from Augustana College, Rock Island, Illinois in 1952 and his Master's (1954) and Doctor's (1959) degrees from the University of Illinois, Urbana, Illinois.

Ostrom worked for the Illinois State Geological Survey beginning in 1953 as a project assistant in Subsurface Geology and in the Coal Section. In 1955 he was appointed as an assistant geologist in the Industrial Minerals Section, where he worked on a variety of subjects including black shales, sandstones, carbonate rocks, and clays. He joined the Wisconsin Geological and Natural History Survey in November 1959 as Assistant State Geologist with principal responsibility for geology and ground water. In 1968 he was promoted to Associate State Geologist and to Associate Professor in the newly created UW-Extension Department of Geology and Geography.

Ostrom was the second of the Directors of the Geological and Natural History Survey to have worked for another State Survey. His experience with the Illinois Geological Survey provided a basis for viewing the Survey in terms of effectiveness consistent with larger and more extensive operations and programs--that is, operations and programs capable of delivering a broad scope of research, information, and service. Coincident with Ostrom's tenure was a revival of interest in Wisconsin's mineral potential, which followed on the heels of several discoveries of substantial base metal mineral deposits in the Precambrian rocks of northern Wisconsin, a continued and growing interest in ground-water issues, a need to maintain a state program in climatology, and a desire to complete the topographic mapping program begun under Hanson.

Thus, in response to the renewed mineral interest, Ostrom was successful in 1976 in gaining continuing annual appropriations of \$91,000 and \$130,000

to conduct geology and mineral programs, respectively. These programs led to the preparation of a series of 1:250,000 scale bedrock geologic maps, the organization of a core/sample repository, and development of a minerals information/assistance program. A 1:100,000 county bedrock geologic mapping program was started in 1980 with the principal purpose of focusing on problem areas identified in the 1:250,000 mapping program.

Responding to public concern for ground-water issues in 1977 the Wisconsin Department of Administration reviewed the ground-water programs in the WGNHS and the Wisconsin Department of Natural Resources. These reviews, prompted by legislative concern that the state's efforts and expenditures for ground water should be coordinated, led the Department of Administration to require a Memorandum of Agreement on ground-water programs between the two agencies. With completion of the Memorandum in 1979, the Department released a joint annual appropriation to the two agencies of approximately \$300,000 for ground-water studies. The Survey's initial request was for funds for ground-water monitoring research data management, and county resource inventories. The program was later expanded to include accelerated county resource inventories incorporating ground-water quality, soils and geologic mapping at a scale of 1:100,000. Principal geologic focus was on Pleistocene geology because these deposits have the most impact on ground-water quality. By 1982 this program received strong county support, including some local funding.

In 1974 the federal government decided to discontinue funding support of its state climatologist program. Thus, the office of State Climatologist was created in the Survey, with the support of the Wisconsin Natural Resources Council of State Agencies and several

departments in the University System. In the beginning funding was provided 50/50 by the National Weather Service and the UW-Extension. When federal funding ceased, the Survey was obliged to redirect some \$20,000 from its minerals program to keep the climatology program active. For the first time a state office of climatology was supported solely by the state budget and located in the Survey.

The topographic mapping program was completed under Ostrom in 1986 with the advice and strong support of the Topographic Mapping Advisory Committee (composed of representatives from the Departments of Transportation, Natural Resources, and Administration, the State Cartographer, and the UW-Madison Department of Civil Engineering), which he created in 1972. Thus, for the first time Wisconsin achieved complete coverage with one series of topographic maps. Because of the need for periodic updating, the committee expressed concern that the program not be dropped. Their concern was shared by Governor Anthony Earl, who indicated his strong support for a continuing maintenance program. Despite this concern, funding levels for a maintenance program have been severely cut. The Topographic Mapping Committee under Ostrom also initiated and completed a county topographic map series at the 1:100,000 scale. This county series, begun in 1985 and completed in 1987, is published in the conventional English system.

A University of Wisconsin-Extension review of WGNHS programs, budget, administrative location, and facilities, requested in 1983 by Ostrom, led to several recommended changes; some of which were eventually approved and implemented. The Survey's status was changed from Department to a special missions unit in UW-Extension--a designation that more accurately reflected its statutory

functions and responsibilities and its program involvements. In addition, in 1985 the Survey moved to improved but still rented quarters.

Under Ostrom's tenure beginning in 1972 the WGNHS base budget grew from \$365,325 to more than \$1,000,000. The staff has included as many as 10 geologists, 3 part-time soil scientists, 4 hydrogeologists, 1.5 climatologists, 0.5 biologists, 3 technicians, 2 computer specialists, 1 editor, 4 cartographers, 1 administrative assistant, and 5 secretaries, plus more than 20 students. The period was marked by publication of a new 1:1,000,000 scale bedrock geologic map, the first 1:500,000 Pleistocene geologic map, and more than 200 maps and reports.

### THE FUTURE

It is anticipated that certain basic/traditional programs of the WGNHS will continue in the future. For example, the WGNHS will continue to collect subsurface samples of drill cuttings from water wells and cores from mineral exploration and engineering test holes, to study these materials, and to prepare geologic logs. The Survey will also continue to conduct field studies to locate and describe surface rock exposures and to prepare geologic maps. These are examples of the basic kinds of information essential to interpreting geologic conditions and thus to making decisions and setting policy in both public and private arenas involving land use, resource, and environmental issues such as mineral development, waste disposal, ground-water pollution, ground-water availability, construction siting, and others.

Although these basic data programs are likely to continue, it can also be anticipated that program efforts directed to more topical and specific problems are likely to increase. For example, growing concern about ground-water pollution problems has led to increased effort on the part of the

WGNHS to conduct detailed hydrologic and geologic studies. Another example, also related to ground-water pollution potential is the investigation of fractured rock hydrology in areas of shallow bedrock and especially in areas where such rock is coincident with higher population density and land uses that have a potential to contaminate ground water.

The use of computers for data cataloging, filing, and analysis, for map preparation and analysis, and for integrated geographic information systems incorporating a host of geologic, mineralogic, hydrologic, soils, and climatologic factors is also growing. It has been difficult to accommodate these changes within the existing organizational and budget structure. Such new methods of handling data and maps require a closer working relationship with other agencies and disciplines as information developed by all parties is incorporated into a more comprehensive and dynamic whole. The WGNHS has begun to adjust to these changes, which forecast the future.

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## WYOMING

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Laramie, Wyoming 82071.  
Phone 307-742-2054, 721-3920, or 766-2286.

### HISTORICAL SEQUENCE OF ORGANIZATIONAL NAME:

Territorial Assay Office, 1877  
Office of the Territorial Geologist and Mining Engineer, 1879  
Office of the State Geologist, 1890  
Geological Survey of Wyoming, 1933

### NAMES AND TITLES OF ORGANIZATIONAL DIRECTORS AND DATES SERVED:

#### Territorial period, 1877-90

John G. Murphy, Territorial Assayer, 1878-80  
Frederick J. Stanton, Territorial Geologist, 1881-82  
Gilbert E. Bailey, Territorial Geologist, 1882-84  
Samuel Aughey, Territorial Geologist, 1884-87  
Louis D. Ricketts, Territorial Geologist, 1887-90

#### Office of the State Geologist, 1890-1933

Vacant, State Geologist\*, 1890-96  
Wilbur C. Knight, State Geologist\*\*, 1897-1901  
Henry C. Beeler, State Geologist, 1901-08  
Edwin Hall, State Geologist, 1909-10  
Claude E. Jamison, State Geologist, 1911-13  
Loyal W. Trumbull, State Geologist, 1913-19  
Glenn B. Morgan, State Geologist, 1919-23  
Albert B. Bartlett, State Geologist, 1923-27  
John G. Marzel, State Geologist, 1927-33

#### Geological Survey of Wyoming, 1933-present

Samuel H. Knight, State Geologist, 1933-41  
Horace D. Thomas, State Geologist, 1941-67  
Donald L. Blackstone, Jr., State Geologist, 1967-69  
Daniel N. Miller, Jr., State Geologist, 1969-81  
Gary B. Glass, State Geologist, 1981-present

\* The Wyoming Constitution in 1890 authorized a State Geologist, but his duties, salary, and supporting appropriations were not established until 1901.

\*\* This was apparently an honorary appointment by the Governor without any financial remuneration.

### HISTORY OF THE GEOLOGICAL SURVEY OF WYOMING

By Sheila M. Roberts

Many of the historical photographs are from the archives of the American Heritage Center, University of Wyoming.

### ACKNOWLEDGMENTS

Much of this history is condensed from *A History of the Geological Survey of Wyoming* by William Bryans (1).

### INTRODUCTION

At least 3.4 billion years of earth activity set the stage for the overwhelming importance of geology in the

lives of Wyoming's people. During that time, the State received its portion of mineral wealth--weighted heavily toward oil, gas, coal, uranium, and trona. Easily recoverable gold and silver, good soil, and water were less generously endowed. In the process of coping with its unbalanced gifts, Wyoming has maintained a geological survey (or predecessor office) to study and promote development of the State's geologic resources. The methods and results varied considerably with the personalities involved and the events and persuasions of the times. It is an interesting human history, full of grand and mundane doings, true western characters, and politics, and always guided and constrained by the hard facts of Wyoming's geology.

Except for the High Plains Indians and a few fur trappers, very few people chose to make a home in Wyoming until it was time to build a transcontinental railroad. Then the irresistible geologic combination of plentiful coal and an easy route across the mountains drew the Union Pacific tracks through southern Wyoming. Taking advantage of the brief burst of population growth that accompanied railroad construction, Wyoming applied for and received territorial status in 1869. The next goal was to get enough people to become a state. One truly novel approach to attracting settlers was to become the first place in the modern world to give women the right to vote and hold office, which Wyoming did in 1869 (2). It took a few more years for the government to become involved in promotion and regulation of mineral development as a path to growth.

A gold strike in 1867 put South Pass, Wyoming, on the map, but most of the activity was over within a few years. Between 1868 and 1875 there were short copper and gold mining booms in Wyoming, all of which fizzled. By the mid-1870's, at least a few of the territorial policy makers were be-

ginning to think mining might need help to get on its feet in Wyoming. Providing cheap accurate assays to prospectors was one obvious way to promote mining. The idea was first proposed to the 1875 Legislature by Governor John M. Thayer and adopted in 1877 (3). The new Territorial Assayer performed his first assays in a rented stable outside Rawlins, Wyoming, in November 1878. From that point on, Wyoming's government had an official hand in promoting development of mineral wealth.

The history of the agency is divided into three major eras: the Territorial Period (1878-90), the Office of the State Geologist (1890-1933), and the Geological Survey of Wyoming (1933-present) (figs. 1, 2, and 3). The changes in the office reflect changes in Wyoming. In Territorial times, the emphasis was almost entirely on promotion, reflecting the immediate need to increase the economic base and attract enough people to meet statehood requirements. Later, the Office of the State Geologist not only promoted and studied mineral deposits but also began to regulate development as the State acquired some successful mineral industries and a new set of problems accompanying them. In 1933, economics of the Great Depression forced the transfer of the State Geologist's duties to the head of the University's Geology Department, and other agencies assumed its regulatory functions. The activities of the Geological Survey of Wyoming shifted toward promotion through scientific studies and publications. Throughout its varied history, the agency has continuously provided technical and statistical information and advice to other branches of government and served the public by publishing information and answering individual inquiries.

For the first 93 years, the agency's history is primarily the story of the individual men who were Territorial



Frederick J. Stanton  
(1881-1882)



Gilbert E. Bailey  
(1882-1884)

**TERRITORIAL  
PERIOD**

Not pictured: John G.  
Murphy, Territorial  
Assayer (1878-1880)



Samuel Aughey  
(1884-1887)



Louis D. Ricketts  
(1887-1890)

Figure 1. Territorial Geologists.



Wilbur C. Knight  
(1897-1901)



Henry C. Beeler  
(1901-1908)



Loyal W. Trumbull  
(1913-1919)

OFFICE OF THE  
STATE GEOLOGIST

Vacant 1890-1897.  
Not pictured: Edwin Hall  
(1909-1910) and Claude E.  
Jamison (1911-1913).



Glenn B. Morgan  
(1919-1923)



Albert B. Bartlett  
(1923-1927)



John G. Marzell  
(1927-1933)

Figure 2. State Geologists, Office of the State Geologist.





Horce D. Thomas  
(1941-1967)



Samuel H. Knight  
(1933-1941)



Donald L. Blackstone, Jr.  
(1967-1969)

GEOLOGICAL  
SURVEY OF  
WYOMING



Daniel N. Miller, Jr.  
(1969-1981)



Gary B. Glass  
(1981-Present)

Figure 3. State Geologists, Geological Survey of Wyoming.

and State Geologists. Since 1969, however, the State Geologist has coordinated the activities of an increasing number of people, and the history documents a larger group effort.

## THE TERRITORIAL PERIOD

### John G. Murphy: 1878-80

The year before John G. Murphy became the first (and only) Wyoming Territorial Assayer he had acquired civil and mining engineering degrees from Columbia School of Mines and been superintendent of some mines in Venezuela. His vision for the new office was probably bigger than the legislators' and certainly bigger than his tiny budget (\$1,000 for 2 years) could sustain. He was the first of a series of men who dipped into their own pockets to keep their offices afloat. During the first year, Murphy performed 253 assays and spent all of his budgeted funds plus \$351.91 of his own money (1).

The conservative, cattleman-dominated Territorial Legislature had miscalculated the cost of an assayer's office and also failed to understand the needs and character of prospectors. The legislation required that all assays be accompanied by detailed information on the location and nature of the prospect and the prospector's name. This information and the results of the assays were to be open to the public. There was a \$300 fine for samples sent for assay without the required information. The legislative intent was to speed up development of promising areas. However, prospectors often require secrecy to do their work; they do not desire public attention until their claims are established and evaluated.

Murphy resigned in 1880, and the Legislature officially abolished the Territorial Assay Office in 1882. It had already been replaced by an Office of the Territorial Geologist and Mining Engineer, with a new mandate to

produce reports on mining properties (for a fee), which could be used to attract investors (4).

This was an entirely new commission, requiring scientific expertise and salesmanship. The problem, in the legislators' minds, was not a lack of mineral deposits but the scarcity of capital to find and develop them. Wyoming people fully expected to share in the tremendous development occurring in neighboring states--if they could attract the cash. The four men who held the Office of the Territorial Geologist and Mining Engineer all approached this challenge enthusiastically, each from a different educational and philosophical background. Activities of all the Territorial Geologists were limited by insufficient funds. None of them had the money to match their vision. An even more serious problem was the high turnover, a consequence of factors including poor funding and the nature of their office, as political appointees of the Governor.

### Frederick J. Stanton: 1881-82

Frederick J. Stanton, the first Territorial Geologist, had a professional background that reads like the archetypal Western adventurer. Bryans (1) and other sources list his previous occupations as Indian fighter, banker, writer and newspaper publisher, engineer and surveyor, historian, lawyer, and (geology) teacher. He received private geology instruction in England and ran private schools of mines in Denver, Cheyenne, and Laramie before and during his term as Territorial Geologist.

During his year in office, Stanton exhibited Wyoming minerals at the Nebraska and Illinois State Fairs and in Chicago, Milwaukee, and Omaha, much of the tour paid for by himself. Such exhibits were a popular and effective means of advertising. Stanton's annual report, presented in 1882, concentrated on Wyoming's copper prospects. There

were two new copper camps in Wyoming, at Copperopolis on Casper Mountain and at Hartville in eastern Wyoming. The new electrical industry was expanding the copper market and Stanton predicted that copper mining would be "the great specialty of Wyoming in the near future." In fact, the Grand Encampment district in the Sierra Madre, whose huge copper reserves were unrecognized in 1882, did put Wyoming on the world copper map for a short time near the turn of the century.

#### **Gilbert E. Bailey: 1882-84**

Although the historical records are conflicting, it is probable that Stanton left his post at the end of March 1882 and that it was vacant until August, when Governor Hoyt appointed Gilbert E. Bailey (1). Bailey was well educated for the post, with degrees in civil and mining engineering from Chicago University and University of Michigan (some records also list a Ph.D. from Franklin College in Indiana). His experience included teaching natural science at the University of Nebraska and surveying and doing geological reconnaissance work in Wyoming.

This was an era of great field geologists. Between August 1882 and November 1883, Bailey spent 231 days in the field becoming acquainted with Wyoming's mineral resources and writing reports (1). A photograph of Bailey from that time shows a gentlemen in a three-piece suit sitting at a roll-top desk doing paper work. The photographer may have caught him at an uncharacteristic moment. Of course, all that field work was not in the budget--in the first year Bailey spent about twice the \$1,500 annual appropriation, making up the difference from personal funds. The additional \$500 that was appropriated could not have been enough to match Bailey's capacity for field work. He was probably relieved to be out of office by mid-

October 1884 when Samuel Aughey was appointed (1).

#### **Samuel Aughey: 1884-87**

Samuel Aughey was a committed "scientific promoter" of the West, and in that sense was the perfect man for the job (6). He had a degree from Pennsylvania College and a theology degree from Lutheran Seminary at Gettysburg, Pennsylvania. During his pastoral career he was an outspoken abolitionist. After serving with Ferdinand V. Hayden's Geological and Geographical Survey of the Territories in the 1860's, he became the first natural science professor at the University of Nebraska in 1871.

On at least two subjects, oil development and preservation of Wyoming fossils in State museums, Aughey showed unique insight into the resources of Wyoming. At a time when the first commercial oil well had just been drilled at Dallas Dome (in 1884), Aughey inspected an undrilled area north of Casper, Salt Creek, and predicted that it would be a great oil field. The field was initially drilled in 1908 and quickly became the first giant oil field in Wyoming. His report to the governor for the 1884-85 period described all the known oil basins in Wyoming and predicted their success:

...when transportation is once provided, and any one of these oil basins are worked on business principles, they will develop into magnificently paying properties.

Wyoming had been attracting fossil hunters at least since the late 1860's. In 1877, a wonderful deposit of fossil dinosaurs and other Jurassic fauna was discovered at Como Bluff, Wyoming, by a railroad worker, William H. Reed. Reed notified the famous Yale University paleontologist O. C. Marsh and together they excavated the fossils, finding magnificent specimens, particularly sauropod dinosaurs, which were promptly shipped outside the State to museums in the eastern United

States and Europe. In 1885, in an effort to create a good collection of fossils for Wyoming, Aughey hired (at his own expense) a former student from the University of Nebraska, Wilbur C. Knight, to collect fossils at the Como Bluff locality. The fossils were eventually displayed in the Capitol Building in Cheyenne, and even more importantly, Wilbur Knight was inspired to begin his career as a pioneer Wyoming geologist.

Late in Aughey's term, he was involved in a controversial assay case that still threatens his reputation. Aughey developed a new technique for treating ore for assay and applied it to samples from the Silver Crown gold and copper district west of Cheyenne with very favorable results. But other assays showed far less gold. A rerun in Cheyenne, with Wilbur Knight performing the assay, apparently confirmed Aughey's assay, but Knight was suspicious of the results and some historians have suggested Aughey "salted" the sample (more extensive discussion in [1]). Copper and gold were mined in the Silver Crown district from 1879 to sometime around 1917, and exploration has continued to the present, but production never matched Aughey's predictions.

Aughey resigned at the end of his term in March 1887.

#### Louis D. Ricketts: 1887-90

The next Territorial Geologist came with high academic and professional credentials, but his work was stifled by a lack of funding that occurred before and during the transition from Territory to State. Louis D. Ricketts had a Ph.D. in economic geology from Princeton University and had been a successful surveyor and superintendent of mines in Leadville and Silverton, Colorado.

Ricketts' ambitious plans included collecting data for a state geologic map, gathering minerals and fossil

specimens for a museum, conducting experiments on the coking properties of Wyoming coal, and periodically publishing bulletins on mineral resources. He did succeed in gathering some information for the state map, although it was not published during his term. Ricketts later became a leading figure in Arizona copper mining.

At the end of the Territorial Period, the only really successful mining venture in Wyoming was coal, which employed perhaps 2,000 men (2) and had been developed by the Union Pacific Railroad and others without State assistance. State promotion of the minerals industry was hardly a smashing success. Was it worth it? The combined Offices of the Territorial Assayer and Territorial Geologist and Mining Engineer had set a precedent. The appointees had maintained the credibility of the idea of a Territorial/State Geologist and prepared the way for a more active role by gradually increasing the range of activities and budget. The annual reports to the Governor probably maintained the visibility of mineral resources to a Legislature that was more concerned with ranching, and the reports certainly did generate some useful information and outside interest.

#### OFFICE OF THE STATE GEOLOGIST: 1890-1933

The idea of a State Geologist was written into the new Wyoming Constitution (Article IX Mines and Mining) but in reality, when Wyoming entered the Union in 1890, the position could not be filled. The Constitution gave the Governor authority to appoint a State Geologist and *ex officio* Inspector of Mines for a 6-year term. The legislation specified the qualifications of the appointee, but it did not define the duties of the office or set a salary.

The 1889 Constitution also included a provision for a production tax on



minerals (severance tax) but, under heavy pressure from the railroad lobby, lawmakers failed to establish a rate. Both the Constitutional Convention and the 1890 Legislature were dominated by stockmen (2). Mineral development and resulting tax revenues were simply not major concerns.

Thus, Wyoming was without a State Geologist when the big copper strike at Encampment developed and the oil industry began its long-term boom. From the 1860's through the 1890's many geologists had been working in Wyoming, publishing their research in reports of the U.S. Geological and Geographical Survey of the Territories (especially the expeditions led by F. V. Hayden), the 40th Parallel exploration reports (especially Clarence King's), and in numerous scholarly journals. All of this paved the way for serious exploration. By the 1890's enough geologic information was available to facilitate the systematic search for mineral and petroleum deposits.

#### **Wilbur C. Knight (*de facto*, 1897-1901)**

In the early 1890's, W. C. Knight (Samuel Aughey's field assistant during the Territorial period), by then professor of geology and mining engineering at the new University of Wyoming, published several reports on Wyoming's geology. By 1897, he was *de facto* State Geologist, acting under an appointment from Governor William A. Richards, without Senate confirmation and without pay. The *de facto* appointment came after the Governor had unsuccessfully attempted to get the position funded by the 1895 and 1897 Legislatures (1).

Knight's promotional activities centered on presentation of scientific and economic information. From 1897 to 1902, he published reports on Wyoming's oil and gas fields, building stone deposits, natural soda (alkali

lake) deposits, artesian basins, fossils, and the Sweetwater (South Pass) mining district (7). He apparently did not write annual reports to the Governor. His work was published in professional journals, in various University of Wyoming bulletins, and even the *National Geographic* (7). One of Knight's most important accomplishments was the 1900 publication of the first geologic map of Wyoming (part of his report on artesian basins). He continued to contribute information about Wyoming geology until his death in 1903.

#### **Henry C. Beeler: 1901-08**

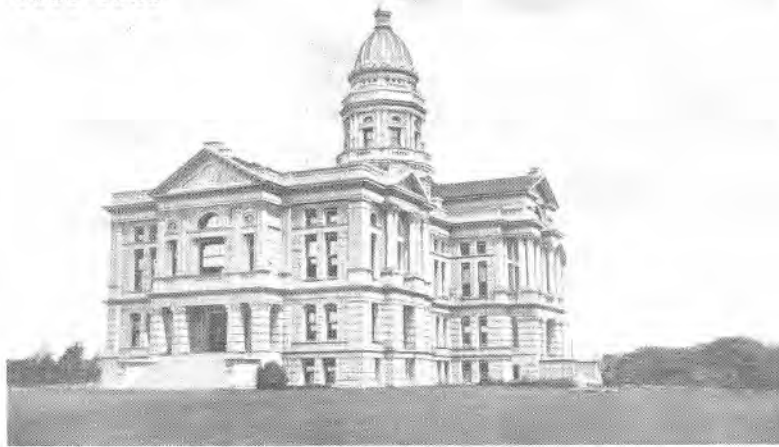
As the century ended, mining activity in Wyoming experienced another boom, with the Grand Encampment copper strike, iron ore at Hartville, and a growing oil industry. The 1901 Legislature finally decided to fund a State Geologist, located in Cheyenne (fig. 4) and appointed by the Governor. The State Geologist's prescribed duties included writing mineral prospectus reports for stock markets and collecting data as before, and also publishing and circulating information, identifying rock and mineral specimens free of charge, and acting as *ex officio* Inspector of Mines (8).

Henry C. Beeler was appointed by Governor DeForest Richards as the first salaried State Geologist. He had a degree from Colorado School of Mines and employment experience as a mining engineer and chemist in, among other places, the Grand Encampment copper district and several Wyoming coal mines. He was well prepared to visit and report on mining properties, which he began immediately.

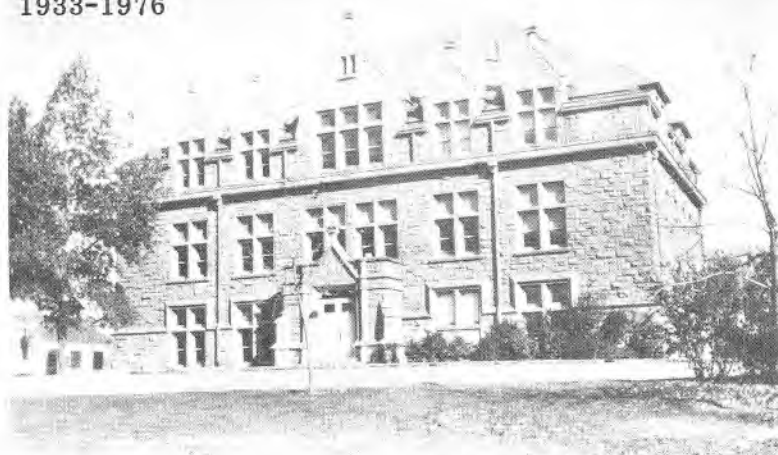
During Beeler's term, and usually at his recommendation, the Legislature vastly expanded the responsibilities of the Office. The 1903 Legislature defined the State Geologist's responsibilities as *ex officio* Inspector of Mines (other than coal) to include examining mines and

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1933-1976



1976-Present



Figure 4. (Top) the State Capitol Building in Cheyenne in the early 1900s; (middle) Science Hall (S.H. Knight Geology Building), University of Wyoming campus, in 1935; (bottom) the new Geological Survey of Wyoming Building in 1976.

mills with regard to worker safety, investigating accidents, attending coroner's inquests on fatal accidents, and regulating the amount of explosives kept in mining camps and the methods of storage. Beeler understood that potential investors would not be attracted to states with bad reputations for accidents and explosions--encouraging mine safety was an extension of his mandate to promote development. He was also actively involved in investigating mine swindles.

The Office of the State Geologist accelerated its publishing efforts and even circulated promotional literature at the 1904 Exposition in St. Louis. Beeler provided data for an industrial map of Wyoming, which was published by a Denver firm in 1907. He also attempted, with some success, to produce and disseminate accurate statistical information about Wyoming's mineral industry. That activity was limited by legislation that made reporting by mining companies voluntary rather than mandatory. In 1907, the State Geologist became responsible for writing mineral reports on state-owned lands and was named to the new Department of Immigration, which was created to advertise Wyoming and attract settlers and investors. In this capacity, Beeler authored several publications including one entitled *Wyoming - why not?* Beeler's publications and promotions attracted prospectors, miners, and mining companies to Wyoming, and were probably one of the most important factors in creating the great copper boom of the early 1900's.

With all this activity, it is not surprising that Beeler ran out of money and time. He made several suggestions to the Governor and Legislature to improve funding and organization of the Office that were never acted upon. Beeler's term of office spanned a time of prosperity and expansion for Wyoming's mineral industry, and most

of his activities were concerned with base and precious metals development. He left office in 1908 about the same time the metals industry in Wyoming experienced a sharp decline. His 7½-year tenure as State Geologist was the record for the Office of State Geologist period.

#### **Edwin Hall: 1909-10**

Bryans (1) reported little success in discovering the details of Edwin Hall's life or his term of office. After a 3-month tour of the State's mining camps and oil fields, Hall wrote a report to the Governor in 1910 expressing his opinion that Wyoming's mineral resources were adequate, but that development was hindered by transportation problems, absorption of capital by the livestock industry, and bad publicity resulting from fraudulent mining schemes.

Hall proposed a massive reorganization of the agency (in some ways predicting the Geological Survey) and then resigned before the new Governor took office. Bryans (1) suggested that the tendency of new governors to appoint their own officials probably prompted this and some other resignations during the period.

#### **Claude E. Jamison: 1911-13**

A degree from the Missouri School of Mines and Metallurgy and employment in Wyoming's oil industry prepared Claude Jamison for his appointment. His official tour of Wyoming's mining and oil regions included geologic mapping of parts of Fremont, Converse, Carbon, and Natrona Counties.

Jamison published the first numbered Bulletin of the Office of the State Geologist and answered several thousand letters of inquiry about the State's mineral and oil resources. Apparently, his efforts were appreciated by the Legislature, which awarded a \$15,000 contingency fund for printing more publications. When Governor Carey reduced the sum to \$10,000

before signing the bill, Jamison initiated a lawsuit challenging the Governor's right to that action. Carey then cut off all funds to the agency and in the fracas that followed, Jamison resigned.

#### **Loyal W. Trumbull: 1913-19**

Loyal Trumbull published his first report on Wyoming geology in 1907 (7) when he was teaching geology and mining engineering at the University of Wyoming. The graduate of Colorado School of Mines was no stranger to the State, and his tenure as State Geologist was productive.

In 1917, after 4 years of mapping and compilation and overcoming problems with funding, Trumbull published the first colored geologic map of Wyoming. His office published 12 new bulletins, including the first bibliography of Wyoming geology. Trumbull was also the first State Geologist to issue unfavorable reports about properties he considered to be of questionable value. During Trumbull's term, the minerals industry was depressed while the petroleum industry was growing. He publicized new fields and his office identified two structures that became oil and gas fields. He also anticipated the need for regulation of oil and gas waste.

Trumbull participated in the beginning of a controversy that still rages over withdrawal of public lands from commercial exploitation. The Withdrawal Act of 1910 gave the President power to withhold certain public lands from development. Trumbull was extremely critical of any Federal government intervention in land use, which he felt had hindered the petroleum industry in Wyoming.

At the end of his term, Trumbull made some suggestions for reorganization that were used by Governor Carey in an unsuccessful argument to disband the Office of the State Geologist.

#### **Glenn Beckly Morgan: 1919-23**

The Office survived, and the Governor appointed the next State Geologist, Glenn Beckly Morgan, a graduate of Missouri School of Mines and former mineral and oil expert for the Department of the Interior.

Although Governor Carey continued to resist funding increases, the Legislature expanded the duties of the State Geologist with respect to evaluating the minerals (especially petroleum) potential of state lands and regulation of the petroleum industry. In 1921, the overworked State Geologist was granted two oil and gas inspectors. Publications during Morgan's tenure were almost entirely mimeographed, in-house press bulletins promoting the oil and gas industry.

#### **Albert B. Bartlett: 1923-27**

When the Democrats regained the Governor's chair in 1923, Governor William Ross replaced Morgan with a new appointee--the first to have been born in Wyoming. Albert Bartlett was the son of historian I. S. Bartlett. He had a mining engineering degree from Missouri School of Mines and his experience included work as U.S. Mineral Surveyor and a term as Wyoming Deputy State Engineer.

In 1923, mining, agriculture, livestock, and railroads were experiencing postwar recessions, but Americans were buying and driving automobiles at record rates and the oil industry was growing rapidly. Teapot Dome, south of Salt Creek oil field, was world famous, partly because of its oil reserves and partly because of a national fraud and bribery scandal over the Interior Department's leasing it without competitive bid. In 1923, Wyoming's 44-million-barrel oil production was an overwhelming 61 percent of the state's products valuation (2). In that year, Governor Ross requested a severance tax on oil. Although there was support



for the tax from both political parties, the constitutional amendment to create a 1 percent severance tax was defeated in the 1924 election. Subsequently, competition from other states forced a drop in Wyoming oil production and the subject of taxation died.

Bartlett's office was busy with oil and gas inspections and evaluating the petroleum potential of State lands. The inspection aspect had grown so much by 1924 that, at Bartlett's request, the inspectors were relocated to Casper, Wyoming's oil center. The State Geologist, with a budget devoted mostly to petroleum regulation, also attempted to help the mining industry find markets, published two new bulletins, worked on creating a new collection of Wyoming minerals for display, and (of course) presented his case for increased funding.

#### **John G. Marzel: 1927-33**

A new governor in 1927 meant a new State Geologist. John G. Marzel's education was in mining and civil engineering, with a degree from Case School of Applied Science in Cleveland. He had supervised irrigation projects for the U.S. Reclamation Service, conducted a private civil engineering practice, been Goshen County Surveyor and Torrington City Engineer, and would have preferred to be State Engineer (1).

Marzel was a competent State Geologist through an extremely difficult time. The price of oil dropped and production declined until, in 1933, it was only about one-quarter what it had been in 1923 (2). All other mining enterprises were already depressed. Nearly all of Marzel's requests for additional funding and staff were refused. Nevertheless, for a brief time, Marzel headed an expanded office. The 1927 Legislature had added the supervision of mining operations on State and school lands to his duties. For the first time, the State Geologist had

legislative approval to hire a deputy. By 1930, the Office included Marzel, his Deputy Director C. S. Dietz, the State Mineral Production Supervisor Cyrus O. Wertz, a full-time oil and gas inspector, two stenographers, and a clerk. Legislation also allowed the Office to cooperate with other State and Federal agencies to produce surveys and other studies that would encourage economic development.

Marzel's efforts to get funding for cooperative projects with other agencies were stifled by the depression. His bold suggestions to the Legislature to regulate waste in the petroleum industry were also unsuccessful. It is a credit to his perseverance that Marzel's term was productive in several areas. Three bulletins were published. Marzel advertised Wyoming's mineral resources at State fairs and other regional exhibits. He successfully promoted geology education in public schools. Toward the end of his term, he inspected dam and reservoir sites for the Federal government's work projects and had a pamphlet on placer gold mining prepared to help the unemployed.

#### **THE GEOLOGICAL SURVEY OF WYOMING**

Against Marzel's advice, the financially strapped 1933 Legislature abolished the Office of the State Geologist and adopted an idea that had been around at least since 1910, to make the head of the Geology Department at the University of Wyoming the State Geologist. The original impetus for change was a budget cut; the actual result was a whole new concept. When the legislators finished, the regulatory function of the Office had been transferred to the State Land Board and the mandate to promote mineral development was totally redirected toward obtaining and disseminating knowledge about the State's geology. The legislation required the new Survey to study Wyoming's geology (especially

metallic and nonmetallic resources), topography, and fossils; prepare, publish, and distribute reports and maps descriptive of the mineral resources, geology, and fossil life; and produce bibliographies of published literature on the geology of Wyoming (9). The State Geologist's term of office was left undefined (later changed to 6 years). A \$1,500 contingency fund was appropriated to pay for publications, field expenses, and an assistant's wages, but it would be 20 years before the State Geologist would receive any additional compensation besides his University pay.

Bryans (1) listed the advantages of the new arrangement, some of which had been enumerated in 1926 by S. H. Knight: longer tenure for the State Geologist would give him time to become familiar with Wyoming's complex geology; locating the office at the University (fig. 4) would provide students with valuable training experiences and make their labor available to the State at low cost; and the proximity of library facilities and University faculty would aid research.

#### **Samuel H. Knight: 1933-41**

The first administrator of the Geological Survey of Wyoming was the son of the first (*de facto*) State Geologist, Wilbur C. Knight. Bryans (1) said Samuel Knight was "destined" for the job, having spent nearly his whole life with Wyoming geology. As a youth, Knight worked Wyoming's fossil fields with William H. Reed, discoverer of the Como Bluff dinosaurs. He had a Bachelor of Arts degree from the University of Wyoming and Masters and Ph.D. degrees in geology from Columbia University. His graduate degrees were acquired with research on Wyoming's geology. Knight had been head of the Geology Department at the University of Wyoming since 1917 (a position he held until he retired in 1963) and had already turned down the

State Geologist position 10 years earlier (1).

During at least the first 3 years of Knight's term, he and his faculty and student assistants were preoccupied with drought relief. They wrote reports on State and Federal drought-relief projects and proposed dam, reservoir, and diversion sites; studied the water supplies of several Wyoming towns; performed regional ground-water research; and helped locate wells. Later, the Survey also investigated some of the nonmetallic resources of Wyoming, including bentonite, asbestos, and phosphate.

The advantage of the new Survey's connection with the Geology Department was obvious when five of the seven numbered bulletins printed during Knight's term were the results of masters thesis work. One of these was by John David Love, who later authored many important studies of Wyoming geology and the 1955 and 1985 versions of the *Geologic Map of Wyoming* (1:500,000) during his long career with the U.S. Geological Survey. When money was short, Knight personally helped fund some of his students' research.

During Samuel Knight's term, the State Planning Board unsuccessfully attempted to move the Geological Survey back to Cheyenne. Knight's 1938 letter to Governor Leslie Miller opposing the move contains a statement that illuminated his feelings about his job:

... I realize that services without salary are usually lightly held and considered by others of little value. Our compensation has been an opportunity to be of service to the state. [For more complete text see (1).]

Knight resigned as State Geologist in 1940, having set the course for the Survey.

#### **Horace D. Thomas: 1941-67**

Knight was succeeded by another University of Wyoming geology pro-

fessor, Horace D. Thomas, who served an amazing 26 years in office, the record for a Wyoming State Geologist. He was also a Wyoming native, educated at the University of Wyoming and Columbia University (Ph.D.). He had worked for the Union Pacific Railroad and Union Oil Company of California.

Less than a year after Thomas took office, the United States was at war and the country was looking to Wyoming for fuel and strategic minerals. The war initially strained the resources of the Geological Survey because professors were busy training new geologists and students were employed by private industry and unavailable for summer field work. In 1943, the Legislature relieved Thomas and his assistant of teaching duties and appropriated \$10,000 for Survey work. Most of the remaining war-time activity was devoted to the search for and evaluation of fuels and strategic minerals of Wyoming. This was accomplished in cooperation with other agencies and was well funded. An important offshoot of a cooperative project with the U.S. Geological Survey Fuels Section was the establishment, in 1943, of a well core and sample repository in Laramie, which made cores and cuttings from Wyoming's deep wells available in one place for study. Although the strategic minerals search did not directly result in development of deposits, it did provide a much needed data base, including information on some previously undefined resources.

Thomas served on a number of war-related committees and testified in Congress about Wyoming's coal resources. He also testified against President Franklin Roosevelt's creation of the Jackson Hole National Monument in 1943. The mountainous part of the Tetons had been set aside as a National Park in 1929, and creation of the monument was a controversial effort to protect some of the adjacent valley to the east, including Jackson

Lake. Thomas joined other Wyoming public figures to try to prevent what they saw as an infringement of State's rights (1, 10).

After the war, Thomas continued as State Geologist, but his teaching duties resumed. In 1945, the Legislature redefined the State Geologist's duties, reminiscent of the position before 1933, to include making mineral assessments (other than coal and petroleum) on State or school lands, compiling information on the State's mineral resources, designating and supervising mining operations on State and school lands, and maintaining records of Survey activities. The 1951 Legislature made the State Geologist a member of the new Oil and Gas Conservation Commission, which was created to regulate and prevent waste in Wyoming's petroleum industry.

In 1951, the Survey acquired its first full-time geologist, William H. Wilson. By 1966, Thomas' staff included several part-time geologists and assistants, a secretary, a part-time draftsman and a part-time librarian. In 1953, the Legislature granted the State Geologist a small salary in addition to his University pay.

The expanding Survey moved to new quarters in the enlarged Geology Building in 1955. During the 1950's and 1960's, water studies continued, Wyoming assisted the U.S. Geological Survey in producing a new State geologic map (1955) at 1:500,000 scale, and laboratory facilities were improved. An electric log file for wells in Wyoming was created and has been continually updated to the present. The Survey played an important role in studying and promoting the development of U.S. Steel's Atlantic City iron mine. In 1957, a huge project to map and evaluate the economic minerals potential of Precambrian rocks in southeast Wyoming was begun under the direction of Dr. Robert Houston. This work continued for over 10 years and resulted in a series

of maps and other publications. In the 1950's and 1960's, the uranium boom in the basins of Wyoming made the State the second largest producer in the Nation. Dr. Thomas and his staff provided invaluable basic data to this expanding industry.

Publications in the post-war period of Thomas' tenure included around 40 additions to the regular series plus open file reports, reprints, and miscellaneous publications. Several new publications, for example, *A Field Guide to the Rocks and Minerals of Wyoming*, summarized and synthesized geological information about Wyoming in a convenient form for the first time.

In the middle of actively planning for Survey growth and increased service to the State, Thomas died in office in 1967.

#### **Donald L. Blackstone, Jr.: 1967-69**

Governor Hathaway appointed a professor and former head of the Geology Department at the University of Wyoming to fill Thomas' unexpired term. Dr. D. L. Blackstone, Jr., was educated at the University of Washington (B.S.), Montana State University (now University of Montana, M.S.), and Princeton University (Ph.D.). He worked for Carter Oil Company and was a professor at the University of Missouri before coming to the University of Wyoming in 1946.

Under Blackstone's leadership, a colored geologic map of the Precambrian project study area was issued in 1968 and the project was completed in 1969. A study of mineralized areas in the Absaroka Mountains, begun during Thomas' administration by William H. Wilson, interested several companies in exploring for copper and molybdenum in northwest Wyoming. The Survey also studied Wyoming's glass sand, limestone, bentonite, and iron deposits, continued its cooperative programs with State and Federal agencies,

published a bulletin and four preliminary reports, and prepared the *Bibliography of Wyoming Geology (1917-1945)* for publication.

Perhaps Dr. Blackstone's most important contribution to the Survey during his tenure was the vision he offered for reorganization of the agency. In 1969, acting under advice from Blackstone and Governor Hathaway, the Legislature separated the Survey from the Geology Department, creating a full-time State Geologist/Survey Director (still located in Laramie). The three-person Advisory Board, which was established in the 1933 reorganization, was expanded to eight members. The budget nearly doubled, to \$190,000 (11). Dr. Blackstone resigned to return to teaching in 1969, but he remains involved with the Survey as a member of the Advisory Board.

Why was the 1969 Legislature so receptive to the petitions for reorganization and increased funding? Bryans (1986) pointed to the slow growth of Wyoming's general economy during the 1960's and Governor Hathaway's assertion that the State should have a full-time State Geologist and expanded staff to assist economic development of its mineral resources. Another important act of the 1969 Legislature may have contributed. In that year, the State was looking for a new source of revenue and the petroleum, uranium, iron ore, coal, and trona industries were all relatively prosperous compared to other segments of the economy. The 1 percent severance tax enacted in 1969 represented increased recognition of the importance of mining and petroleum in Wyoming's economy; the argument for an expanded and more professional Geological Survey made sense.

#### **Daniel N. Miller, Jr.: 1969-81**

Governor Hathaway's new appointee was Chairman of the Geology Department of Southern Illinois



University. After receiving a Ph.D. from the University of Texas, Daniel N. Miller, Jr., had worked in petroleum research and exploration before becoming a professor.

Miller's term spanned a wonderful decade (plus) for Wyoming's mineral economy and the Geological Survey, thanks largely to world events that created an energy crisis. The price of oil quadrupled after the Arab oil embargo in 1973, and exploration and production rose accordingly in Wyoming, with big new discoveries, especially in the Overthrust Belt and Powder River Basin. After a long decline, beginning when railroads switched from coal- to diesel-powered engines in the 1950's, coal was in demand again for electric generating plants. The price of uranium, the fuel for nuclear power plants, was five times higher after the embargo (2), which encouraged accelerated mining and exploration.

The Survey's full-time staff grew from 4 in 1969 to 12 in 1980, including the Director, 5 staff geologists, an editor, 2 cartographers, 2 clerk-stenographers, and a secretary. Each staff geologist headed an operational section that included part-time employees. The sections--oil and gas, minerals, coal, environmental geology, and stratigraphy--were created to handle increasing demands of public and government inquiries, which now consumed 60 to 80 percent of the Survey's time, and to enhance Survey research activities. By 1976, the severance tax income to Wyoming was \$40 million, mostly from oil production (2), and the Geological Survey had a brand new \$1 million building on the University of Wyoming Campus to replace the outgrown quarters in the Geology Building addition (fig. 4).

The increased activity of the expanded Survey is reflected in publications. During Miller's tenure, the Survey issued nearly 80 new publications in addition to the biennial

reports. Several bulletins for the general public were written on specific aspects of Wyoming geology--fossils, general geology, minerals and rocks, caves, and thermal springs. Miller also initiated four new series of publications: public information circulars, memoirs, a numbered map series, and a county resource series.

Miller served on the Wyoming Oil and Gas Conservation Commission, the Interstate Oil and Gas Compact Commission, and the Governors' Interdepartmental Water Planning Conference. He was named Minerals Industry Man of the Year by the Casper Chamber of Commerce in 1976. In 1982, he resigned to become Assistant Secretary for Energy and Minerals for the U.S. Department of the Interior.

#### **Gary B. Glass: 1981-present**

The new State Geologist, appointed by Governor Ed Herschler, was the Survey's Coal Geologist and Deputy Director during Miller's administration. Gary B. Glass graduated from Lehigh University with a Master's degree in geology. After 3 years active duty with the U.S. Army Corps of Engineers, he had worked for the Pennsylvania Topographic and Geological Survey before coming to Wyoming in 1971.

The pendulum of Wyoming's mineral economy began to swing away from good times in the early 1980's. After the 1979 Three Mile Island nuclear power plant accident, construction of new nuclear power plants in the United States slowed markedly, and the market for domestic uranium fell. Of the 17 uranium mines operating in 1979, only one remained active in 1987. The market for coal began to level off. The price of oil plunged when Third World producers flooded the market, and many exploration and development companies moved their offices and activities out of Wyoming. The last iron mine operating in Wyoming closed in 1983.

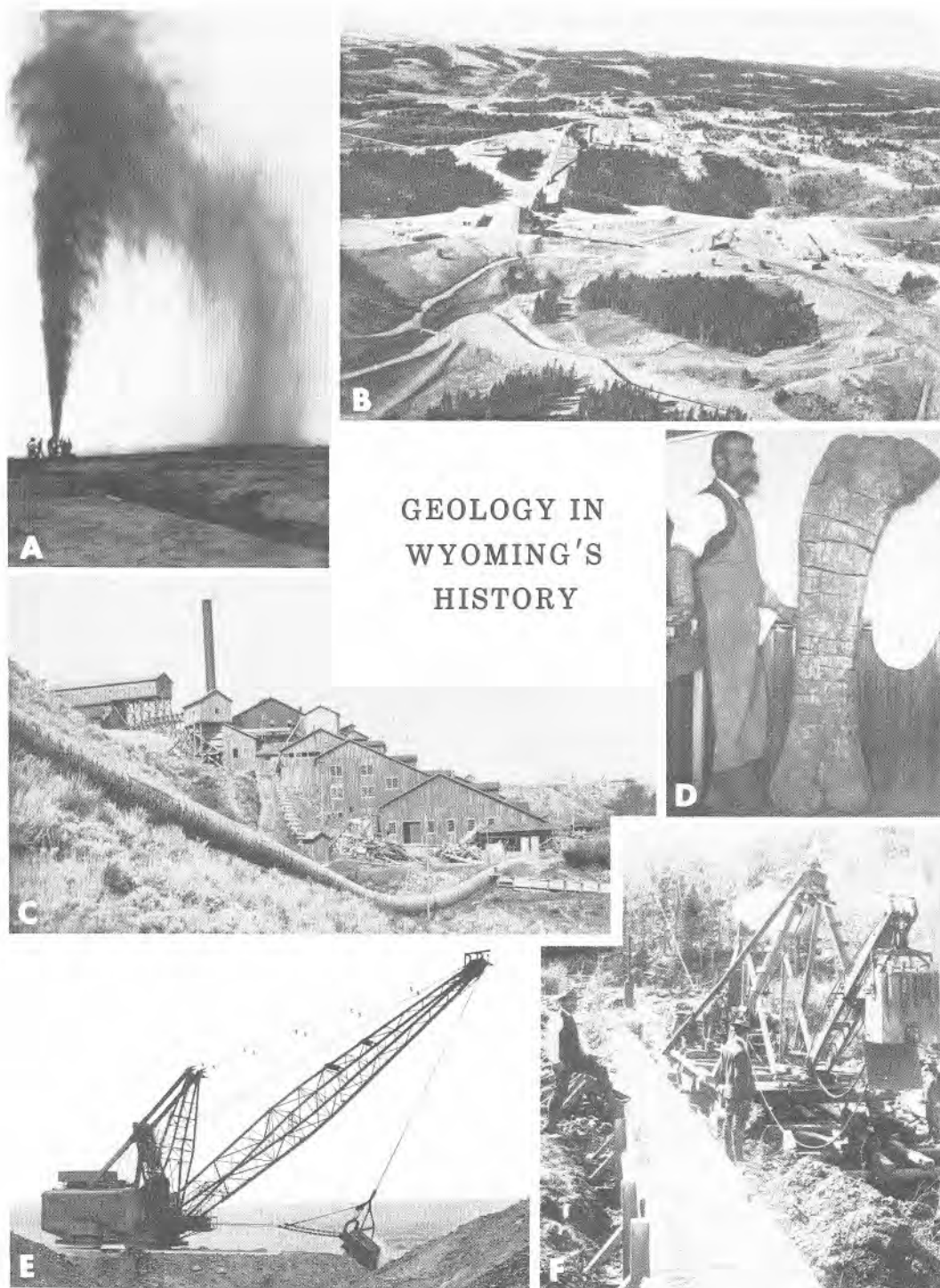


Figure 5. Geology in Wyoming's historical past and present: (A) a gusher at Salt Creek oil field, 1920s; (B) U.S. Steel's Atlantic City iron mine, 1963; (C) Grand Encampment Smelter, circa 1905; (D) William H. Reed, discoverer of Como Bluff fossil locality, with dinosaur bone, circa 1898; (E) coal dragline, 1974; (F) steam shovel operating at a Wyoming placer mine, 1905.

The slowdown in the mining and petroleum industries did not result in reduced Survey activity. Minerals (especially oil, gas, and coal) remained the largest single source of tax revenue to the State. The Geological Survey continued providing advice and information to government agencies; reviewing environmental impact statements, resource management plans, and industrial siting permits; and answering thousands of inquiries from the public, industry, business, and universities. In fact, the number of these inquiries doubled between 1981 and 1987 and is well over 5,000 annually.

Because technical maps and reports are essential for wise management of mineral resources, to maintain exploration interest and activity, and to create an information base for the next boom, Glass accelerated the Survey's publication activities. Between 1981 and 1987 the Survey printed about 70 new publications in the regular series and dozens of miscellaneous publications. In addition, nearly 90 open file reports were issued. In 1984, Glass and the geological staff began a new publication series, *Wyoming Geo-notes*, a quarterly digest of mineral production, exploration, and Survey activities (a single issue was produced in 1978). New 1:500,000-scale maps of some of Wyoming's most important resources appeared—oil and gas (1984), metallic and industrial minerals (1985), and construction materials (1986). As a service to the public, the Survey also expanded sales of U.S. Geological Survey topographic and geologic maps.

Organizational changes during Glass' term include the 1983 separation of the Minerals Division into a Metallic Minerals Division and an Industrial Minerals and Uranium Division. Also in 1983, membership in the State's new Consensus Revenue Estimating Group, which presents revenue forecasts to the Governor and Legislature, was added to

the State Geologist's duties. In 1986, the name of the Environmental Geology Division was changed to the Geologic Hazards Division, reflecting that Division's emphasis on studies of landslides and other potentially hazardous geologic conditions in Wyoming.

In 1983, during Glass' term, the Geological Survey of Wyoming celebrated 50 years of service. Actually, there could have been a centennial in 1978, commemorating the original Territorial Assayer's office; or the State Geologist could mark 1997 or 2001 for centennial ceremonies. By whatever name, the agency has grown and changed along with Wyoming, promoting the diverse geological resources of the State (fig. 5) for over 100 years.

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