Association of American State Geologists

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Front Cover Photo: Bear Den Member of the Golden Valley Formation (Paleocene) in North Dakota. **Credit:** North Dakota Department of Mineral Resources

Contents Page Photo: 2023 AASG Annual Meeting in Colorado **Credit:** Unknown

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PRESIDENT'S LETTER



James E. Faulds

During the 2022–2023 year, AASG returned fully to normal activities, after several years of adjustments induced by the COVID pandemic. After a virtual fall liaison meeting in September 2022, both the 2022 mid-year and 2023 spring liaison meetings were held in person. This was followed by a fantastic annual meeting in Glenwood Springs, Colorado, in June 2023. Although we all

appreciated the return to in-person activities, we have not forgotten lessons learned from the COVID years, and thus we continue to offer virtual options for many of our activities that increase participation for more states, AASG associate members, and federal partners.

Major AASG goals in the past year included: (1) revamping AASG committees; (2) developing additional opportunities for communication within AASG; (3) continuing to build on our special partnership with the USGS; (4) strengthening our relationship with DOE; and (5) reviewing DEI efforts within state geological surveys.

The first two goals were prompted in part by dramatic changes in AASG membership in recent years. About 20 of our State Geologists are new since 2020. We had eight new State Geologists in just the past year. Based on the large influx of new State Geologists and feedback received at the 2022 Annual Meeting, additional opportunities for communication within AASG were developed. The first involved guarterly updates aimed at informing all members of activities of the Executive Committee and important events affecting membership. Three quarterly updates were held through the year, with one each in September, January, and April. Topics covered at these meetings included updates on marquee programs (e.g., STATEMAP, EarthMRI, NGGDPP), relevant legislation, federal budgets, AASG committees, and AASG business items. These meetings were also used to assist with planning for the fall and spring liaisons. In addition, considering the large number of new State Geologists, a general AASG orientation meeting was held in mid-December to review the various components of AASG (e.g., Executive Committee and officer duties), describe AASG events, and provide a platform for asking questions about AASG.

A major effort was directed toward revamping AASG committees, with the goal of returning to an earlier model whereby committees focused on a set of discrete goals in a given year, produced an annual 1,000-word abstract describ-

ing their activities, and led breakout sessions at the annual meeting. Although some committees had been very active, some were not. Several committee chairs were also serving as AASG officers and thus spread thin in their capacity to lead committees. Considering the many new state geologists in the past few years, this was also a great opportunity to engage many of our new members in AASG activities. In the end, new chairs were appointed for nine of the 13 committees, excellent 1,000-word abstracts were received from the committees in May, and the committees organized superb breakout sessions for the Annual Meeting. In recruiting new chairs for the committees, it was realized that we did not have information on the expertise of our State Geologists. Thus, State Geologists were asked to list their expertise in the contact information spreadsheet on the Google Drive (see "SG Mailing and Capabilities").

Our fall and spring liaison meetings were a great success in 2022–2023. President-Elect John Metesh, Elizabeth Duffy, and Caleb Chappell did an excellent job for both meetings, with the spring meeting being the first in-person liaison since February 2020. We structured our meetings with the USGS and some federal agencies a bit differently than in the past. In the fall, we had longer, more in-depth virtual meetings with the USGS that spanned two full days. In addition, we had a longer meeting with the DOE at the fall liaison. For the in-person spring liaison, we held a full-day meeting with the USGS, as well as longer, more in-depth meetings with both the DOE and the National Academies of Sciences. Elizabeth Duffy arranged for meetings with congressional staffers, focusing on further enhancing long-term strategic relationships with the offices of key Senators and Representatives, as well as establishing new relationships with new members of Congress with seats on important committees. Over the past several years, Elizabeth has been instrumental in strategizing to gain support for our major legislative goals. In addition to the meetings with congressional staffers and federal agencies, we held the first Pick and Gavel Banquet since 2020. The banquet was very successful and included remarks by Tanya Trujillo (Assistant Secretary, Department of Interior) and David Applegate (USGS Director). In addition, the Pick and Gavel Award was presented to Senator Cortez Masto of Nevada, with Kyle Chapman (her Senior Policy Advisor) accepting the award on her behalf at the banquet.

We made further progress on funding for major federal programs for state geological surveys in 2022–2023. For example, funding for the National Cooperative Geologic Mapping Program (NCGMP) continued to increase, with an additional ~\$2M of funding for FY23. However, ~\$1M of that increase was allocated to "fixed costs" within the USGS and was not directed toward STATEMAP and FEDMAP activities, amounting to \$500k less than expected for the STATEMAP program. Thanks to the Bipartisan Infrastructure

President's Letter

Law (Infrastructure Investment and Jobs Act), enhanced funding continued for the EarthMRI program and NGGDPP. The USGS provided monthly updates on all of their major programs to the AASG Executive Committee. Our continued strong partnership with the USGS enabled AASG to help coordinate and implement funding for these and other programs. Thanks to the enhanced funding, the scope of these programs has been broadened and the programs now benefit more state geological surveys. We very much appreciate the leadership of our colleagues and friends at the USGS in administering these programs and fostering such a strong relationship with AASG and State Geological Surveys. These programs epitomize the many benefits that can be gleaned from strong federal and state partnerships.

Initial planning began in 2022–2023 to maintain high levels of funding in several of these programs once the Bipartisan Infrastructure Law expires in a few years. Documenting the progress and success stories is important for maintaining these higher levels of funding. Thus, a call went out to all state surveys to provide examples of the positive impacts of the enhanced funding. Dozens of success stories were received and organized on the AASG Google Drive. Both AASG and the USGS will use these examples to further promote these programs.

The goal to review DEI efforts in State Geological Survey in 2022–2023 involved two approaches. First, Rich Ortt (State Geologist of Maryland) spearheaded a survey to provide information on which efforts have worked or not worked in our respective organizations to improve diversity, equity, and inclusion. Second, a subsequent survey obtained baseline data on the current overall composition (gender and race) of State Geological Surveys, with the understanding that this would go into a national database and could not be used to identify any individuals within any state survey. The reasoning for the second survey was that it's difficult to chart a path forward without knowing where things stand at the moment. A total of 34 state surveys were able to provide data on both gender and race, with another five state surveys supplying information on gender only. The 39 reporting state surveys employ ~1,551 individuals. For gender, ~61% of state survey employees are male, and ~39% are female. In terms of race, ~86% are white and ~14% are from underrepresented groups (e.g., Black, Hispanic, and Asian). Workforce and related DEIJA issues continue to be a focus for AASG, and we hope that the information gathered in these surveys will contribute toward progress in these efforts.

The AASG Annual Meeting is always a major highlight of any year, and 2023 was no exception. I want to thank Colorado State Geologist Matt Morgan, President-Elect John Metesh, and Vice-President Jessica Moore for a fantastic Annual Meeting in Glenwood Springs, Colorado, in June 2023. Matt Morgan and the Colorado Geological Survey hosted a truly wonderful meeting at an iconic venue in the heart of the beautiful Rocky Mountains. Excellent plenary and technical sessions, fantastic field trips, great food, and camaraderie were highlights of the meeting. We are very much indebted to Matt and his staff for such a great meeting. An important new element for this year's annual meeting and future AASG meetings was inception of the AASG Events Code of Conduct, which the AASG Executive Committee developed this year. This document was adapted from the GSA Events Code of Conduct to fit AASG. Our main objective in incorporating the Code of Conduct is to help foster a professional, respectful, and inclusive environment at all of our events.

Past President Erin Campbell, President Elect John Metesh, Vice President Jessica Moore, Treasurer Phil Pearthree, and two Secretaries (split between Nelia Dunbar and Harvey Thorleifson) served on the Executive Committee and were all instrumental in making this a successful year. I would like to personally thank each of them for their countless contributions through the year. Their knowledge, skills, and dedication to AASG are very admirable. I would also like to thank all State Geologists and Associate Members for your contributions in the past year, including efforts on the various committees, organizing technical sessions at the Annual Meeting, participation in the liaison meetings, and so much more. It has been truly an honor to serve the AASG community in the past year.

Although our membership has been rapidly evolving, we continue to be a vibrant organization with both new and seasoned State Geologists and many associates and honorary members volunteering on multiple fronts to attain tangible results. Although the size and structure (e.g. independent state agency vs. part of university) of State Geological Surveys can vary, we all have similar missions-that is, conducting applied unbiased Earth science for the public good. Looking back over the past several decades, all of the accomplishments of AASG are astonishing. The demand for our expertise and services will continue to grow in coming years as we strive to meet the many challenges of our time, including addressing climate change, facilitating the energy transition, assessing and discovering critical minerals, helping to resolve supply chain issues, mitigating geologic hazards, infrastructure planning, workforce development, and making progress on diversity, equity, and inclusion in the geosciences.

The State Geologists Journal highlights the many accomplishments of State Geological Surveys during the past year and documents the amazing breadth and extent of our collective contributions, which have so many positive impacts on the Earth Sciences, public safety, and economic development across the nation. Please enjoy this year's edition of the State Geologists Journal.

Sincerely, James E. Faulds AASG President

ALABAMA

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Alabama

INTRODUCTION

The Geological Survey of Alabama (GSA), established in 1848, is an independent state agency that reports to the Alabama Legislature and to the Governor. The GSA's mandate is to survey and investigate the mineral, energy, water, coastal, and biological resources of the state; to maintain adequate geologic, topographic, hydrologic, and biologic databases; and to prepare maps and reports on the state's natural resources to encourage the safe and prudent development of Alabama's natural resources while providing for the safety, health, and well-being of all Alabamians. The State Geologist is Director of the GSA and, by virtue of the position, is also the Oil and Gas Supervisor (i.e., director) of the State Oil and Gas Board of Alabama (OGB). The OGB is the state's regulatory agency for all oil and gas exploration, production, and development, as well as for the geologic storage of carbon dioxide and other gases.

GEOLOGIC MAPPING

The Geologic Investigations Program (GIP) researches, documents, and maps Alabama's geology, nonfuel minerals, paleontological resources, and geologic hazards. The GIP conducts projects to (1) generate geologic and geospatial information and data used in groundwater, environmental, and urban planning; (2) increase natural hazards situational awareness; and (3) educate the public on Alabama's mineral, rock, and paleontological resources.

Bedrock with Minor Surficial Mapping

The GSA generally produces bedrock geologic maps. However, quadrangle maps also include surficial units, such as alluvium, terrace, artificial fill, and paleokarst deposits as needed. The Geologic Map Schema (GeMS) GIS data for these maps are provided in two layers, but this method may change in the future.

The GSA's primary source of map funding has been the STATEMAP component of the National Cooperative Geologic Mapping Program (NCGMP), administered by the U.S. Geological Survey (USGS).

Three 7.5-minute quadrangle maps in northeastern Alabama were completed for STATEMAP in September 2022: Cedar Bluff and Jamestown (Gadsden area) and Farley and Limrock (Huntsville area). Beginning in September 2022, GSA started the next STATEMAP project: new field mapping and map production for three 7.5-minute quadrangles: Chavies, Rodentown, and Indian Mountain (all in the larger Gadsden area).

The GSA also receives funding from the USGS NCGMP Earth Mapping Resources Initiative (Earth MRI) for geologic mapping and critical minerals sampling and analysis. In September 2021, GSA began a two-year project to map the Mitchell Dam and Flag Mountain 7.5-minute quadrangles in the historic Alabama graphite-vanadium belt, with project deliverables that included draft geological maps, GeMS-compliant geospatial data and metadata, and a report summarizing the critical mineral contents of 100 samples of flake graphite-bearing lithologies in the map areas. In September 2023, GSA began another three-year Earth MRI project to map the Micaville, Newell, and Wedowee quadrangles in an area recently identified as part of the Alabama graphite-vanadium belt. Deliverables for this project will include geological maps, GeMS-compliant geospatial data and metadata, and a report summarizing the geochemistry of 200 samples from these and adjacent quadrangles to characterize the critical minerals potential of this newly-identified Earth MRI focus area.

Reasons for Mapping in Locations

STATEMAP projects are based on multiple criteria and STATE-MAP Advisory Committee (SMAC) discussions. The SMAC, led by the GIP STATEMAP leader, meets once a year to review geologic mapping projects, urban development, water resources, mineral resource needs, and other characteristics, and identifies Alabama's mapping priority areas.

Earth MRI mapping projects are chosen by GSA and USGS and reflect critical minerals of particular national interest. Regional discussions among the USGS and other state geological surveys are held annually to examine geologic mapping needs and domestic critical minerals priorities. Geophysical data acquisition activities are also discussed, in support of the Earth MRI's geologic mapping needs.

OTHER PROGRAM HIGHLIGHTS

Between September 2022 and September 2023, the GSA curated and conserved 1,601 fossil specimens, updated the fossil catalog data, and generated 1,601 fossil specimen digital photos for the USGS's National Geological and Geophysical Data Preservation Program (NGGDPP). These fossil data were uploaded to the National database Registry of Scientific Collections (ReSciColl).

The Coastal Resources Program (CRP) is engaged in projects to assess offshore sand deposits and geological frameworks, to monitor gulf-fronting beaches, to disseminate data for the coastal area multidiscipline geographic information systems , and to assess estuarine sediment characteristics and geochemistry. Current Gulf of Mexico evaluations include the recovery of legacy geophysical and core data, the acquisition of new geophysical and core data, the development and maintenance of a comprehensive geophysical and core geodatabase, and modeling of lithofacies and sediment suitability. The Offshore Alabama Sand Information System reflects this work (<u>https://www.gsa.state.al.us/apps/oasis/</u>). Offshore sand resources are vital to address restoration needs which support Alabama's economy and the resiliency of coastal habitat and development. Beach and nearshore monitoring documents the storm- and human-induced changes that occur within the beach environment and littoral system. The CRP maintains a robust inventory of geospatial data (see <u>https://coastal-alabama-geospatial-data-hub-gsaogb.</u> <u>hub.arcgis.com/</u>) and leads the Coastal Alabama Geospatial Data Users Group. The estuarine areas of Mobile Bay and Mississippi are being investigated for fundamental sediment characteristics, mineralogy, and geochemistry to further our understanding of their geospatial and temporal distribution.

The Groundwater Assessment Program has completed development of WaterSTAR, a new geospatial database in conjunction with the Groundwater Protection Council and Coordinate Solutions. WaterSTAR is being added to the GSA servers and protocols for sharing real-time groundwater level data with the USGS National Groundwater Monitoring Network. Program personnel are working in conjunction with members of the Ecosystems Investigations Program to evaluate groundwater controls relating to listed species habitats on Redstone Arsenal in north Alabama, spring aquatic species habitats in the Cahaba Valley, and on an abandoned coal mine reclamation project in central Alabama. Program personnel are currently working with the Geologic Investigations Program on Cenozoic and Mesozoic stratigraphic correlations across the eastern Gulf of Mexico basin and coordinating a western Gulf Coast project in conjunction with the Arkansas Office of the State Geologist, the Louisiana Geological Survey, the Mississippi Geological Survey, the Tennessee Geological Survey, and the Texas Bureau of Economic Geology. These projects aim to refine the stratigraphic nomenclature and hydrostratigraphy across the northern Gulf Coast basin.

The Ecosystems Investigation Program has conducted scores of aquatic biodiversity studies, assisting sister agencies in basin-wide and more localized surveys of fishes and mussels, crayfishes, cave shrimp, and other aquatic invertebrates; status surveys of federally listed threatened and endangered species and state conservation priority species; and analysis of water quality, sediment quality, and land uses that affect those populations. Work continues on projects in the Highland Rim, Cumberland Plateau, and Valley and Ridge provinces focused on habitat controls for several endangered species and state conservation priority species. New projects were initiated to identify and map springs in the Cahaba River watershed related to a federally listed spring-dwelling snail species found there, to assist with survey efforts for riverine fishes in the lower Alabama River in support of an effort to allow passage of migratory fishes past dams, and to assist with a regionwide assessment of habitat on the Cumberland Plateau suitable for native grass restoration. Other initiatives include leadership roles in the newly created Southeast Aquatic Resources Partnership statewide Stream Assessment Team.

The Energy Investigations Program works on carbon capture, utilization, and storage (CCUS) projects, supporting geologic models, permitting requirements, regulation needs, and community engagement. Energy staff are working on CCUS assessment projects in the northern Gulf of Mexico and across the southeastern US. A critical minerals assessment in the southern Appalachian basin is underway. The Program manages GSA's core facility, which serves students, academics, and industry interested in the subsurface geology of Alabama. In August 2021, our database of over 12,000 cores and cutting sets and 7,000 thin sections was published, allowing researchers and the general public to view and search the collection.

ARKANSAS

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GEOLOGICAL SURVEY

The Arkansas Office of the State Geologist (AOSG), formerly known as the Arkansas Geological Survey, is a non-regulatory agency that is responsible for the collection and dissemination of unbiased and sound geologic data and information pertaining to the State of Arkansas since 1857. In April of 2019, the Transformation and Efficiencies Act of 2019 authorized the reduction of the number of cabinet-level agencies from 42 to 15. At this time, our agency, known as the Arkansas Geological Survey, was merged into the Division of Energy and Mineral Resources of the Department of Energy and Environment (E&E). In July of 2023, Act 697 abolished the Arkansas Geological Survey and reconstituted it as the Office of the State Geologist under the direction of the Arkansas Oil and Gas Commission. The AOSG is now located at the recently designated E&E building in North Little Rock, Arkansas.

GEOLOGIC MAPPING

Bedrock Mapping

The Office of the State Geologist conducted one geologic mapping project in North Arkansas from July 2022 to June 30, 2023 for the STATEMAP program. We were awarded \$64,999 to map the geology of the Interior Highlands portion of the Cord, Grange, and Strawberry guadrangles in northeast Arkansas. Previous mapping published for this area was inferred from regional projections at the 1:500,000 scale. The current mapping project involved extensive ground reconnaissance and on-site data collection which has been compiled into a searchable geodatabase. Data collection from 78 days of field work included: 1,101 field locations recorded and described in detail; 182 strike and dip measurements (most depicted on the maps); 554 joint orientations (depicted in a rose diagrams of strike frequency); 74 karst datapoints; 158 rock samples collected and described; 68 thin sections for petrographic and provenance studies; ~9,400 photographs documenting outcrops and lithologies encountered; 23 guarries, mines, prospects, and pits visited, photographed, and described; and 12 new structural features including fault, folds, and monoclines.

Approximately \$19,549 of the grant funding remained at the conclusion of field work, and a no-cost extension until September 30th was requested to use the remaining funds to generate geologic data in a previously understudied part of the state. This includes radionuclide dating of Tertiary (?) gravel deposits; palynology, biostratigraphy, and detrital zircon dating of Cretaceous deposits; and trace element analysis of lead/zinc deposits. The extension also includes a proposal for geologic mapping of the Ozark Plateaus portion of the Strangers Home quadrangle.

OTHER PROGRAM HIGHLIGHTS

In addition to geologic mapping, the OSG concentrated on a landslide inventory, published a gas storage report, and continued collaborative work with the USGS on lithium concentrations in south Arkansas. We were awarded a FEMA Hazard Mitigation Grant to create a landslide inventory of Newton, Madison, and Washington counties in north Arkansas. Newton County was completed in June of 2023. The research geologist concluded that 17.3% of the surface area within Newton County contains landslides that are identified with a distinct headscarp, flank, toe, and other components.

In response to a historic winter storm in February 2021, it was recommended that geologists at the Oil and Gas Commission and the OSG conduct a preliminary study identifying mature gas fields suitable for future natural gas storage operations. The study resulted in Information Circular 46, "Potential for additional natural gas storage capacity in the Arkoma Basin in Arkansas" by Jay Hansen, Peng Li, and Ciara Mills, published by the OSG. They identified 13 nearly depleted natural gas fields that warrant future investigation for underground natural gas storage.



Figure 1. Study area and previous resolution of the Cord, Grange, and Strawberry 7.5-minute quadrangles. (Adapted from the Geologic Map of Arkansas, Haley et al., 1976, 1:500,000 scale.)

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Arkansas

The OSG continued a collaboration with the USGS Lower Mississippi-Gulf Water Science Center to assess the potential lithium resources in southern Arkansas. This area of the Coastal Lowlands contains high bromine and lithium concentrations in brines from the Jurassic Smackover Formation. The goals are to:

- Assess gaps in historical Smackover Formation brine and geologic datasets.
- Sample produced waters to quantify lithium concentrations where water quality data gaps exist.
- Map the spatial variability of lithium in southern Arkansas.
- Better understand the variation, migration, and geochemical evolution of lithium-containing brines.

CALIFORNIA

CALIFORNIA GEOLOGICAL SURVEY

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The mission of the California Geological Survey (CGS) is to provide scientific products and services about the state's geology, seismology, and mineral resources, including their related hazards, that affect the health, safety, and business interests of the people of California.

The Office of the State Geologist was created in 1851, and CGS was established by the State Legislature in 1860. The CGS is a division within the Department of Conservation, which is under the umbrella of the Natural Resources Agency. The CGS has its headquarters in Sacramento and five field offices throughout the State. The CGS employs 139 geologists, engineers, seismologists, GIS cartographers, field instrument technicians, and administrative staff.

The CGS consists of six programs: Forest and Watershed Geology, Burned Watershed Geohazards, Mineral Resources, Regional Geologic and Landslide Mapping, Seismic Hazards, and Earthquake Engineering. The Burned Watershed Geohazards Program, formed in 2022, is the newest program to the Survey.

GEOLOGIC MAPPING

Geologic mapping is completed by the Regional Geologic and Landslide Mapping Program (RGLMP) and the Forest and Watershed Geology Program. In addition, the Mineral Resources Program performs new mapping under a cooperative agreement with the USGS Earth Mapping Resources Initiative (MRI) program. Each year CGS completes new geologic mapping, compiles geologic maps into regional maps, converts existing map data to GeMS-compliant formats, and works to publish geologic maps of California. These geologic maps and data form the basis for many derivative maps depicting geologic hazards and resources in the state. CGS also maps landslides by quadrangle and watershed boundaries in support of seismic hazards mapping, timber harvest review, and other state risk reduction objectives. These landslide data are presented in a statewide landslide inventory database.

The RGLMP completed two 7.5-minute quadrangle geologic mapping projects under STATEMAP in the Columbia and Liebre Mountain quadrangles in Calaveras and Tuolumne counties and in Los Angeles County, respectively (Figure 1). CGS also directed work on the Sierra Nevada Digital Earth Science Atlas (the SN Atlas). This project was initiated by the USGS in 2018 as a multi-agency effort, with CGS involvement starting in 2019. The SN Atlas is a 1:400,000-scale, 42,000-square-mile digital compilation of geologic mapping, geophysical data, metallogenic belts, carbonate bodies, geochronology, and neotectonic features. The SN Atlas will be completed as a STATEMAP project in 2024. Additional related geologic mapping efforts included the development of GeMS-compliant databases for each of these mapping projects. <complex-block>

Figure 1. Preliminary Geologic Map of the Columbia 7.5-minute quadrangle, Calaveras and Tuolumne Counties, California.

3D Geologic Modeling

In 2021, the California governor and legislature approved funding for the CGS to develop a multi-benefit three-dimensional geologic framework mapping pilot project (3D Geo) to support the state in sustainable groundwater management, seismic hazard mitigation, geologic carbon sequestration, and mineral resource evaluations. The development of a pilot project in the southern San Joaquin Valley continued in 2022 and 2023 as a two-year STATEMAP-funded effort, with a target completion date of June 2024. Figure 2 depicts a slice of the geologic data model as of June 2023. In 2024, the 3D Geo team will transition into becoming the Geologic Carbon Sequestration Group in support of the state's 2045 carbon neutrality goals.

Winter Storm 2023 Emergency Response

Between late December 2022 and March 2023 significant rainfall occurred across California as a result of 14 atmospheric river events. Large portions of California were inundated with rainfall at amounts exceeding 150 to 200 percent of water year averages. Working with the California Governor's Office of Emergency Services (CalOES), CGS provided updates on conditions that could lead to landslides, provided information on mapped, deep-seated landslide susceptibility and social vulnerability, advised on post-fire watershed conditions that could lead to debris flows, contextualized current landslide activity against rainfall accumulation that led to past widespread landslide events, and compiled a database of reported landslide events by partner agencies, social media, and citizen scientists. In support of CalOES, CGS geologists were quickly mobilized to locations across the state to support mitigation actions where public safety and critical infrastructure concerns were identified.

OTHER PROGRAM HIGHLIGHTS

The Mineral Resources Program identified six priority areas for implementing a statewide geochemistry reconnaissance





Figure 2. Three-dimensional perspective view and two-dimensional cross section for the San Joaquin Valley pilot project three-dimensional volumetric framework model.

initiative. This initiative aims to enhance our understanding of rock geochemistry, an essential aspect of evaluating the state's mineral resources, including critical and hazardous minerals. The initiative involves collecting samples for multi-element geochemistry, petrography, and geochronology. The geochemical reconnaissance data will guide the development of a comprehensive statewide sampling program, support the prioritization of new mapping projects, and contribute to the development of derivative products. The current focus of the sampling campaign is on mineral resources to support a decarbonized economy, targeting nickel-cobalt laterites in NW California. This effort was completed in 2023, and the program will transition to sampling the Plumas County Copper Belt in 2024. The findings will be published as a data release on the CGS website.

Post-fire runoff and debris bulking can be multiple times larger than pre-fire conditions and have resulted in damaging flood and debris flow events that have caused significant impacts to infrastructure and resulted in loss of life. To better address post-fire hazards, CGS has implemented a new Burned Watershed Geohazards Program (BWGP). The BWGP began in 2022 as one of California's first climate adaptation technical support functions around geologic hazards exacerbated by a warming planet. The primary goals of the BWGP are to provide pre- and post-fire assessments to characterize the magnitude and spatial extent of debris flows, landslides, and other geohazards exacerbated by wildfire; perform burned area monitoring to improve understanding of rainfall thresholds and magnitude of watershed response; and to support emergency response planning, public education, and awareness.

The BWGP is active in supporting federal, state, local and tribal partners. After numerous fires affected the Klamath River watershed in the northern portion of the state, the BWGP worked with the USGS's Landslide Hazard Program to provide pre-fire hazard mapping to a multiagency team evaluating ecological impacts focused on salmonids. The work involved modeling debris flow likelihood and debris flow volumes to identify areas with an elevated threat of post-fire impacts within 10 HUC 10 watersheds in the Klamath River basin. The multi-scale maps were developed for the Salmon and Sediment impacts team led by the U.S. Forest Service and local tribes to identify potential post-fire hazards by individual basin, to prioritize treatments such as fuels reduction within individual basins, and to inform operational plans during active fire suppression activities (Figure 3).



Figure 3. Regional-scale pre-fire debris flow likelihood map used to support the multiagency Salmon and Sediment Impacts assessment on in the Klamath River watershed. Larger scale mapping was also conducted at the sub-square mile watershed scale.

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The Connecticut Geological and Natural History Survey was established in 1903 by the CT Legislature (CGS Ch462). The Survey is responsible for coordination and implementation of statewide natural resource data collection inventories in the following areas: surficial and bedrock geology; mines and mineral resources; inventories of fauna and flora, including endangered species; and the development and operation of resource-oriented database management systems. The mission of the Connecticut Geological and Natural History Survey is defined in the Connecticut State Statutes (Ch 462, Sec 24-1 to 24-4). In 2023, the Connecticut Department of Energy and Environmental Protection (CT DEEP) reorganized with the Geological Survey within the Bureau of Central Services, Engineering, Safety, and Sustainability Division. The Natural History Survey has been within the Bureau of Natural Resources Wildlife Division since 2006. This report pertains to the Connecticut Geological Survey. The Connecticut Geological Survey Program is coordinated by Meghan Seremet, State Geologist.

GEOLOGIC MAPPING

Bedrock Mapping

The Connecticut Geological Survey, in conjunction with the State Geologic Mapping Advisory Committee, adopted a long-range Bedrock Mapping Plan in 2015, with the goal of producing a new statewide bedrock geological map of Connecticut. The vision is an integration of modern mapping and interpretations, within a digital geologic framework. New detailed bedrock mapping projects are being pursued as contributions toward the overall effort. Within the National Cooperative Geologic Mapping Program, STATEMAP component, and EDMAP educational component, the Connecticut Survey is actively working with federal and academic partners to update the Connecticut Bedrock Map. The strategic plan was developed in 2021 by the State Geologist, in consultation with scientists representing mapping expertise in Connecticut's crystalline rocks of the eastern and western uplands, and in the Mesozoic rocks of the central valley. In conjunction with the goals of the previously adopted longrange plan, the 7.5-minute quadrangles in Connecticut were assigned mapping and digital compilation priority ratings. Each 7.5-minute guadrangle was given priority ratings for both bedrock mapping and for the USGS National Geologic Map Schema (GeMS) as high, medium, and low priority. For mapping, an assessment of the magnitude of field mapping, geochemistry, geochronology, and structural analysis required for individual quadrangle areas was used to determine priority ratings. The detailed Bedrock Map Revision Strategic Plan is available online through the Connecticut Geological Survey.

As part of an effort to modernize the state bedrock geologic map, the Connecticut Geological Survey is remapping the igneous rocks of the Mesozoic Hartford basin at a 1:100,000 scale. The reinterpretation is being supported by petrographic and geochemical analyses and by incorporating previous data.

Surficial Mapping

1:24,000-scale surficial and Quaternary geologic mapping, developed cooperatively by the Connecticut Geological Survey and the USGS, is available statewide, both onshore and within Long Island Sound. It has been published as USGS Scientific Investigations Map 2784 (Stone et al., 2005). The digital geologic data is one of the primary resource layers used in environmental analysis by the CT DEEP, and is available for download through the Connecticut Environmental Conditions Online (CT ECO) portal (<u>https://maps.</u> <u>cteco.uconn.edu/map-services/</u>).

OTHER PROGRAM HIGHLIGHTS

Geologic Hazards

Crumbling concrete foundations in eastern and central Connecticut are a crisis affecting hundreds or thousands of homeowners, businesses, and municipalities. The deterioration is caused by chemical weathering of sulfides-notably pyrrhotite—in the crushed rock aggregate of the concrete. The CT State Geologist serves as a technical resource on this issue, has been involved in legislative hearings, and has provided technical review of scientific reports. State legislation, PA-21-120, An Act Concerning Concrete Foundations, requires guarries producing aggregate for use in concrete to prepare and submit Geologic Source Reports to the State Geologist. State legislation, PA-23-185, An Act Concerning Certain Producers of Concrete, requires non-quarry source aggregate producers that produce concrete for use in residential or commercial foundations to prepare and submit Geologic Source Reports to the State Geologist.

The Connecticut Survey has prepared online interactive mapping on the statewide distribution of pyrrhotite in Connecticut bedrock. Blasting and rock crushing operations involving sulfide minerals can also have an impact on environmental quality by causing acid drainage, which is detrimental to drinking water quality and can have ecological impacts.

Partnerships

The Connecticut Geological Survey continues to develop cooperative partnerships toward the goal of improved geoscience information for DEEP programs and for the citizens of Connecticut. Geologic mapping, topical research projects, and database enhancements are pursued through a combination of federal, state, academic, and non-profit

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collaborations. The Survey office at the University of Connecticut furthers student engagement in applied geoscience and environmental projects. These collaborations provide valuable work experiences for students, contribute to DEEP environmental protection efforts, and further the Survey mission toward improved geoscience information for resource assessments, hazard mitigation, environmental quality, and outdoor recreation.

FLORIDA

FLORIDA GEOLOGICAL SURVEY

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The Florida Geological Survey (FGS) was established as an autonomous state agency in 1907 by the Florida Legislature. Today, the FGS is a division within the Regulatory Programs of the Florida Department of Environmental Protection (DEP), the state's lead agency for environmental management and stewardship, protecting our air, water, and land.

The FGS collects, archives, interprets, and distributes geologic information to benefit Florida. FGS uses geologic data to create maps and models that improve our understanding of the surficial and subsurface geology of Florida. A better understanding of Florida's geology helps inform decision makers and our citizens about surface water and groundwater issues, mineral resources, geological hazards such as sinkholes, and other environmental issues.

From July 2022 through June 2023, the FGS conducted research on the state's geology, geomorphology, hydrogeologic systems, and geohazards. The FGS reached thousands of customers through field trips, presentations, and newsletters. Staff members served on the Florida Board of Professional Geologists, the American Society for Testing and Materials Karst Subcommittee, the Bureau of Ocean Energy Management's Gulf Coast Geology Working Group, and the STATEMAP Advisory Committee.



Figure 1. FGS project areas for July 2022 through June 2023.

GEOLOGIC MAPPING

The Florida Geological Survey Mapping Initiative (FGSMI) was created to accelerate completion of a new statewide surficial geologic map of Florida. In addition to the STATEMAP Program, the FGSMI includes the Florida Geologic Mapping Program (FLAGMAP), which works in areas adjacent to USGS STATEMAP-funded quadrangles to maximize mapping efforts. FLAGMAP is internally funded. Projects funded through the USGS Earth Mapping Resources Initiative (Earth MRI), discussed below, also contribute to FGSMI goals.

Surficial & Bedrock Mapping

The FGS FLAGMAP program conducted surficial geologic mapping in the Titusville, New Smyrna Beach, Cross City, Cedar Keys, Charlotte Harbor, Sanibel, Fernandina Beach, Lake City, and Okefenokee Swamp USGS 30- x 60-minute quadrangles between July 2022 and June 2023. These FLAGMAP project areas are adjacent and complimentary to earlier and current STATEMAP project areas.

The USGS National Cooperative Geologic Mapping Program (NCGMP) granted a project extension to the <u>FGS</u> <u>STATEMAP Program</u> for the FY21 award for mapping the West Palm Beach and Cape Canaveral 30- x 60-minute USGS quadrangles due to lingering delays from the COVID-19 pandemic. The West Palm Beach and Cape Canaveral mapping project resulted in publication of 11 geologic cross-sections, two geologic maps, and two Open-File Reports for the two quadrangles. The FGS mapped 2,777 square miles at \$211.48 per square mile (including matching funds) for this project.

For federal FY22, the USGS awarded the FGS STATEMAP Program \$435,868. The FY22 award allocates \$345,330 to map the entire Fort Myers 30- x 60-minute USGS quadrangle and to begin mapping the Naples 30- x 60-minute USGS quadrangle, and \$90,538 to produce GeMS Level 3 databases for the Bartow, Orlando, and Kissimmee 30- x 60-minute USGS quadrangles. The FY22 award is for a two-year period of performance (2022–2024).

For federal FY23, the USGS awarded the FGS STATEMAP Program \$417,851. The FY23 award includes \$369,766 to map the Fort Lauderdale 30- x 60-minute USGS quadrangle and to finish mapping the Naples 30- x 60-minute USGS quadrangle, along with supplying GeMS Level 3 databases for both quadrangles. This award includes an added \$48,085 for a status map of the two-dimensional and three-dimensional 1:100,000-scale geologic mapping GIS coverages in Florida. The FY23 award is for a two-year period of performance (2023–2025).

OTHER PROGRAM HIGHLIGHTS

The FGS was awarded \$100,000 by the USGS in 2020 to complete a two-year study of the distribution and geochemistry of heavy mineral placer deposits adjacent to and along Trail Ridge in northeastern Florida. This funding came through the USGS's Earth MRI based on interest in mineral commodities hosting Rare Earth Elements (REE). Project deliverables, due December 2023, will include a surficial geologic map of the <u>Florida Focus Area</u>, an approximately 750 square mile zone along the Georgia border, and geochemical analyses of samples containing heavy mineral sand.

The FGS was awarded \$246,792 by the USGS in 2022 to complete a two-year study of critical minerals and REE-associated phosphate mine waste streams in both the north- and central-Florida phosphate mining districts. This funding came through the USGS Earth MRI Program and is focused on critical mineral commodities associated with mining waste streams. The study began in December 2022. Project deliverables, due November 2024, will include geochemical characterization of waste streams associated with phosphate mining in Florida.

The FGS is collaborating with the Geological Survey of Alabama and with the Mississippi Department of Environmental Quality's Office of Geology on the East Gulf Coastal Plain Stratigraphic Reconciliation Initiative. This interstate cooperative project, funded by the USGS National Geologic Map Database program, addresses stratigraphic framework issues across state boundaries. This work will advance the creation of an integrated geologic map for the nation. Deliverables—cross sections, stratigraphic charts, and lithostratigraphic nomenclature revisions—will be provided to the USGS in 2024.

The USGS, FGS, Geological Survey of Alabama, and the South Carolina Geological Survey worked together to propose boundaries where future airborne geophysical surveys could be conducted with funding through the USGS Earth MRI program. In 2023, hyperspectral surveys were flown over Florida's industrial mineral mining districts, and airborne magnetic and radiometric surveys covering approximately 8,000 square miles of northeast Florida began. A third survey, covering approximately 6,000 square miles, was funded and is scheduled to collect magnetic and radiometric data beginning early 2024.

FGS received \$51,168 from the USGS National Geological and Geophysical Data Preservation Program (NGGDPP) to preserve cuttings samples from Underground Injection Control (UIC) wells. The goals for the project were to process and accession samples from South Florida and to add lithologic descriptions to the associated borehole records. Over the course of the project, the FGS processed 12,376 samples from 58 UIC wells and added lithologic descriptions for 35 boreholes to its GEO-logic Data Enterprise System (GEODES). Work began in June of 2022 and the deliverable was finalized in August of 2024.

ILLINOIS

ILLINOIS STATE GEOLOGICAL SURVEY

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IILLINOIS

Illinois State Geological Survey PRAIRIE RESEARCH INSTITUTE

The Illinois State Geological Survey (ISGS) was first formed in 1851, but has been operational continually since 1905 when it was officially established as a state agency by an Act of Illinois' General Assembly. In 2008, the University of Illinois State Scientific Surveys Act was passed by the General Assembly, and that placed the ISGS and four other scientific surveys within an institute of the University of Illinois at Urbana-Champaign. The Prairie Research Institute now houses the ISGS, Illinois Natural History Survey, Illinois State Water Survey, Illinois State Archeological Survey, and Illinois Sustainable Technology Center—together employing over 900 scientists, support staff, and students. The ISGS has over 180 scientists, support staff, students, and affiliates.

This past year has been busy for the ISGS with increased funding opportunities provided by the US DOE, USGS, and others for geological characterization research that has attracted the attention of many industrial partners. Work has focused on the transition to green technologies, aiming to achieve a sustainable balance between water, energy, and mineral resource extraction and environmental protection while also considering the uncertainties of climate change and its direct impact on economic development. A key component for success has been our overall scientific understanding of Illinois' geology.

GEOLOGIC MAPPING

Bedrock Mapping

In September 2022 four bedrock quadrangles were submitted to the USGS—three in the Quad Cities (Andalusia, Port Byron, and Green Rock Quadrangles) and one in Jo Daviess County (Galena Quadrangle). This cycle of mapping also included compilations of Alexander, Pulaski, and Massac Counties in extreme southern Illinois. The ISGS followed the USGS Geologic Mapping Schema (GeMS), tracking information such as contact line confidence and data sources. This mapping has continued under the USGS-ISGS cooperative STATEMAP program.

The ISGS submitted a bedrock proposal for FY 2022– 2023 to map six quadrangles (Montpelier, Illinois City, and Muscatine Quadrangles in the Quad Cities and Menominee, Bellevue, and Hanover quadrangles in Jo Daviess County). However, due to reduced funding on original (category one) maps, only the Hanover Quadrangle was mapped for bedrock.

One of the primary scientific findings in the Hanover Quadrangle was a carbon isotope excursion obtained from the Chapman #GC-4 well (API120852209700, C14555, total depth: 564 feet). Excursion C1 corresponds to the early Katian/Guttenberg Isotope Carbon Excursion (GICE). This worldwide excursion is attributed to volcanic activity that triggered a perturbation of the global carbon cycle and climate cooling.

Category two bedrock maps for FY 2022–2023 included the compilation of Saline and Gallatin Counties in southern IL. The two counties were mapped with accompanying GeMS databases and 16 previously published quadrangles were converted to GeMS to update the National Geologic Map Database (NGMDB). With new aeromagnetic data from the USGS, the ISGS accurately mapped previously known and unknown igneous dikes within both counties. Significant changes were made to the Shawneetown, Rudement, Equality, and Herod Quadrangles. This included completing the compilation work that involved remapping faults for edge-matching, updating unit names from what was previously the Modesto Formation to the Patoka and Shelburn Formations, and stripping off surficial units to display the bedrock geology of these counties. Also, a new formation, the Permian aged Mauzy Formation, known to exist within the Rough Creek Graben in Kentucky, is now represented in Illinois. It was introduced to the Illinois stratigraphic column by confirmation through recent core studies.

Surficial Mapping

Detailed mapping of the Greater Chicago region continued under the USGS-STATEMAP program in 2023–24. However, in the first year of a planned five-year program, the remaining unmapped areas of Cook and DuPage Counties will be studied synoptically rather than on a guad-by-guad basis, with a focus on producing specific regional datasets or contoured surfaces. Initial efforts are on geophysical profiling, compilation of archived data, analysis of the resulting well boring database, and the beginning of shallow coring. This work will improve workflows to promote data-sharing amongst stakeholders, to support characterization of anthropogenic soils, and to establish a preliminary three-dimensional geologic framework that will be further developed under the Great Lakes Geologic Mapping Coalition (GLGMC) program. Characterization of anthropogenic as well as natural geologic materials at the land surface and shallow subsurface is necessary for a range of redevelopment issues, some of which are motivated by social justice, equity, diversity, and inclusion principles. In 2023, the ISGS established a new partnership with the Subsurface Opportunities + Innovations Laboratory (SOIL) at Northwestern University to help develop a new correlation system linking engineering geology soil boring descriptions with STATEMAP geologic stratigraphic units. Supported by the NSF-DOE Geothermal INTERN program, a PhD graduate student is gaining extramural professional experience by analyzing ISGS' database of geotechnical properties in soil borings. That work will also help advance a model of the subsurface urban heat island phenomenon across Chicago's Loop district.

The ISGS is beginning its fourth year (Phase four) of a five-year project to revise the surficial (Quaternary) geology map of Illinois that is partly funded by the USGS-STATEMAP program. During 2022–23, Phase 3 mapping was completed

in south-central and north-central Illinois. It connected to prior mapping of the Chicago, St. Louis Metropolitan, and southern regions that was compiled during Phases one and two. This new Quaternary map updates the 1979 map with findings from detailed guadrangle and county mapping (1:24,000 to 1:62,500 scales) during the interim. The availability of LiDAR, digital USDS-NRCS soil maps, subsurface boring databases, and archived field notes greatly aided the project. Mapping follows the USGS geologic mapping schema (GeMS) to facilitate future development of a seamless national map. Contact lines were drafted digitally in GIS at 1:80,000–1:100,000 scale, with anticipated map publication at the 1:250,000 or 1:500,000 scale. New Phase three data address statewide stratigraphic issues and included four electrical resistivity transects, six shallow test holes, and 13 radiocarbon ages. To aid characterization and correlation of Quaternary sediments, 40 samples were analyzed for particle-size distribution and elemental composition, and 30 samples were analyzed for clay mineralogy. New geological findings included documenting the extent and dimensions of an ice-walled or subglacial channel in Christian County (central Illinois) used for local groundwater supply and the recognition of a southern Illinois esker ridge in Wayne County. In north-central Illinois, new cores and analytical data on glacial tills helped to delineate the Yorkville and Batestown Members of the Lemont Formation.

Three-dimensional Mapping

The ISGS completed the second year of a three-year three-dimensional geologic mapping project in Boone County, Illinois. The first year mainly included database management and some field data collection. The second year focused on the processing/interpretation of data from year one and more data collection, including 155 one-dimensional seismic soundings to address subsurface bedrock topography at specific sites. Both two-dimensional seismic and electrical geophysical profiles will be collected in subsequent years, and they will be compiled and interpreted using three-dimensional geologic modeling software and distributed with an online geologic model viewer. The resulting three-dimensional geologic model will be incorporated into three-dimensional groundwater flow models, which will benefit local and regional decision makers with long-term natural resource management and protection planning.

The ISGS has also initiated an airborne geophysical program using helicopter-based electromagnetics to map shallow sand and gravel aquifer systems in east-central Illinois' Mahomet aquifer, a federally designated sole-source aquifer. The ISGS has secured both local and federal funding to conduct these high-resolution geophysical surveys across four counties in eastern Illinois. The first phase of data collection was completed in December 2022, and the second phase will be completed to develop detailed three-dimensional geologic frameworks of the Mahomet aquifer system. In turn, these geologic models will also be incorporated into local and regional groundwater flow models to improve

predictions of long-term sustainability and protection of the aquifer.

OTHER PROGRAM HIGHLIGHTS

Progress on Energy

Through DOE's Carbon Storage Assurance Facility Enterprise (CarbonSAFE) Initiative, the ISGS was awarded two new projects in Mitchell, IN, and Springfield, IL to characterize the subsurface for carbon storage associated with cement production and coal-fired energy generation, respectively. The value of these projects exceeds \$30M. Since 2017, there are now six CarbonSAFE projects at seven sites in IL and IN, in addition to the two earlier DOE-funded carbon storage project sites at Archers Daniels Midland site in Decatur.

The ISGS helped secure \$17.4M for the Illinois DNR as part of the U.S. EPA and DOE's Inflation Reduction Act (IRA) —Mitigating Emissions from Marginal Conventional Wells program. The program will (1) mitigate methane emissions, (2) conduct environmental restoration as part of a well plugging process, (3) develop improved understanding of the characteristics of natural gas resources across the Illinois Basin, and (4) create and support high-paying jobs with a free and fair chance to join a union.

Lake Michigan Coastal Program

The ISGS' Coastal Geology program completed a five-year, pre-breakwater construction topobathymetric survey effort at Illinois Beach State Park in 2023. Drone-based topographic and sonar-based bathymetric mapping, at monthly and biannual periodicities along the park's non-armored beach shoreline, were completed to understand beach-shoreline and nearshore morphodynamics in response to storms, winter-ice cover, and fluctuating lake levels. Continued monitoring of shorelines evaluates impacts of newly emplaced offshore emergent shoreline-protection structures, installed in 2023–2024 as part of a \$74M state capital development project designed to protect coastal wetland and strand environments along an ecologically unique and fragile coastal system. ISGS geological monitoring data are processed, affixed with metadata, and made available through the Illinois Geospatial Data Clearinghouse. These activities are central to the ISGS' growing coastal research program and overlap with other externally funded endeavors to better understand coastal sand distributions and routing patterns.

Active geological monitoring efforts have also been underway at priority beaches in Chicago, including Montrose Ave., within the Uptown region, and at Rainbow Beach (South Shore neighborhood). These bi-annual topobathymetric surveys, funded by the IDNR-CMP and supported by the Chicago Park District, help urban beach managers make informed decisions (based on up-to-date survey data during the beach recovery phase following high lake levels

Illinois

of 2019-21) regarding geomorphic impacts of different urban beach-management activities, including summertime grooming of recreational terrains and emplacement of sand fencing to promote foredune development across bird-nesting habitat.

Coastal activities also included collecting 20 offshore sediment cores and more than 200 Ponar grab samples from along the Chicago offshore. These data supplemented archival data and geophysical reflection imagery collected in 2022 from beaches using GPR, and from the offshore using a 'chirper' source, as part of an IL-IN Sea Grant-funded effort to map lake-bottom geology and stratigraphy across the SW Lake Michigan coastal margin.

Lastly, passive monitoring activities included placing of hydrodynamic instrument cages, maintaining an onshore weather station, and deploying cameras, all part of a NOAA-funded project, completed in 2022, that installed three parallel, submerged rubble-mound ridges at IBSP. This was part of a high-profile Great Lakes Restoration Initiative project testing the efficacy of less intrusive and less permanent shoreline-protection measures. Hydrodynamic studies have been a collaboration between ISGS and Michigan State University researchers, and impacts on marine ecology were evaluated by the Illinois Natural History Survey, all to inform how the submerged structures are functioning as (1) shoreline protection (and modifiers of nearshore storm hydrodynamics), and (2) marine habitat (e.g., to fish).

Critical Minerals

The ISGS is working to establish a Hicks Dome Critical Mineral Facility to develop a novel process technology dedicated to continuous and sustainable extraction of critical minerals from Hicks Dome in southern Illinois. Hicks Dome is a REE-enriched volcanic structure containing one of North America's largest untapped fluorspar resources with additional enrichment in important permanent elements required for magnets.

The ISGS' Illinois Rare Earth Novel Extract & Supply project will design a system to use mine waste from the last industrial revolution to provide a domestic supply of critical minerals to enhance US competitiveness, to create new high paying union jobs, to tackle the climate crisis, and to ensure access to economic benefits for disadvantaged communities.

The ISGS' EarthMRI Upper Mississippi Valley project, funded by the USGS, will geologically map and characterize the Upper Mississippi Valley Zinc and Lead District in Illinois, lowa, and Wisconsin for critical mineral potential. Critical minerals of significance include sphalerite and residuum associated with barite, both with potential for other associated critical minerals such as U, Cd, Ag, Ga, In, and Ge-bearing minerals.

The ISGS has a multiyear DOE project to develop coalbased graphene oxide and reduced graphene oxide that can result in the production of synthetic graphite. Carbon in its graphite form is an essential element, along with lithium, in batteries. Currently, there is a 100% foreign reliance on this critical mineral.

Geothermal

The ISGS began work on two DOE-funded projects awarded in 2022. In the first, the ISGS collaborated with several DOE National Laboratories and universities to provide technical assistance to the DoD's Detroit Arsenal and West Point Military Academy for developing geoexchange systems in various buildings with a range of energy demands. For the second project, the ISGS is leading a University of Illinois team that is partnering with several community and workforce non-profits to demonstrate a community geothermal system in a disadvantaged and underserved neighborhood on the south side of Chicago. For both projects, the ISGS is studying how local geology and hydrogeology impacts the efficiency of borehole heat exchangers. In addition, the ISGS is contributing to a new energy transport simulation for MODFLOW 6 that integrates an innovative thermal transport simulation capacity in groundwater flow and across interfaces in saturated and unsaturated conditions.

National Benefit Cost Study of Geological Mapping

The ISGS prepares preliminary environmental site assessments (PESAs) for new highway construction and improvement to existing roadway and bridge projects proposed by the Illinois Department of Transportation (IDOT). These assessments provide IDOT with information about potential environmental concerns, natural features, and natural hazards that may be present on existing IDOT right-of-ways or on properties proposed for acquisition. As an example, the Bob Michel Bridge (IL Route 40 over the Illinois River in Peoria Illinois) was closed to traffic in March 2023 for rehabilitation. ISGS staff conducted PESAs prior to the rehabilitation of the bridge. Potential environmental hazards were investigated at more than 20 properties surrounding this bridge. The leading recognized environmental conditions were former and potential underground storage tanks. Other environmental hazards included evidence of chemical use, soil impacted with volatile organic compounds, semi-volatile organic compounds and metals, and former aboveground storage tanks on historic industrial properties. A 75-page report sent to IDOT documented these findings and provided preliminary information that will serve as the basis for additional environmental work. The redesigned bridge includes a multi-use path with a concrete barrier wall that separates pedestrians motorists. The 28-year-old multi-girder bridge was scheduled to reopen in December 2023.

INDIANA

INDIANA GEOLOGICAL AND WATER SURVEY

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The Indiana Geological and Water Survey (IGWS), founded in 1837, has been a research institute of Indiana University (IU) since 1993. Its mission is to provide geological information that contributes to the wise stewardship of energy, mineral, and water resources and that mitigates potential geologic hazards. Indiana residents continue to benefit from focused research initiatives, geologic sample and data collection and archiving, and dissemination of information through the peer-reviewed Indiana Journal of Earth Sciences, databases, and outreach programs.

In June, the IGWS's Learning Lab turned one year old. Part hands-on museum, part classroom, the lab introduces students to geologic specimens, collections, and technology. A total of 3,493 people visited during the year.

Geologic mapping teams, researchers, and information services staff juggled nearly two dozen grant-funded deliverables at varying degrees of completion. Four staff members departed and nine were hired. Also, the vast IGWS core and chipset library had to be moved (for the second time in five years) and was inaccessible to the public for several months.

Despite those pressures and a flatlined state budget appropriation, the IGWS celebrated several successes: piloting an internship program, launching IGWS Digital Collections and Indiana Springs portals, and landing a \$342,000 grant for data preservation.

GEOLOGIC MAPPING

The IGWS's long-range geologic mapping goal is to map the state at 1:100,000 scale and its metropolitan areas at 1:24,000 scale by the IGWS bicentennial in 2037. In June 2023, the IGWS was granted \$347,190 from STATEMAP to continue working toward this goal and to develop associated geodatabases. The IGWS also received funding from the Great Lakes Geologic Mapping Coalition (GLGMC).

Several STATEMAP-funded projects—four databases, two maps, and one pamphlet to accompany a map—were published in the Indiana Journal of Earth Sciences toward the end of 2023. Five other projects—two for GLGMC and three for STATEMAP—were being drafted with target publish dates in 2024 or 2025. Mapping projects in progress by June 2023 included:

Bedrock Mapping

Geologic Map of the Bedford 30- x 60-minute Quadrangle, Indiana (1:100,000 scale) (<u>link</u>)

This map shows Mississippian and lower Pennsylvanian bedrock units and Pleistocene and Holocene deposits distributed over eight counties and five physiographic divisions. The pamphlet includes full unit descriptions and links to documents related to 100+ bedrock data points. (Published in December 2023).

Geologic Map of the Indiana portions of the 30- x 60-minute Jasper and Tell City Quadrangles (1:100,000 scale)

This map area extends over eight counties and five physiographic provinces. Agriculture and industrial mineral production dominate land use and influence water quality through intense sinkhole, cave, and spring development. Much of the surface has been modified by extensive coal mining. Planned highway extensions in this area necessitate greater understanding of the subsurface and natural hazards.

Preliminary Bedrock Geologic Map of the Princeton 30- x 60-minute Quadrangle (1:100,000 scale)

This quad includes portions of eight Indiana counties and portions of three Illinois counties. Pennsylvanian siliciclastics host economically important coal seams. Surface and underground mining have been extensive with significant landscape impacts.



Figure 1. Location of the Flatwoods region in Indiana: (A) study area relative to the glacial boundaries in the Midwest; (B) study area relative to glacial boundaries and physiographic provinces; and (C) study area topography with roads, streams, and other features referred to in the text.



Figure 2. IGWS Research Scientist Tracy Branam takes stream flow measurements at Stoner Spring in rural southern Indiana. | Photo credit: Sara Clifford, IGWS

Surficial Mapping

Quaternary Geology of the Washington-Jasper Area (1:100,000 scale) (link)

This map shows the distribution of glacial and postglacial surface deposits along with basic bedrock geology across four counties. Isolated terraces along the Patoka River display weathered sediments of the oldest Quaternary unit in the area. (Published in December 2023)

Surficial Geology of the Indiana Portions of the Chicago and the Northern Half of the Kankakee 30- x 60-minute Quadrangles (1:100,000 scale)

Mapped landforms and near-surface deposits reflect the retreat of the Lake Michigan lobe of the Laurentide ice sheet (LIS), as ancestral Lake Michigan levels fell and the subsequent rebound resulted in deposition of barrier beach, beach ridge, eolian, and paludal sediments, and the formation of large dunes. Formal and informal map unit names are introduced.

Quaternary Geology of the Indiana Portion of the Southern Half of the Kankakee 30- x 60-minute Quadrangle (1:100,000 scale)

Landforms and near-surface deposits record glacial processes associated with the Lake Michigan Lobe and Huron-Erie lobe of the LIS and with postglacial changes. Formal and informal map unit names are introduced. Quaternary Geology of the Bloomington Quadrangle (1:100,000)

This area includes portions of 10 counties. Establishing the Quaternary geologic framework is important because glacial deposits host significant water resources at the southern margin of the Indianapolis metropolitan area.

OTHER PROGRAM HIGHLIGHTS

New Internship Program

With money from a designated, annual endowment, the IGWS welcomed its first class of Paul Edwin Potter interns during the summer of 2023. The four undergraduate and graduate students aided IGWS staff with core preparation, mapping, and field data collection. Two of those students were eventually hired as full-time staff.

Springs Data

The IGWS Center for Water launched the Indiana Springs data portal in April, making the most comprehensive data about Indiana springs available to the public since 1901. The portal contains chemical analyses, photos, and other information about 110 springs around the state and invites participation from residents who have observations to add.

New Equipment

The IGWS received funding from IU to buy a Bookeye scanner to capture images of unwieldy, fragile, three-dimensional, and/or dirty objects that have yet to be added to IGWS Digital Collections. The Learning Lab acquired an augmented reality sandbox with a three-dimensional camera, data projector, and software to project an elevation color map and topographic contours onto the sand, which adjust as the sand is reshaped.

Outreach Successes

IGWS outreach programs reached 8,817 people, including visitors to the Learning Lab. The second annual Indiana Limestone Fest, during Limestone Month in June, attracted a record 400 people to the IGWS grounds for stone-themed activities. Area teachers attended two workshops, one in cooperation with the Indiana Mineral Aggregates Association and the other focusing on limestone heritage.

Data Preservation

IGWS Digital Collections went live in October 2022. This years-running, grant-funded project has made more than 50,000 images, maps, documents, publications, and other types of data freely available when many of those items had been largely inaccessible. In February, the IGWS was

awarded another \$342,000 federal grant to digitize tens of thousands of additional items in the IGWS's physical collections and to continue the process of opening the IGWS Records Center. Most paper records have been in offsite storage since 2019.

Diverse Publications

While mapping projects were being prepared, the Indiana Journal of Earth Sciences published two research papers about rare earth elements (REEs) and critical minerals. One examined Pennsylvanian black shales as possible sources of critical minerals; the other studied whether Indiana's vast stores of coal byproducts could be viable sources of REE.

A master's intern worked with IGWS staff to produce a digital StoryMap focused on IGWS rock and mineral collections entitled "Curiosity Cabinets: Revitalizing the Cabinet of Curiosity for the 21st Century with the IGWS Learning Lab."

An IGWS team that included a 100-year-old volunteer affiliate, his former mentee (now a professor), and three IGWS staff members published an extensive investigation of the stratigraphy and geomorphic history of the Flatwoods region of Owen and Monroe Counties. They built on observations from Indiana geologists starting as early as 1876, adding optically-stimulated luminescence data to determine the age of glacial sediment that shaped the landscape, and adding new bedrock data from a deep test hole. Director Thompson plans to submit this project for consideration for the AASG Charles J. Mankin Memorial Award.



Figure 3. IGWS Potter Intern Elena Cruz helps visitors to the 2023 Limestone Fest craft "crinoids" out of Cheerios. | Photo credit: Kristen Wilkins, IGWS

IOWA

IOWA GEOLOGICAL SURVEY

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Iowa Geological Survey



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The Iowa Geological Survey (IGS) was established by the Iowa legislature in 1855. The IGS is a part of IIHR-Hydroscience & Engineering, a research institute within the University of Iowa's College of Engineering. The IGS currently reports through the Board of Regents State of Iowa, having been legislatively transferred to the University of Iowa in 2018 from the Iowa Department of Natural Resources.

The IGS currently employs 12 full-time professional, two part-time professional, and one part-time support positions on a mix of state appropriations, grants, and contracts.

The mission of the Survey is to collect, reposit, and interpret geologic and hydrogeologic data, to conduct foundational research, and to provide lowans with knowledge to effectively manage our natural resources for long-term sustainability and economic development.

GEOLOGIC MAPPING

Recently completed mapping by the IGS under the USGS STATEMAP program included two subprojects in vastly different geologic areas of the state with a focus on impaired watersheds and developing areas. Following six years of quadrangle mapping in southeast lowa and completion of county-scale maps of Lee County, surficial and bedrock geologic maps of Des Moines County were completed at 1:100,000 scale. Quaternary mapping efforts focused on refining the characterization of glacial deposits, improving the location of the Illinoian moraine boundary, better understanding the alluvial systems and terrace deposits of the Des Moines and Mississippi river systems, confirming loess thickness, and delineating areas of shallow bedrock. Bedrock mapping subdivided the Augusta Group into the Warsaw, Keokuk, and Burlington formations and refined the distribution of Pennsylvanian outliers. Research objectives included determining whether the McCraney Formation is correlative to the type McCraney in Illinois; assessing the relationship between the Prospect Hill Formation and the type Hannibal Formation in Missouri; and evaluating whether some of the "St. Louis" Formation strata should be reassigned to the Ste. Genevieve Formation. Combining bedrock and surficial map information allows stakeholders to address key guestions related to land use in shallow bedrock areas, aggregate resource potential and protection, and groundwater vulnerability.

The IGS conducted additional surficial and bedrock geologic mapping of the Cedar River watershed in Muscatine County. The second phase produced a 1:24,000-scale bedrock geologic map of the Atalissa Quadrangle which subdivided the Middle Devonian Wapsipinicon and Cedar Valley groups and initiated cross-state collaborations with the Illinois State Geological Survey (ISGS) to begin addressing lithostratigraphic nomenclatural issues across the border. Surficial geologic mapping was completed for the Muscatine NW Quadrangle and focused on characterization of Illinoian glacial deposits and terrace mapping in the Cedar River. The IGS will continue mapping efforts in Muscatine County for the next several years.

A third project focused on interstate collaboration with the Kansas Geological Survey (KGS) to help reconcile stratigraphic nomenclature discrepancies for the Upper Pennsylvanian (Missourian North American Regional Stage) Kansas City Group (of Kansas and Missouri) and the Bronson and Kansas City groups of Iowa. This work builds upon the efforts of the regional working group created and led by the KGS (through a National Geologic Map Database [NGMDB] initiative) to unify Pennsylvanian stratigraphic nomenclature across the state boundaries of Kansas, Missouri, Iowa, Nebraska, and Oklahoma. Both the lower boundary of the Kansas City Group (Bronson Group of Iowa) and the hierarchical framework used to subdivide the lithostratigraphic units within this/these group(s) needs to be resolved. The goal of this ongoing collaboration, both via STATEMAP and NGMDB, is to produce a standardized interstate nomenclature for the Pennsylvanian succession in the Midcontinent at a level appropriate for the regional mapping of these lithostratigraphic units (at the group, subgroup, and formation levels).

OTHER PROGRAM HIGHLIGHTS

Geophysics

The IGS incorporates electrical and seismic geophysical methods as a primary data collection tool for a host of geologic and hydrogeologic research projects. In shallow groundwater investigations, geophysical surveying was used alongside geologic mapping, groundwater modeling, and drilling to characterize well fields. Geophysical surveying was used to inform geologic hazard efforts, including imaging sinkholes, karst terrain, underground mines, embankments/levees, and landslide slopes. Passive seismic methods are being used by the IGS to help determine the depth to bedrock in areas lacking existing information. The IGS recently began a multiyear statewide effort to image levees using electromagnetic field methods.

Data Preservation

The IGS completed three projects for the National Geological and Geophysical Data Preservation Program. The first project incorporated data from over 3,300 sites managed by the lowa Office of the State Archaeologist into the IGS GeoSam database. Of these sites, 2,403 contained detailed geological descriptions and 2,917 contained detailed stratigraphic information. The dataset will aid IGS geologists in the creation of surficial geologic maps and will help other researchers for a myriad of research projects. The second project expanded well cutting storage at the IGS's Oakdale repository. New wooden shelving was constructed on-site. The third project

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digitized scanned geophysical logs to LAS files to improve the accessibility and utility of the data. Eighty-one scanned natural gamma logs, which penetrate Upper Ordovician sedimentary rocks, were converted to LAS files. The newly created LAS files have been used to evaluate critical mineral potential, to aid carbon capture utilization and storage studies, and to support NSF-funded hydrogeology projects.

Water Resources

The Water Resources Management program of the IGS evaluates the availability and sustainability of Iowa's groundwater resources and drinking water supplies. A new IGS project with the City of Decorah included hydrogeologic mapping, geophysical surveys, aguifer pumping tests, and numerical modeling to better delineate the municipal utility's wellhead protection area. The IGS also provided hydrologic characterization and mapping of the Iowa River alluvial aguifer for lowa City. The IGS employed geologic mapping, geophysical methods, drilling, and predictive modeling to identify potential vertical production well locations to supplement the collector wells. IGS worked with several private sector firms and with municipalities to provide specialty well siting services for the City of Iowa Falls by completing a desktop survey and by performing hydrogeologic mapping of potential groundwater supply within a proposed city annexation. IGS projects also included identifying potential karst features in relation to proposed mining operations, conducting groundwater modeling of guarry dewatering and its drawdown impact on nearby water wells, and mapping aguifer boundaries and elevation surfaces for university modeling of climate-groundwater interactions.

IGS partnered with a variety of state and federal agencies to conduct aquifer vulnerability mapping, to provide shallow alluvial aquifer water level updates during drought, to determine appropriate siting of conservation practices in watersheds, and to quantify the effectiveness of conservation practices once they have been installed.

MARYLAND

MARYLAND GEOLOGICAL SURVEY

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Maryland

INTRODUCTION

The Maryland Geological Survey (MGS) was founded in 1896 as an independent agency of the State housed at Johns Hopkins University, with primary responsibilities to:

- Conduct topographic, geologic, hydrographic, and geophysical surveys.
- Prepare topographic, geologic, and other types of maps to meet specific needs.
- Prepare reports on the extent and character of the geology, minerals, and water resources.
- Periodically assess the paleontological resources of the State.

These responsibilities remain incorporated into the Code of Maryland Regulations. Since 1969, the Survey has been incorporated into the Department of Natural Resources, and many of the activities and functions that the Survey performs support management activities of the Department. Additionally, the Survey conducts studies in support of other regulatory agencies.

Currently, staffing levels are 19 scientists, five contractual scientists, one full-time support staff, and one part-time support staff.

GEOLOGIC MAPPING

Bedrock Mapping

MGS continued bedrock mapping through the STATEMAP program in 2022–2023 with the submission of draft geologic maps for the Barton-Westernport, Clarksville, Woodbine, Libertytown, and Cecilton 1:24,000-scale quadrangles. The geological mapping continues our long-term strategy in the Appalachian Plateau, Piedmont, and Coastal Plain physio-graphic provinces.

MGS began new geologic mapping in the Oakland, Grantsville, Sykesville, Littlestown, Sandy Spring, and Winfield quadrangles in 2023. This new mapping furthers work in the Appalachian Plateau and in the Maryland Piedmont, which continues to experience suburban development at a very high rate.

The STATEMAP USGS program is also funding the compilation and conversion of geologic maps to GIS formats—the first is a 1:100,000-scale regional map of Western Maryland, and the others are 1:24,000-scale geologic maps of nine quadrangles in the Appalachian Plateau and Piedmont.

Mapping funded by the USGS EarthMRI program was completed in the Blue Ridge Summit quadrangle at 1:24,000 scale, completing the mapping of all of Maryland's Blue Ridge Province. This funding was also used for the conversion of six other 1:24,000-scale Blue Ridge geologic maps into GIS format using the USGS GeMS database format.

Mineral Mapping

Through the USGS EarthMRI program, MGS continued work on a grant to study volcanogenic mineralization in the Westminster terrane in Maryland's western Piedmont. This project is the second EarthMRI study undertaken by the survey. Geologists are currently mapping and sampling mineralized zones in interlayered carbonate and volcanogenic rocks and overlying soils of eastern Frederick County and western Carroll County. Mineralization consists of a copper, iron, zinc, and magnesium minerals that mainly formed at or near the contact of these two units, interpreted as the result of primary fluids associated with volcanism. Drilling at the New Windsor and Union Bridge sites was completed with retrieval of 50 feet of bedrock at each location that are currently being analyzed. New maps of bedrock distribution and mineralization at 1:24,000 scale are in process and will be completed using new aeromagnetic data flown by the USGS Appalachian transect. Once completed, the resulting maps will be made available both as GIS shapefiles and in the USGS GeMS geodatabase format.

Land Subsidence Mapping

MGS <u>continues to work with other government agencies</u> <u>and universities</u> to collect high-precision GPS satellite observations at 55 geodetic benchmarks surrounding Chesapeake Bay annually. Data from multiple years' surveys will be used to better isolate short-term changes in land subsidence due to human activities such as groundwater extraction and from long-term geologic signals such as glacial cycles and deep Earth processes. The findings will be used to produce revised maps depicting the variability of land subsidence, and will also be used to improve models that predict possible effects of land subsidence and aquifer management decisions on critical wetland habitat.

OTHER MAJOR ACCOMPLISHMENTS

Marine Seafloor Sediment Mapping

MGS staff focused on expanded marine seafloor habitat mapping tasks in Eastern Bay, Chesapeake Bay, MD. Datasets included swath bathymetry, side scan imagery, sub-bottom seismic, and marine magnetometer data which were analyzed, filtered, and processed for generation of map products and seabed substrate class maps using the NOAA Coastal and Marine Ecological Classification System (CMECS). Approximately 14,900 acres of Eastern Bay—covering all navigable portions of 17 Yates oyster bars—were previously mapped in late 2020. In 2023, MGS surveyed an additional 26,000 acres of Eastern Bay to include Cox Creek, Prospect Bay, Miles River, and Wye River, covering all naviga-



Figure 1. MGS geologists Heather Quinn (I) and Isabel Glasman (r) examine a core sample collected for the Mid-Atlantic Stratigraphic Reconciliation project.

ble portions of 82 Yates oyster bars. Staff completed processing of the low-frequency side scan and swath bathymetry data with the additional Priority 2 data, and generated side scan mosaics and a seamless bathymetric surface map. Staff proposed procurement of a new 26-foot survey vessel to be equipped with a full suite of acoustic mapping systems that will provide greater mobility and access to shallow water sites. Acquisition of this vessel is expected in the next year. Four long term contractual positions have also been filled, increasing data-processing and product-generation capabilities.

National Groundwater Monitoring Network

MGS and the USGS work together under an annual Joint Funding Agreement to collect water-level data from approximately 460 wells throughout Maryland. We share the concerns of other agencies and organizations which monitor our nation's groundwater—that the collected data should be reliable, consistent, and comparable. Many of the wells used to collect water-level data are valuable long-term data sources, but for this reason, they are also vulnerable to deterioration or blockage related to their old age and lack of pumping. To help accomplish our goal of collecting and presenting quality data, MGS has received funding in recent years through the USGS National Groundwater Monitoring Network grant to conduct GPS/total station surveying and well integrity testing on a subset of 112 wells that comprise the Maryland National Groundwater Monitoring Network (NGWMN). Slug testing and well-camera surveys conducted with help from the grant have identified problem wells that will require repair, redevelopment, or replacement.

Mid-Atlantic Stratigraphic Reconciliation Initiative (MAtStrat)

MGS geologists continue to participate to identify conflicts in regional stratigraphy, to create strategies for reconciliation, and to determine implications for correlation of regional aquifers and geologic resources. In the past year, MGS geologists collaborated with the Delaware Geological Survey to conduct continuous coring at sites in Maryland to better define coastal plain stratigraphy near our common border.

A similar project is being conducted in the Western region of the state between Virginia, Pennsylvania, West Virginia, Maryland, and the USGS.

MASSACHUSETTS

MASSACHUSETTS GEOLOGICAL SURVEY

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The Massachusetts Geological Survey (MGS) is housed in the Department of Earth, Geographic, and Climate Sciences at the University of Massachusetts Amherst campus. The State Geologist reports to the Vice Chancellor for Research and Engagement. The mission of the Survey is to serve the needs of state government, industry, and the citizens of the Commonwealth of Massachusetts by providing earth science information and research relevant to natural resources, environmental quality, economic vitality, and public safety. Statutory authority for the Survey is in the Massachusetts General Laws Chapter 21A, Section 7B.

GEOLOGIC MAPPING

This year we completed the Massachusetts Top of Rock Project. This represents the culmination of nearly three years of work. This project was funded by the Massachusetts Department of Transportation (MassDOT) and the Massachusetts Emergency Management Agency. The project goals were to collect as much depth to bedrock information as practical from easily accessible drillhole and geophysical data sources, and to create maps of the altitude of the bedrock surface and of the thickness of the overburden at 100-meter resolution, along with their associated uncertainties. The main purpose of the project was to provide a tool for Mass-DOT to help reduce the uncertainty associated with planning subsurface investigations for highway transportation projects. However, the information is also useful for groundwater modeling and for any project that will or is planning to disturb the earth's surface. This work also supports the U.S. GeoFrameworks Initiative.

The final 172-page technical report documents every step taken to collect, process, and model the data. The report also includes modeling scripts used in the project. The report was designed in "cookbook" fashion so that the model can be rerun by anyone as more borehole information becomes available. The final report—with links to all the deliverables on page 77 of the report—can be found <u>here</u>.

Figures 1 and 2 show the final bedrock altitude and depth to bedrock maps for Massachusetts. The information is already being used as intended. MassDOT has all the maps on their geoDOT webpage (MassDOT's spatial data clearinghouse) where the information can be used for preliminary transportation project planning. The maps of the altitude of the bedrock surface and depth to bedrock are also being used to create a new statewide Hydrogeologic Atlas of Massachusetts. The maps have also been provided to several geothermal companies and drillers working in Massachusetts.



Figure 1. Map showing the altitude (NAVD 88) of the top of the bedrock surface at 100-meter resolution.



Figure 2. Map showing the thickness of the overburden (m) at 100-meter resolution.

Quaternary Geologic Map of Massachusetts

We are continuing to collaborate with the USGS to complete the new statewide Quaternary Geologic Map of Massachusetts. The map is nearing completion. This will be a companion product to the surficial materials geodatabase published in 2019. The Massachusetts Geological Survey's role in the Quaternary Map will be to provide 20-meter structure contours of the top of the bedrock surface for the major alluvial fill valleys and sand and gravel deposits throughout Massachusetts. The structure contours are generated from the Top of Rock Project but still require some manual editing.
OTHER PROGRAM HIGHLIGHTS

Pyrrhotite Evaluation Program

Throughout the year, the MGS continued to work with the MassDOT to develop a licensing program for all quarry and sand and gravel operations providing aggregate for use or sale in concrete. The goal is to limit the use of aggregate containing pyrrhotite for any commercial, residential, or MassDOT project. The work has involved developing an online data management and licensing portal, geologic source report template, operations plan template, testing procedures, and communication plan. The new law requiring licensing will go into effect on July 1, 2024.

Identifying Stratigraphic Problems in New England

The New England States Geologic Mapping Coalition (NES-GMC) is working on a grant from the National Cooperative Geologic Mapping Program. The purpose of the project is to identify, research, and summarize cross-border stratigraphic inconsistencies to support the U.S. GeoFrameworks Initiative. The project includes three objectives: (1) select lithotectonic domains affecting Coalition states that present significant stratigraphic issues; (2) research and assemble the body of literature relevant to the stratigraphic issues in each domain; and (3) summarize the most significant stratigraphic problems in each domain and prepare a preliminary list of possible projects or methods to resolve some of the issues. Four lithotectonic domains were selected as high priority. Work began on this project in January 2023 and is continuing.

National Ground Water Monitoring Network Program

In July 2022, we began work on a subcontract with the Massachusetts Department of Conservation and Recreation (MADCR) to help populate the National Ground Water Monitoring Network (NGWMN) data portal with well data from the Massachusetts monitoring well network. Massachusetts maintains 124 wells in the network. However, many of the fields in the database were not populated. Our charge was to go through historic records, gather as much information about each well, and to provide missing information so the database can be updated.

Climate Response Network

The MGS continues to contribute to the Climate Response Network—a network of over 70 wells—used to monitor ground water levels across the state. MGS monitors seven wells in the western part of the state monthly and reports results to the USGS. This work is done in collaboration with the Massachusetts Department of Recreation and Conservation (MA DCR) and the Department of Environmental Protection (MA DEP). Some of these wells have been in service since the 1950s. The dataset is used by the State's Drought Management Task Force and provides a valuable time series of historic droughts against which current dry periods can be compared.

Well Driller's Database

Massachusetts requires every driller that completes a test boring, test hole, water supply well, geothermal well, or monitoring well to complete a well completion report and to submit it to the Massachusetts Department of Environmental Protection (MADEP). This report provides information such as total depth, depth to bedrock, water level, casing length, and stratigraphic information. There are currently over 200,000 wells in the database. However, only 32% have street addresses and can be matched to statewide parcel data. The MGS is working with MADEP to help verify street addresses for the wells lacking valid addresses. The work involves going town by town, one well record at a time, tracing well owners and property transfers in the Registry of Deeds, and examining assessor's data and subdivision plans until the homeowner of record is verified with a valid street address. The well is then manually moved to the correct parcel using an online mapping tool provided by MADEP. About 5% of MGS time was spent helping with this validation process. Approximately 177,000 wells have been reviewed, of which 122,800 have now been parcel-validated, raising the percentage of wells in the database with valid locations from 32% to 69%. When the project is complete, it is estimated that this will provide an additional 40,000 to 50,000 wells with depth to bedrock information that can be added to the Massachusetts Top of Rock database.

MINNESOTA

MINNESOTA GEOLOGICAL SURVEY

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The Minnesota Geological Survey (MGS) is a unit of the School of Earth and Environmental Sciences in the College of Science and Engineering at the University of Minnesota.

MGS carries out geological research and provides service and education in geological matters to the people of Minnesota. Principal activities include geologic mapping in (1) structurally complex Precambrian terranes, (2) essentially un-deformed sedimentary strata of Paleozoic and Mesozoic age, and (3) Quaternary glacial deposits. The mapping is integrated with vigorous research programs. MGS publications and databases serve scientists, decision-makers, and resource managers concerned with groundwater, environmental issues, land-use planning, waste disposal, mineral discovery, and mineral-resource development. The Survey works with state, tribal, county, and regional offices to set up geologic databases and to provide technical guidance for water resource planning, land management and mineral exploration policy, energy system development, and other planning and resource management activities.

The MGS is funded by a special appropriation from the State Legislature and receives significant contract funding for special projects and research from various governmental agencies. We currently have 30 professional geologists, hydrogeologists, geophysicists, and support personnel, and operate on an annual budget of approximately \$3 million. Atlases are complete for 52 of the 87 counties and we currently have active projects in 26 counties (Fig. 1). The goal of the program is to complete CGA coverage statewide.



Figure 1. Status of County Geologic Atlas mapping.

GEOLOGIC MAPPING

County Geologic Atlas Program

Most MGS mapping is conducted as part of the County Geologic Atlas (CGA) program, which provides maps and databases essential for improved management of all geologic resources, with a focus on information relevant to ground and surface water. This is foundational data that supports management of drinking water, domestic and industrial supply, irrigation, and aquatic habitat. CGAs are specifically identified as essential data for sustainable water management. The distribution of geologic materials defines aquifer boundaries and the connection of aquifers to the land surface and to surface water, enabling comprehensive water management.

Mapping at 1:24,000 scale and at a publication scale of 1:100,000 is directed towards ongoing CGA projects. Mapping is being compiled as seamless 1:100,000-scale surficial and bedrock databases, as statewide, consistent 1:500,000-scale maps, and as incrementally updated databases.

USGS Mapping Programs

MGS leverages state funding for the CGA program with federal funding through a variety of USGS programs including STATEMAP, Earth Mapping Resources Initiative (MRI), and the Great Lakes Geologic Mapping Coalition (GLGMC). We are currently cost-sharing mapping of the surficial and/ or bedrock geology of five counties as part of our STATEMAP funding and of four counties (bedrock) as part of our Earth MRI award. Rotary sonic drilling operations for three counties are funded in part by the GLGMC.

It is mutually beneficial for us and for federal agencies to integrate federal funding into our existing mapping programs. Not only are we able to achieve the MGS mission and goals, but we are also able to identify areas that may have potential to contain critical mineral resources and to support the US GeoFramework Initiative.

Watershed mapping

The Department of Health has identified Groundwater Restoration and Protection Strategies (GRAPS) to support water planning. The goal is to provide surface and subsur-



Figure 2. Three-dimensional representation of surficial and bedrock data for the Zumbro River watershed.

face geologic data within selected watershed boundaries in a format suitable for both modelers and for the public. Seamless geologic products are based on a compilation of previously published MGS CGA maps along with new mapping where necessary. These products are displayed as web-based three-dimensional models (Fig. 2) so they can be visualized and used outside of a GIS environment by water planners, state agencies involved in the GRAPS process, and the public.

This type of project is a natural step that follows CGA mapping. We can revisit counties that were mapped decades ago and that may not contain the same digital products as more recent CGAs. Furthermore, adjacent counties within a watershed may not have seamless CGA mapping across their border. We can update a targeted watershed with new water-well data and mapping as necessary, rectify border discrepancies, and produce a seamless three-dimensional map.

OTHER PROGRAM HIGHLIGHTS

Several MGS scientists are lending geologic and hydrologic expertise to various Minnesota agencies and University departments to better understand and mitigate groundwater contamination. The most prominent examples are widespread contamination from agricultural activities (e.g. nitrate), and the PFAS (Per- and Polyfluoroalkyl Substances) plume in the eastern Twin Cities metropolitan area. We are also collaborating on a project on the viability of Managed Aquifer Recharge to mitigate groundwater depletion.

Outside of applied geology, we recently made an exciting discovery of more purely scientific interest. During routine CGA mapping, Minnesota's first impact crater was identified, right here in the Twin Cities! It is located deep in the subsurface, in the Inver Grove Heights area of Dakota County (Fig. 3). You can expect to hear more about this as we more thoroughly piece together the story behind the crater.

STAFFING CHANGES

In February our Director—Harvey Thorleifson—took a position with the Department of Earth and Environ-

mental Sciences. He is still active in the University and you can see him regularly as moderator of the online Geologic Mapping Forum.

Anthony Runkel is the Interim Director and the search is on for a new full-time Director. The application is open until mid-January, we hope to start interviews in February, and aim to have the position filled by early summer.

Over the past year, we have added several new full-time staff. New hires include GIS Specialist W. Grimm; Subsurface Data Specialist M, Dietrich; and Administrative Assistant A. Behling. In addition, we brought in four additional Field Technicians. These are full-time, short-term positions ideal for recent graduates. Three techs were with us only through the field season (three to six month appointments). Two techs assist with laboratory work through the winter and the following field season.



Figure 3. Twin Cities metropolitan area showing the location of the impact crater in Dakota County.

MISSOURI

MISSOURI GEOLOGICAL SURVEY

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The Missouri Geological Survey (MGS) is one of five Divisions of the Missouri Department of Natural Resources. Since 1853, MGS has provided essential geoscience information to steward decision-making that helps to protect Missouri's natural resources and to encourage economic development. These efforts are provided via 142 full-time employees that support six organizational programs. General functions of these programs include:

- Administration of MGS
- Geologic activities such as bedrock mapping, mineral and energy resource assessments, geologic hazards, and groundwater protection
- Dam and reservoir safety
- Reclamation of surface coal, metallic, and industrial minerals mines
- Water resource information and planning
- Soil and water conservation cost-share practices

GEOLOGIC MAPPING

Geologic Mapping

Through the National Cooperative Geologic Mapping Program (NCGMP) STATEMAP Program, MGS completed 1:24,000-scale bedrock mapping of ten 7.5-minute guadrangles along the Interstate 70 corridor in the Kansas City metropolitan area. New mapping refined existing, generalized mapping of Pennsylvanian-age stratigraphy and geologic structures. In addition, MGS completed 1:24,000-scale bedrock mapping of the Knob Lick 7.5-minute guadrangle in the St. Francois Mountains in southeast Missouri to compliment an ongoing EarthMRI project in the same area. MGS also compiled existing 1:24,000-scale bedrock mapping in the Western I-70 Corridor 30- x 60-minute quadrangle into seamless 1:100,000-scale mapping, and 1:24,000-scale bedrock mapping in the Joplin 30- x 60-minute guadrangle was implemented into GeMS. These projects support the USGS GeoFramework Initiative to construct a multi-resolution and seamless national two-dimensional and three-dimensional geologic model.

EarthMRI funding is supporting mapping the bedrock geology of six 7.5-minute quadrangles in the St. Francois Mountains. The mapping area contains major mines of the Fredericktown-Mine La Motte lead-zinc subdistrict, which produced cobalt and nickel in the past. The area also contains the current operations of Missouri Cobalt, working to recover cobalt from tailings and potential new underground mining. New mapping addresses sedimentary facies, previously undefined igneous units, geologic structures, and mineralization indicators.

As part of an agreement with the US Forest Service, Mark Twain National Forest (MTNF), MGS completed reconnaissance field mapping for five 7.5-minute quadrangles in the Eleven Point Ranger District located in south-central Missouri. Detailed geologic mapping of this District is critical to the work of the MTNF Terrestrial Ecological Unit Inventory project.

Earth MRI funding, passed through the National Geological and Geophysical Data Preservation Program (NGGDPP), supported entry of 1,000 core logs into an MGS core log database. Logs entered were in prospective critical mineral areas, contained intercepts of Precambrian igneous rocks, or had associated geochemical data. MGS is continuing this work and adding an additional 1,000 core logs in the current grant cycle.

NGGDPP funds supported scanning and indexing of MGS Mineral Resource files, which contain unpublished data on multiple commodities, including critical minerals found in Missouri. MGS is continuing this project in the current NGGDPP grant cycle.

OTHER PROGRAM HIGHLIGHTS

The Missouri Drought Mitigation and Response Plan was finalized in spring 2023 and became the operative drought plan for Missouri. The updated plan replaces the one published in 2002 and focuses on proactive efforts to improve drought preparedness and resiliency in addition to updating the state's drought response system.

MGS worked on multiple streambank stabilization and ecosystem restoration projects on the Gasconade and Osage rivers with the U.S. Army Corps of Engineers. Work also continued on the Lower Missouri Flood Risk and Resiliency Study, with a focus on reducing repetitive flooding issues at Jefferson City, Brunswick, and Holt County, Missouri.

MGS worked on a USGS National Groundwater Monitoring Network grant to perform aquifer pump tests on four wells within the groundwater level observation well network to determine connectivity of the wells with the aquifer.

MGS received new EarthMRI mine waste funding, supporting a two-year statewide mine waste inventory project and a characterization project to determine critical mineral resource potential in mine waste tailings and ponds in the REE-rich Pea Ridge Mine in east-central Missouri.

MGS participated in a multi-state, Earth MRI-funded project investigating critical mineral potential in Pennsylvanian-age black shales in northern and western Missouri. In addition, MGS is working with multiple states on an ongoing Department of Energy Carbon Ore, Rare Earth, and Critical Minerals (CORE-CM)-funded project investigating critical mineral potential in coals and coaly strata.

MONTANA

MONTANA BUREAU OF MINES AND GEOLOGY

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The Montana Bureau of Mines and Geology (MBMG), founded in 1919, is a non-regulatory, research agency and state geologic survey within the Montana University System and a department of Montana Tech. MBMG provides extensive advisory, technical, and informational services to the public and other agencies to inform responsible development and protection of Montana's mineral, energy, and water resources. MBMG also responds to thousands of informal queries for information and assistance.

MBMG's primary office is on the Montana Tech campus in Butte; a branch office is located in Billings. The staff is comprised of about 70 scientists, 15 technicians and support personnel, and 15 students. MBMG conducts research on all aspects of the geology of Montana including groundwater, mining, and energy development.

GEOLOGIC MAPPING

The main priority of MBMG's geologic mapping program is 1:100,000-scale digital coverage of the State's ninety-four 30- x 60-minute quadrangles. Including several USGS products, 77 quadrangles are now publicly available; two more are imminent. Quadrangles lacking coverage are in the western part of the State. With support from STATEMAP, selected 1:24,000-scale guadrangles are being mapped to (1) resolve the complex structural features and immensely thick stratigraphic sequences of western Montana, leading to eventual 1:100,000-scale coverage or (2) to provide more detailed mapping in valleys and urban areas that are experiencing high growth rates and land-use pressures. The inevitable encroachment of development on mountainsides is commonly accompanied by severe problems with water resources and slope stability. PDF versions of our digital maps are viewable and downloadable from MBMG's website. The focus of our current mapping is southwest Montana in the Dillon and Wisdom 30- x 60-minute guadrangles. MBMG geologists are also working with the Idaho Geologic Survey along our common border to ensure the geology matches.

Critical Minerals Mapping

In 2014 the MBMG's Economic Geology program began to reevaluate the potential for metallic mineral deposits in historic mining districts for future exploration. Currently, the MBMG is continuing to focus on mining districts associated with the Boulder Batholith. There is renewed interest in the mining industry to explore for critical metals used in batteries, high-tech electronics, renewable energy projects, and electric cars. Some of these elements include cobalt, cadmium, lithium, vanadium, germanium, gallium, tellurium, and rare earth elements. These elements are considered critical because 100% of these elements are imported into the U.S. A new program, Earth Mapping Resource Initiative (Earth MRI), was started by the USGS in 2019 to conduct a nationwide inventory identifying geologic environments favorable for critical element resources. Montana was included on the list to receive funding from the Earth MRI program. The first Earth MRI project began in 2020 on the Elkhorn Mountain quadrangle including the Elkhorn mining district, Jefferson County and will be completed in 2024. Other mapping projects started in 2022 will continue through 2024.

Geologic Hazards Mapping

The Geologic Hazards program aims to provide high-quality information on landslides, potentially active faults, and earthquakes. The program's first goals are updating the map and database of active faults and creating a landslide map and database for Montana. Faults are considered active if they have produced an earthquake during the Quaternary and have the potential to generate a future earthquake. The existing map of active faults in Montana contained 116 faults and was published in 2000. The current version, updated by the MBMG, includes 608 faults and is undergoing review to determine which may be potentially active. The MBMG will continue to update the map and database as new geologic mapping and other data become available. The active fault database will be used to prioritize future investigations of active faults and to assess seismic hazards.

Earthquake Studies

MBMG's Earthquake Studies Office monitors earthquake activity in Montana and the surrounding area through a network of 42 in-state stations, plus data from several networks in bordering states. Data are exchanged with seismic research centers in surrounding states and with the USGS National Earthquake Information Center so that the public and emergency responders are rapidly provided with information about the location and severity of significant earthquakes affecting the state. As part of an effort to raise public awareness of the very real seismic hazards in Montana, the Montana Bureau of Mines and Geology has developed a web-based mapping application that displays over 43,000 earthquakes recorded by the Montana regional seismic network since 1982. Also shown are significant historic earthquakes, potentially active faults, and seismic hazard zones. This site allows the public to explore their home towns and see the level of seismic activity, hopefully raising awareness and preparedness.

Ground Water Assessment Program (GWAP)

Montana's 1991 Ground Water Assessment Act provided a three-part program (groundwater characterization, longterm water level monitoring, and a groundwater database) designed to assess Montana's groundwater resources.. Characterization studies are conducted on a drainage-basin scale and result in maps and atlases summarizing the hydrogeology of the basin. The core of GWAP's monitoring program is a statewide network of about 950 wells where water levels are

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collected at least guarterly. About 75 wells are sampled for water-quality analysis annually. The Ground Water Information Center (GWIC) database contains all GWAP data, including that obtained from driller's logs, published reports, field measurements, laboratory analyses, and other sources for about 250,000 sites; groundwater data collected from other MBMG projects; and more recently, groundwater data collected by some private entities. Water well drillers can now submit well records directly to the MBMG. The GWIC database is available publicly at http://mbmggwic.mtech.edu. Scanned images of well logs are also being added. GWIC users average about 44,000 gueries per month from 31,000 registered users. At the end of 2018, the Ground Water Assessment Program had completed field work in 12 areas

Ground Water Investigations Program

(30 counties) and had released 800 maps and reports.

(GWIP)

Recognizing that competition for water resources and the lack of detailed information on groundwater-surface water interaction has challenged informed water-resource management and development in Montana, the 61st Montana Legislature funded the Ground Water Investigation Program. This program operates at the sub-basin scale to investigate local issues related to groundwater development. Since its inception in 2009, GWIP has produced more than 16 MBMG publications related to seven project areas. Both groundwater programs, GWAP and GWIP, were strongly supported in recent meetings of basin advisory councils throughout Montana and are integral to the new Montana State Water Plan.



Figure 1. The MBMG has published over 500 geologic maps. All maps and associated GIS data and databases are available for free download.

NEBRASKA

CONSERVATION AND SURVEY DIVISION

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School of Natural Resources

Nebraska

INTRODUCTION

The Conservation and Survey Division (CSD) is Nebraska's geological, water, and soil survey. In 2023, it marked its 130th year of establishment in state statutes, although the first state geologist was named in 1871, just three years after the founding of the University of Nebraska. CSD's work emphasizes research, but it also includes scholarly service, extension, outreach, formal classroom education, and informal education. Every year CSD personnel answer hundreds of requests for data and scientific analysis, serving thousands of stakeholders and dozens of organizations. CSD publishes the annual Nebraska Statewide Groundwater-Level Monitoring Report as part of a program that began in 1930. CSD personnel also serve as members of boards, panels, and committees; facilitate the long-term Eastern Nebraska Water Resources Assessment (ENWRA) coalition; maintain Nebraska GeoCloud (an internet data repository for groundwater, geology, and geophysics); and coordinate the Nebraska Water Leaders Academy for water professionals in the state. EN-WRA continues evaluation of groundwater in five focus areas under the Water Sustainability Fund (WSF) ENWRA Recharge grant award with the U.S. Geological Survey (USGS) and the eastern Nebraska Natural Resource Districts (NRDs). ENWRA continues to support state and local groundwater-quality inventories. The CSD Geological Sample Repository houses cores, cuttings, and samples in five facilities with a total of

nearly 29,000 square feet of floor space. Approximately 6,500 ft of new drilling and sampling was accomplished by CSD personnel in 2023.

CSD is unique in its comparatively large number of university faculty, its close association with academic programs, its incorporation in the School of Natural Resources (since 2003) as one of six diverse centers, and its inclusion within the Institute of Agriculture and Natural Resources at the University of Nebraska-Lincoln. CSD personnel include ten faculty members (five tenured) and six professional staff. These individuals possess skills in cyberinfrastructure, environmental social science, geochronology (OSL dating), geological and groundwater modeling, geomorphology, geophysics, human dimensions of natural resources, hydrogeology, image analysis, low-temperature geochemistry, machine learning, mapping, mineral resources, paleontology petrography, petroleum, remote sensing, sedimentology, stratigraphy, and surface-water monitoring.

GEOLOGIC MAPPING

CSD personnel produced surficial geologic maps of the Leshara, Mead, Meadville, and Richland 7.5-minute quadrangles under the STATEMAP Cooperative Geologic Mapping Program. The Leshara, Mead, and Richland maps are in the Platte Valley of eastern Nebraska, which was glaciated



Figure 1. Serial electrical resistivity tomography models (August and October) from surveys measured along an irrigation canal and siphon in western Nebraska by CSD's M. Khalil Aboushanab and D. Hallum.



Figure 2. Ground-penetrating radar profile of a linear dune crest in the Nebraska Sand Hills generated in cooperation with H. Jol (University of Wisconsin-Eau Claire-Eau Claire) as part of a study spearheaded by CSD's P. Hanson.

multiple times during the Pleistocene. Late Pleistocene and Holocene alluvial units are widespread in these mapping areas. The Meadville map is in the Niobrara Valley in north-central Nebraska. Oligocene (Rosebud Formation), Miocene (Ogallala Group), and Pliocene (Broadwater Formation) sediments crop out in the canyons along the Niobrara River above the Cretaceous Pierre Shale in this mapping area. Late Pleistocene and Holocene eolian sands are discontinuously distributed on the uplands. The updated mapping goals for STATEMAP in Nebraska are:

- Generate maps that better constrain the usable extents of both paleovalley aquifers and the Dakota aquifer in southeastern Nebraska. These maps will improve our understanding of water resources in these geologically complex but groundwater-sparse landscapes that are experiencing increasing demand for groundwater. Specific quadrangles to be mapped will be selected with input from those managing and/ or regulating groundwater resources in the region, including, but not limited to, personnel of Nebraska's Natural Resource Districts (NRDs) and the USGS.
- 2. Generate maps for the rapidly developing greater Lincoln metropolitan area, particularly areas to the east including the Greenwood, Eagle, and Palmyra 1:24,000-scale quadrangles.
- 3. Continue mapping efforts in the Platte River Valley and other critical areas that will lead to improved understanding of both groundwater resources in the High Plains Aquifer and of construction aggregate resources.

Two CSD faculty initiated work with USGS personnel on a Quaternary geologic map of the state. The annual Nebraska Statewide Groundwater-Level Monitoring Report for 2022, which was published in early 2023, included these newly generated maps: Groundwater-Level Changes in Nebraska (Spring 2021 to Spring 2022); Groundwater-Level Changes in Nebraska (Spring 2012 to Spring 2022); Groundwater-Level Changes in Nebraska (Predevelopment to Spring 2022); Density of Active Registered Irrigation Wells (December 2022).

OTHER PROGRAM HIGHLIGHTS

CCSD personnel published peer-reviewed journal articles on subjects such as geophysical surveys of an earthfill dam, collaborative water management, effective community and stakeholder engagement, Cretaceous isotope chemostratigraphy, and the Cenozoic evolution of fluvial systems on the Great Plains. CSD's T. Gilmore and his student K. Chapman worked on measurement and prediction of stream stage and discharge using ground-based imagery. Their image-based, machine learning approaches produced valuable hydrological information, including stage measurements and models that will likely improve data quality for stream monitoring networks. Geoscientist M. Burbach participated in a \$5 million USDA National Institute of Food and Agriculture-funded multi-institutional grant studying water, agriculture, and community and stakeholder engagement. The 2023 Nebraska Water Leaders Academy graduated 18 participants bringing the total number of graduates to 186 since the program began in 2011. CSD faculty member P. Hanson was a visiting professor at Heidelberg University in Germany and at the University of Lausanne in Switzerland during the spring of 2023. J. Korus presented at the 6th European Meeting on 3D Geological Modeling in Copenhagen, Denmark in May 2023, and M. Joeckel and M. Waszgis were coauthors on a presentation about basement tectonics in southeastern Nebraska at the EGU 2023 General Assembly in Vienna. For the second successive year, the University of Nebraska Soil Judging Team, co-coached by CSD's J. Turk, won first place at the Region 5 Collegiate Soil Judging Contest. CSD Geoscientist S. Lackey was awarded the 2022 Kremer Award by the Nebraska Water Resources Association, making her the seventh CSD employee to win this award since its inception in 1986. She followed in short order as the recipient of the Wayne Madsen Award from the Nebraska Well Drillers Association. Lackey, K. Cameron, and M. Marxsen ran a field trip for drillers and other groundwater professionals in northeastern Nebraska, which was published as CSD Guidebook No. 39. State Geologist Joeckel served as the 2022–23 Chair of the North American Commission on Stratigraphic Nomenclature.



Figure 3. CSD's T. Gilmore, J. Westrop, and others identified a significant relationship between rust staining on center-pivot irrigation systems and groundwater nitrate concentrations in south-central Nebraska and attributed it to biogeochemical conditions.

N. Shrestha (Ph.D. Natural Resources Science) was hired as a Geoscientist in 2023; his research specialty is the measurement and monitoring of water resources using remote sensing observations, and he will also be fulfilling GIS and cartographic functions in CSD. S. Kruse (B.S. Environmental Science with a specialty in Water Science) was hired as a Drilling/Research Technician for CSD. He also serves in the Nebraska Army National Guard.

NEVADA

NEVADA BUREAU OF MINES AND GEOLOGY

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The Nevada Bureau of Mines and Geology (NBMG) is a research and public service unit of the University of Nevada, Reno (UNR), and serves as the state geological survey for Nevada. NBMG is a statewide agency that resides in the Mackay School of Earth Sciences and Engineering within the College of Science at UNR. As defined by state statutes, NBMG is the state's official locus of data, analysis, and exchange on Nevada's geology, natural resources, and geologic hazards. NBMG scientists conduct research and publish reports that facilitate economic development, public safety, and enhancement of the guality of life across the entire state. NBMG products include geological maps and reports on mineral and geothermal resources, as well as earthquake, flood, landslide, and other geological hazards. NBMG disseminates this information to local, state, and federal agencies, major industries, engineers, educators, and the general public. As such, NBMG has cooperative research and information programs with numerous local, state, and federal agencies. In addition, NBMG hosts three major centers of excellence: (1) the Ralph J. Roberts Center for Research in Economic Geology (CREG), (2) Great Basin Center for Geothermal Energy (GBCGE), and (3) Nevada Geodetic Laboratory (NGL). CREG and GBCGE are at the forefront of research in mineral and geothermal resources, respectively, and also play important roles in education through teaching courses and workshops. NGL has built a network of greater than 400 global positioning system (GPS) stations across Nevada and parts of neighboring states. These stations track the motions of crustal blocks and help to define earthquake hazards. NGL is at the cutting edge of global research in geodesy. Programs are also underway to increase public awareness of earthquakes in Nevada and to prepare for emergency response to a major earthquake.

NBMG employs nearly 30 geoscientists and support staff. This includes 12 faculty positions in the geosciences, five specialists in support of publication production (cartography, GIS, and graphics design), two data managers, one information specialist, three management assistants in support of publication sales and administrative and clerical needs, and one development technician. More than half of these positions are funded directly by the state through UNR, with over one third funded by external grants and contracts. In addition, NBMG employs about 15 graduate student assistants, several undergraduate students, and one post-doctoral scholar.

GEOLOGIC MAPPING

Geologic mapping by NBMG addresses the needs of an extraordinary state. For example, Nevada commonly leads the nation in non-fuel mineral production, is the top producer of gold in the country, and is rich in geothermal and critical mineral (e.g., lithium) resources. Nevada is also the third



Figure 1. Status of detailed geological mapping in Nevada. Map shows distribution of completed maps at 1:24,000 and finer scale by NBMG and the USGS.

most seismically active, fastest growing (tectonically speaking), and most urban state (in terms of proportion of citizens living in large cities). NBMG has three priority regions for geological mapping: (1) Clark County in southern Nevada, which is home to Las Vegas and nearly three quarters of Nevada's citizens; (2) the Reno-Carson City urban corridor in western Nevada and adjacent areas rich in geothermal and mineral resources; and (3) north-central to northeastern Nevada due to its wealth of mineral resources and classic setting for extensional tectonics. Northeastern Nevada contains the Carlin Trend, one of the richest regions on Earth for gold production. All regions contain geological hazards (e.g., earthquakes, floods, debris flows, and landslides) that must be reckoned with for infrastructure planning and development. To date, we estimate that ~20-25% of the state (Figure 1) has been mapped in sufficient detail (typically 1:24,000 scale) to adequately understand the geological framework; natural hazards; and mineral, energy, and groundwater resources. Accordingly, significant work remains to produce high-quality, detailed geological maps for the state. The USGS STATEMAP program permits publication of several new quadrangles/areas per year. Although the arid climate greatly facilitates geological mapping in Nevada, the complexity of the geology, with multiple overprinting tectonic episodes since the late Paleozoic, impedes rapid progress on geological mapping. Recent increases in funding for the

STATEMAP program have accelerated the pace of detailed geological mapping by NBMG in the state, including publication of high-quality maps by authors external to NBMG (e.g., USGS geologists and university professors). The USGS EarthMRI program has also provided funding for geological mapping in areas with significant potential for hosting critical minerals (e.g., lithium and rare-earth elements).

Thanks to enhanced funding for the STATEMAP and EarthMRI programs, NBMG was able to publish a record amount of geological maps in the past year, totaling nearly 1% of the state. Some of the notable recent mapping projects include: (1) quadrangle mapping and Quaternary fault studies within and near the Las Vegas metropolitan area, (2) several quadrangles in a transect across highly extended, mineral-rich terrain in northeastern Nevada, (3) metamorphic core complexes in eastern Nevada, (4) mineral districts and highly extended volcanic terrain in southeastern Nevada, (5) lithium-rich areas in west-central and northern Nevada, and 6) an area in southernmost Nevada with potential rare-earth element deposits.

Due mainly to the large amount of public land (~85%), Nevada has, until recently, lagged behind many states in the acquisition of high-resolution lidar and geophysical data that could expedite geological mapping, facilitate exploration of



Figure 2. Location of geothermal systems with operating geothermal power plants in Nevada in 2022. Some geothermal systems (e.g., Steamboat and McGinness Hills) contain more than one power plant.

mineral and geothermal resources, and permit evaluation of geological hazards. However, this has changed significantly in the past few years, as evidenced by the recently completed GeoDAWN project (Geoscience Data Acquisition for Western Nevada), a major collaborative effort between the USGS, Geothermal Technologies Office of the Department of Energy, and other federal agencies. GeoDAWN and related projects will provide high-resolution lidar and relatively detailed aeromagnetic data for over one third of Nevada. Notably, the federal fiscal year 2023 budget contains funding for acquisition of high-resolution lidar for remaining parts of Nevada, with the exception of the Nevada National Security Site (formerly known as the Nevada Test Site).

OTHER PROGRAM HIGHLIGHTS

Nevada is well poised to facilitate the energy transition, as it has abundant geothermal and critical mineral resources. Nevada is particularly rich in lithium, with some of the largest deposits in the world. Nevada also has vast geothermal resources that are largely undeveloped. Geothermal provides a reliable, 24/7 source of renewable energy and has a very low carbon footprint. Significant analyses are still needed, however, to identify and sustain commercially viable geothermal resources and discover new deposits of critical minerals. Most of these resources are hidden beneath the surface. The high-quality geological maps, assessments of mineral and geothermal resource potential, and research to refine exploration methodologies by NBMG are important products that can foster the energy transition for Nevada and the nation.

The total net geothermal power generation (energy to market) in Nevada in 2022 reached 450 MWe from ~18 geothermal systems (Figure 2). One megawatt is enough to power ~750 to 1,000 homes 24/7. In 2022–2023, NBMG's Great Basin Center for Geothermal Energy led three major geothermal research projects in Nevada, which were funded by the U.S. Department of Energy's Geothermal Technologies Office. These projects are briefly described below:

INGENIOUS (Innovative Geothermal Exploration through Novel Investigations Of Undiscovered Systems): The primary goal of this project is to accelerate discoveries of new, commercially viable hidden geothermal systems in the Great Basin region (Figure 3) and significantly reduce exploration risks. Most of the geothermal resources in the region are hidden beneath the surface with no surface hot springs or steam vents. This ambitious five-year project proposes to fully integrate play fairway analysis, three-dimensional and conceptual modeling, resource capacity estimation, machine learning, the application of advanced geostatistics, and value-of-information analysis to develop a comprehensive exploration workflow for the Great Basin region. This toolkit will include predictive geothermal play

fairway maps at both the regional and prospect scale, updated regional geoscience data compilations for much of the region, detailed three-dimensional maps and conceptual models, software tools to facilitate practical use of the refined exploration workflows, and a developer's playbook. In addition, several blind prospects are being analyzed through detailed geological and geophysical investigations followed by drilling thermal-gradient holes.

Understanding a Stratigraphic Hydrothermal Resource – Geophysical Imaging of Steptoe Valley, Nevada: The goal of this project is to advance the understanding of the nature and extent of the hidden, stratigraphic hydrothermal geothermal resource in Steptoe Valley in eastern Nevada and to recommend an optimized strategy for subsequent exploration and development for this resource and analogous resources. This involves supplementing preexisting geophysical and well information with new gravity, magnetic, and magnetotelluric surveys, conducting joint inversion modeling to inform a revised three-dimensional geological model of the basin, and using these data to develop thermal-hydrologic models of the inferred stratigraphic resource in Steptoe Valley.

Nevada Geothermal Machine Learning Project: The objective of this project is to apply machine learning techniques to develop an algorithmic approach to identify new geothermal systems in the Great Basin region and to build on the successes of the previously completed Nevada geothermal play fairway project. An algorithmic approach that empirically learns to estimate weights of influence for diverse parameters may scale and perform better than the play fairway analysis. Project activities included augmenting the number of training sites (positive and negative) that are needed to train the machine learning algorithms, transforming the data into formats suitable for machine learning, and development and testing of the machine learning techniques and outputs. We found that a combination of supervised (e.g., Bayesian neural networks) and unsupervised (e.g., principal component analysis with k-means clustering) machine learning techniques yielded the best results.



Figure 3. Great Basin study area for INGENIOUS project, with locations of known geothermal systems, identified structural settings, previous play fairway projects (Modoc, Nevada, and Utah), and detailed study areas for both the INGENIOUS project (Granite Springs Valley-GSV; Argenta Rise-AR, Buffalo Valley/Jersey Summit-BV, and Lund) and previously completed Nevada play fairway analysis project (Crescent Valley-CV; SE Gabbs Valley-GABBS; Sou Hills-SOU; and Steptoe Valley-STV).

NEW HAMPSHIRE

NEW HAMPSHIRE GEOLOGICAL SURVEY

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The New Hampshire Geological Survey (NHGS) was established in 2001 to "collect data and perform research on the land, mineral, and water resources of the state, and disseminate the findings of such research to the public through maps, reports, and other publications." This redefined the Office of the State Geologist, established in 1839. NHGS has five authorized full-time positions, four of which are filled. One permanent part-time position serves as NHGS outreach coordinator. Two project-specific, part-time positions and six summer intern positions round out the staffing in NHGS. While geologic mapping remains a key function of NHGS, the unit also has responsibility for the statewide Groundwater Level Monitoring Network, for which efforts are ongoing to update its information dissemination infrastructure, as it serves a critical role in statewide drought management. Support for statewide flood mitigation and response efforts, particularly as they relate to failed stream crossing infrastructure and broader stream and river management concerns remains an important role for NHGS. The outreach coordinator serves as the primary public contact point for inquiries about New Hampshire's geology and mineral resources, while also providing outreach to local schools, as requested.

GEOLOGIC MAPPING

NHGS continues to perform bedrock and surficial geologic mapping as part of the U.S. Geological Survey (USGS) STATE-MAP program. NHGS's historical suite of contract geologic mappers are now quickly entering second retirement. As a result, NHGS, with the advice of the Geological Resources Advisory Committee (GRAC), which serves as the SMAC for New Hampshire, is shifting its focus to pairing NHGS staff members with the contract mappers who remain, to maximize the transfer of geologic knowledge to the next generation of geologists.

Bedrock mapping has continued to focus on the White Mountains, a popular New England tourist destination visited annually by thousands. In addition to providing insights into the natural history of the area, many questions remain regarding the timing and sequence of mountain formation. A second focus of bedrock mapping is the Indian Stream area of far northern New Hampshire on the border with Quebec. Though these efforts will be maintained while these contract mappers remain with us, NHGS is making the pivot to focus on bedrock mapping in more populated interior southern New Hampshire, including current plans to perform 1:24,000-scale mapping in the Manchester South guadrangle, which covers a large portion of New Hampshire's largest city. This is an area that has experienced groundwater contamination and availability concerns in recent years. GRAC has charged NHGS with considering an area in central New Hampshire that is a focus for recurring small (<4.5 magnitude) earthquakes among its priorities for 1:24,000-scale bedrock mapping.

This year, NHGS and its contract mappers completed portions of three 1:24,000-scale quadrangles for surficial geology within the White and Ossipee Mountains regions of the state. Given New Hampshire's considerable focus to date on completing surficial geologic mapping, and its needs for aquifer mapping and groundwater availability identification, GRAC has charged NHGS with maintaining a program focus to complete the 1:24,000-scale surficial geologic mapping of the state. The unconsolidated sediments in many of the



Figure 1. Geologic mapping field conference in the Indian Stream area, northern New Hampshire. Photo courtesy of Dyk Eusden.

mapped areas were primarily deposited during the most recent period of continental glaciation, with post-glacial deposition limited to fans, streams, and rivers. The advance and retreat of the glacial ice resulted in the deposition of an assortment of surficial deposits and the formation of a variety of landforms. NHGS continues to integrate use of the Tromino digital tomographic passive seismic unit into its surficial geologic mapping efforts. Use of this unit has helped to determine depth to bedrock at locations where few water wells exist.

OTHER PROGRAM HIGHLIGHTS

For many years, NHGS has been integral to statewide flood hazard efforts, with specific emphasis on undersized stream crossings (culverts) and their failures during floods. A multi-agency team has coordinated the collection of data on the state's stream crossings to identify those at greatest risk for failure. NHGS has hosted summer interns through the years, which, combined with other agency and partner interns, has led to assessment of 71% of the state's crossings and inclusion in the state database. NHGS has a key role in the maintenance of this dataset and in conducting annual training of data collectors. With the slowing of the use of personnel to collect this information, focus is shifting to providing technical assistance to local municipalities for them to assume ownership of the collected data, given the resources that have been invested in their collection. NHGS technical assistance is shifting to working with towns and regional planning commissions in support of this programmatic transition.

NHGS continues a partnership with the New Hampshire Department of Environmental Services Coastal Program and the University of New Hampshire's Center for Coastal and Ocean Mapping, focused on a long-term beach profiling project. Coastal Program staff and trained volunteers regularly survey the contour profiles of select beach sites on New Hampshire's Seacoast to understand their change over time. Data are used to identify trends in beach erosion and accretion, which plays an important role in beach resources management. NHGS maintains the collected data and web access portal for the project. This year, NHGS staff have begun participating in and contributing to the field data collection activities.



Figure 2. NHGS summer interns Jaylin Calistro (left) and Noah Waldron (right) perform a stream crossing assessment.



Figure 3. NHGS monitoring well maintenance visit amid a typical New Hampshire winter. Photo courtesy of Rebecca LeCain, NHGS.

NEW JERSEY

NEW JERSEY GEOLOGICAL AND WATER SURVEY

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The New Jersey Geological and Water Survey (NJGWS) has a wide range of responsibilities. These include management of water supply allocation and well permitting; water supply planning and modeling; groundwater resource assessments; mapping onshore & offshore geology; evaluating natural hazards; advising on energy infrastructure issues (geothermal, natural gas, and wind); site evaluations; and providing earth science information to government agencies and the public to address economic, environmental, public health, and safety issues.

The Survey also provides technical expertise and direction for New Jersey on numerous strategic programs including the State Hazard Mitigation Team, Board of Licensed Site Professionals, Board of Licensed Well Drillers and Pump Installers, Pinelands Commission, Highlands Commission, Delaware River Basin Commission, and the Delaware River Decree Parties.

GEOLOGIC MAPPING

The Geologic Mapping and Coastal Geology Section completed four STATEMAP deliverables and met all Geologic Map Schema (GeMS) federal requirements: bedrock and surficial map of the Shiloh Quadrangle, bedrock and surficial map of the Pleasantville Quadrangle, bedrock and surficial map of the Browns Mills Quadrangle, and karst features map of the Easton Quadrangle.

Bedrock Mapping

The NJGWS published bedrock maps of four quadrangles: Milford/Port Jervis, Newton East, Pittstown, and Bloomsbury.

Surficial Mapping

The NJGWS published surficial geologic maps of five quadrangles: High Bridge, Portland-Stroudsburg, Chester, Bloomsbury and Blairstown.

Combined Surficial and Bedrock Mapping

Two combined surficial/bedrock quadrangle maps were published: Tuckerton/Beach Haven and Williamstown.

OTHER PROGRAM HIGHLIGHTS

Data Preservation

The NJGWS scanned, digitally preserved, and created associated metadata for three sets of historic geologic data for a total of 422 documents. The first collection scanned

contains 200 borehole logs from wells around the state from the 20th century. The NJGWS also scanned 205 mine maps from the New Jersey Zinc Company's mine map collection which was recently donated to the NJGWS. These maps date from about 1840 to 1970. The third collection the NJGWS scanned was a notebook of soil analysis results from a NJ Zinc Company zinc survey in northern New Jersey during 1954-55. This collection included soils analysis results with maps showing sample locations.

Publications and Web

NJGWS published 11 STATEMAP products—one GMS and 10 OFMs—along with one non-STATEMAP map and one bulletin. The Survey website had 12,675 downloads for November 2022 and 90,210 for January through June 2023 of 157 geologic maps. The website downloads were not available for the other months of 2022.

Water Supply Modeling

NJGWS provided technical support to water resource planning and permitting groups within and external to State government. Major work efforts included the development of the 2024 Statewide Water Supply Plan (due out early 2024), which included assessments of climate change impacts to water supplies, water use data trends and forecasts, emerging contaminant and new (Maximum Contaminant Level (MCL) impacts to drinking water supplies, and water supply impacts specific to overburdened communities. Surface water modeling support was provided to quantify risks to drinking water reservoirs from Harmful Algal Blooms (HABs) during the summer of 2022. Drought monitoring and technical support was provided for a Statewide Drought Watch issued in August and for near-drought conditions in the spring of 2023. NJGWS also provides support to the Delaware River Basin Commission.

Offshore Sand Resources

NJGWS entered and began working on a Cooperative Agreement with the US Bureau of Marine and Energy Management (BOEM) to evaluate and prioritize sand and gravel resources along portions of the New Jersey Coast to support coastal resilience project needs, with consideration of project lifetime and scale. The study will develop a methodology, with a capacity to be applied on a regional scale, to evaluate and prioritize resources, to assess the availability and quality of offshore sand deposits for future coastal resilience projects, and to accommodate BOEM renewable energy transmission corridors.

Water Allocation, Hydrogeologic Analysis, and Well Permitting

The NJGWS is responsible for analyzing and permitting major water withdrawals and wells in NJ. For this period, NJGWS issued 17 new or major modification to agricultural certifica-

tions or registrations, 150 renewed or minor modifications to agricultural certifications or registrations, six new temporary dewatering permits, 13 new or major modifications to water allocation permits, 18 renewed or minor modifications to water allocation permits or equivalencies, and 42 new or modified water use registrations. NJGWS also granted seven aquifer test waivers and approved three aquifer test proposals. NJGWS completed eight reviews of proposed new and (or) increased withdrawals to determine the potential impacts on existing users, streamflow depletion, and movement of saltwater and anthropogenic contaminants.

For the period July 1, 2022, to June 30, 2023, the NJGWS issued 10,096 new well permits, reviewed 11,103 well records, and reviewed 8,168 well decommissioning reports. Twenty-six test well permits were issued, which are often redesignated to public supply. There were also three new public supply well permits issued during this period.

Groundwater Quality

NJGWS sampled 50 monitoring wells as part of the New Jersey Ambient Groundwater Quality Monitoring Network (AGWQMN). The network is designed to assess geogenic and anthropogenic impacts to the unconfined aquifers of New Jersey. Emerging contaminants 1,4 dioxane and per-and polyfluoroalkyl (PFAS) substances were included in the parameter list, along with the network's traditional field, nutrient, major ion, trace element, VOC, and pesticide schedules. PFAS sampling from all 150 monitoring wells has been completed and PFAS will be sampled in future to assess trends. The measurement of 1,4 dioxane in the AGWQMN will be included in the 2023 sampling event.

Sampling was conducted in 23 monitoring wells installed along the Delaware Bay to assess saltwater intrusion/ inundation in the Kirkwood-Cohansey aquifer. The following parameters are being analyzed in this multi-year project: dating (carbon-14, sulfur hexafluoride, tritiogenic helium (helium-3)), major anions and cations, trace elements, oxygen and hydrogen stable isotope ratios, major dissolved gases, radon-222, radium, nutrients, and field parameters. Five continuous monitoring probes were deployed to record specific conductivity, temperature, and water levels once every hour.

NJGWS began the process of designing digital dashboards which will be made available to the public to disseminate groundwater quality data and trends.

Mined Underground Storage Caverns

An Act passed under the Laws of 1951, concerning the permitting of underground storage of natural or artificial gas or of petroleum products and their derivatives, required the State Geologist and the Water Policy and Supply Council to advise the Commissioner to either grant or deny the permit. The New Jersey Geological Survey was involved in the permitting of six underground storage caverns, five at one site and one at another site. Following the 2015 sale of the single cavern site, the new owners sought to construct additional cavern(s). This required the NJ Department of Environmental Protection to develop new regulations to ensure that the caverns are designed to protect against releases of hazardous substances and to protect the State's waters, air, and natural resources, in accordance with the Department's mission. NJGWS, along with several other department programs, provided technical input to the new mined rock regulations. The new regulations (N.J.A.C. 7:1F, Underground Storage Caverns) were promulgated May 1, 2023 and applications for two new mined hard rock caverns at the site have been submitted.

NEW MEXICO

NEW MEXICO BUREAU OF GEOLOGY AND MINERAL RESOURCES

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Established by legislation in 1927, the New Mexico Bureau of Geology & Mineral Resources is a non-regulatory state agency that serves as the geological survey for the State of New Mexico. Through our offices, museum, store, laboratories, publications, and website, our staff serves the diverse population of New Mexico. From elementary students to research and industry scientists, there is something at the Bureau of Geology for everyone who has an interest in the exceptional geology and natural resources of New Mexico. Our multifaceted organization consists of interwoven programs, including geologic mapping; energy, mineral, and water resources; basic geologic research; archiving and disseminating mining, petroleum, and rock core data; assessing geologic hazards; and public education and outreach. During the past year, we had a staff of approximately 72 full- and part-time employees, supported by a mix of state appropriations and by funds obtained from grants and contracts.

GEOLOGIC MAPPING

Geologic mapping provides the foundation of most research conducted by our organization. Our mission is to produce modern, digital geological maps of New Mexico at a variety of scales. These maps address topics such as the location and abundance of energy, mineral, and groundwater resources, as well as geological hazards. Our geologic maps are critical for natural resource management, infrastructure planning, and research, thus serving a wide audience. Our goal is to provide two-dimensional and three-dimensional geologic and resource maps online in an interactive, web-based application.

Our mapping program continues to grow in size and scope as new funding opportunities become available. Partial funding for our mapping is provided by the STATEMAP component of the National Cooperative Geologic Mapping Program. This year, our program secured \$640,321, bringing the cumulative total of STATEMAP funding received by New Mexico to \$7,321,942—the most of any state during the 31-year history of the program. Geologic mapping of 7.5-minute guadrangles at 1:24,000 scale continues in our three long-term target areas of the Rio Grande watershed, Lower Pecos watershed, and San Juan basin. Our mapping program has reorganized projects to align with the goals of the U.S. GeoFramework Initiative (USGI). Most of our 7.5-minute guadrangle mapping is now focused on laying the groundwork for 1:100,000-scale compilations of 30- x 60-minute quadrangles. The creation of three-dimensional subsurface models, data synthesis projects (supporting the USGS's Geochronology Database with results from our ⁴⁰Ar/³⁹Ar laboratory), and updating published maps to GeMS Level-3 standards together support development of a multi-resolution, three-dimensional geologic framework of the nation. Additional mapping projects focused on the

REE deposits of the Cornudas Mountains and on erosional hazards impacting oil and gas infrastructure in the Jicarilla Apache Nation. In total, ~480 square miles were mapped, ~2,880 square miles of legacy maps were compiled into 1:100,000-scale maps, eight maps were digitized and served, and 33 maps were completed in ArcGIS layout. There were more than 2.3 million visits to our webmap application, and ~133 GB of data were downloaded. Lastly, 23 students were trained in GIS by our staff, and six students were employed to work on GIS digitization of maps, ensuring the next generation of geologists is prepared for geologic mapping in the 21st century.

3D Subsurface Mapping

Using existing subsurface data, our three-dimensional mapping efforts have resulted in geologic models that cover approximately 18,700 square miles of New Mexico with an additional 14,800 square miles currently under development. Together, these ArcGIS models will depict the freshwater-bearing zones of depths up to 10,000 ft of over 28% of the State. This work is supported through multiple funding sources, initiated with philanthropic funding, and built upon with funding from state agencies and the STATE-MAP program. The process of developing these models is iterative as the team moves from regions of higher to lower subsurface data density. The Bureau is currently developing surface-to-basement three-dimensional models for the Delaware Basin in southeast NM and Central High Plains in east-central NM. An accurate model for this large area is only possible due to the wealth of existing oil, gas, and groundwater subsurface data in the region. For mapping in data-poor regions, the Bureau is developing a diverse three-dimensional subsurface modeling team of hydrogeologists, field and structural geologist mappers, petroleum geologists, and geophysicists to support this work. Products are available as ArcGIS Map Packages, Esri Story Maps, and soon as three-dimensional, interactive PDFs.

OTHER PROGRAM HIGHLIGHTS

Hydrogeology

In a desert state, a detailed understanding of our aquifers is critical, especially in the face of a changing climate. During 2023, we worked on eight regional and five statewide studies of aquifers and their changes. We continued to grow our groundwater monitoring network, adding an additional 98 new monitoring sites this year. Our hydrologists have been mentoring undergraduate students from both Navajo Technical University and New Mexico Tech in collecting water quality samples and measuring depth-to-water in wells in the Navajo Nation. We have also been working with Socorro County high school students to sample groundwater and to understand the hydrologic properties of their local setting.

Geothermal

During the 2023 legislative session, funding was directed to our organization to focus on building the capacity to better understand New Mexico's geothermal resources, providing high-quality scientific information to our stakeholders, seeking out grant opportunities to expand research prospects, and promoting communication on the challenges and opportunities of geothermal energy in New Mexico. This funding will aim to develop and disseminate key information about geothermal resources in New Mexico, focusing on illuminating opportunities and challenges. A workshop was convened in September 2023 to examine geothermal development in New Mexico. The workshop attendees included geothermal researchers at New Mexico Tech as well as representatives from the private sector, state government, academia, and national laboratories.

Energy

Early in 2023, we received DOE funding to investigate a novel, long-term carbon sequestration technique in basalt, a volcanic rock common in New Mexico. When CO_2 is pumped into basalt, the carbon can react with calcium to form carbonate minerals, a process known as carbon mineralization. Bureau scientists are examining how different minerals in basalt interact with CO_2 and considering where there could be appropriate basalt for a large-scale project in New Mexico.

Minerals

The Bureau's Minerals Group enjoys continued funding success through the USGS Earth MRI Program and DOE. Several field-based projects were active in 2023, including the examination of critical mineral deposits in the Cornudas Mountains and Laramide porphyry systems in southwestern New Mexico, and the examination of critical minerals in mine waste and in coals of the San Juan and Raton Basins. These field studies are complemented by the Bureau's Critical Minerals experimental laboratory, which receives funding from the DOE and NSF for thermodynamic studies to better understand critical mineral formation. Our Minerals Group has been successful in engaging undergraduate, graduate, and post-doctoral researchers in all aspects of their research. This workforce development is key in order for our country to maintain a skilled workforce in the mineral resources industry.

Laboratories

Our laboratories supported research work for 184 users, including 89 students from New Mexico Tech and beyond, investigating a wide range of research topics. The laboratories supported several graduate and undergraduate projects, including salary and analytical support for the students. Total income to bureau lab service centers was ~\$309,000, used to pay salaries, to maintain and expand equipment,



Figure 1. Scientists and legislators at a field stop during the Water Leaders Workshop, held in December 2023.

and to facilitate research on societally relevant projects. We are excited to receive funding for a new single-crystal X-ray diffractometer to expand our analytical capabilities. Installation of this new instrument is anticipated to occur in 2024. Bureau laboratories support the entire mission of the bureau by contributing analytical data to all research programs.

Outreach and Education

During 2023, our organization undertook a program to educate decision-makers in our state about the water challenges that we face given our increasingly arid climate. Most recently, in December 2023, we hosted a workshop in Las Cruces, NM, focused on the Lower Rio Grande region's surface water and aguifers. The workshop had close to 100 registrants from state agencies, the legislature, conservancy districts, cities and municipalities, non-profits, and others. Funded by a one-time legislative appropriation, the meeting is a reinvention of our popular "Decision-Makers" field trips that ran between 2001 and 2009 and represents a great venue for communication between a group of people with a broad range of backgrounds. During the workshop, participants had the chance to attend indoor presentation/ panel discussion sessions and traveled to field sites to learn about geology (Fig. 1), water management, infrastructure, and other topics.

NORTH DAKOTA

NORTH DAKOTA GEOLOGICAL SURVEY

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The North Dakota Geological Survey (NDGS) was established in 1895 under the guidance of the State Board of Higher Education. The State Geologist also served as Chairman of the Department of Geology at the University of North Dakota in Grand Forks until 1985. In 1981, the ND Industrial Commission Oil and Gas Division was split from the Geological Survey, and in 1989 the Geological Survey was placed under the ND State Industrial Commission and moved to Bismarck. In July 2005, the Geological Survey became a division, and both it and the Oil and Gas Division were placed within the newly formed Department of Mineral Resources (DMR). The State Geologist is director of the Survey and an assistant director within the DMR. The State Geologist reports to the Industrial Commission on a guarterly or as-needed basis. The NDGS shares an office and warehouse with the ND Oil and Gas Division in Bismarck. We also maintain the Johnsrud Paleontology Laboratory in the North Dakota Heritage Center & State Museum in Bismarck. The NDGS operates the Wilson M. Laird Core and Sample Library on the campus of the University of North Dakota in Grand Forks. We recently obtained three new state-funded positions: a critical minerals geologist, a paleontology technician, and a subsurface geologist.

OTHER PROGRAMS

Core Library

Over the last twelve months, industry, academic, and government scientists studied 40,100 feet of core in the Wilson M. Laird Core and Sample Library at the University of North Dakota. Additionally, NDGS temporary employees (university students) photographed 20,554 feet of core generating 32,836 photographs for the DMR subscription site. Since 2004, 699,000 feet of core have been studied, 239,000 feet of core have been photographed (49% of the core in the core library), and 369,000 core photographs have been posted to the website. Additionally, 143,000 photomicrographs from 19,600 thin sections have also been posted to the site. From our own core studies, we recently completed two reports on the Deadwood Formation.

Critical Minerals

During the 12-month period, the NDGS authored three critical mineral reports. This brings the number of critical mineral reports we have authored in the last six years to a total of eight. The last two reports—NDGS Reports of Investigation nos. 133 and 134—focused on two, 20- to 30-foot-thick

GEOLOGIC MAPPING

Landslide Mapping

In 2021, we completed mapping landslides across the entire state of North Dakota at a scale of 1:24,000 (1,400 Phase II quadrangles). We mapped 179 quadrangles during this reporting period, bringing the total number of landslides identified in North Dakota to 62,300. The current Phase III landslide mapping program compares two lidar coverages that have been flown approximately ten years apart enabling us to identify areas of recent slope movement.

Surficial Mapping

Survey geologists have continued a multi-year mapping program of the surficial deposits in the Fargo area. Over the last 12 months, we completed six quadrangles in that area: Argusville, Durbin, Casselton, Casselton SE, Georgetown, and Perley. We continue to delineate the depths and extent of shallow subsurface sediments that have the potential to be problematic for infrastructure in the Fargo area.



Figure 1. Brightly colored, iron-stained rocks of the Bear Den Member of the Golden Valley Formation (Paleocene) outcrop at the base of a small butte in western North Dakota. A pick and a gallon-sized Ziploc sample bags provide scale in the foreground.



Figure 2. Bright white rocks of the Rhame bed at the top of the Slope Formation (Paleocene) outcrop in the Little Missouri River Badlands in western North Dakota.

Paleocene paleosols that are stratigraphically 1,000 feet apart (the Rhame bed of the Slope Formation and the Bear Den Member of the Golden Valley Formation). Report of Investigation 133 focused on the Bear Den Member (Figure 1) and contained a rare earth element concentration of 2,570 ppm on a dry coal basis, the highest concentration we had found up to that time for a North Dakota lignite.

Report of Investigation no. 134 was our most extensive work to date, containing 165 measured sections and 768 rock analyses (Figure 2). We found that lignites immediately below the kaolinite-rich paleosol could be significantly enriched in antimony, arsenic, barium, beryllium, germanium, lithium, molybdenum, and uranium. A thin Rhame bed coal contained a new high concentration of 2,792 ppm for rare earth elements (dry coal). Although the lignites associated with these paleosols have so far tended to only be about two feet thick, they can average more than 1,100 ppm REE (dry coal) throughout the entire bed.

Geologic Reviews

During the reporting period, the ND Geological Survey conducted 313 geologic reviews of infrastructure projects, an 80% increase over the previous period. These reviews were for road projects (41%), water projects (32%), transmission line corridors and wind farms (13%), oil and gas pipeline corridors and well pads (10%), and general construction projects (4%).

Outreach

As it has been for the last 20 years, the majority of outreach during this period was through our paleontology program,

primarily in the form of tours of the geologic time gallery in the state museum, of our paleontology laboratory, and of the state fossil collection. In total, we participated in 100 outreach activities involving 2,500 participants, including tours, presentations, core workshops, and field trips. We generally jump at the chance to discuss science with middle school and high school students given the declining numbers in undergraduate geoscience majors. Along those lines, I wrote a letter to the President of North Dakota State University in February telling him he was shortsighted in considering eliminating their geology department because of the projections I had read regarding a shortfall of geoscientists by the year 2030—he eliminated the department anyway.

Paleontology Program

We ran four public fossil digs over this period—one in northeastern North Dakota, one in the south-central part of the state, and two in the western part of the state. The digs involved 400 participants—roughly half in-state and half out-of-state visitors—with a waiting list of hundreds of people. These public digs are extremely popular and are so productive that we currently have a backlog of 765 fossil field jackets (Figure 3). The new paleontology technician position was created to eliminate this backlog within the next five to ten years. We recently completed evaluating the fossil potential for a state dinosaur park on 21 Trust Land tracts in southwestern and south-central North Dakota. Paleontologists also performed 433 paleontological resource impact reviews for infrastructure projects, Trust Lands oil and gas lease tracts, and Trust Lands right of way requests.



Figure 3. An NDGS paleontology technician removes sediment from a field jacket containing the front half of a skeleton of Bison antiquus that was unearthed during construction of an oil and gas pad in northwestern North Dakota.

OHIO

OHIO GEOLOGICAL SURVEY

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The Ohio Department of Natural Resources (ODNR) Division of Geological Survey was founded in 1837 and has been continuously authorized since 1869. Our mission is to provide the geologic information and services needed for responsible management of Ohio's natural resources. We research and report on the geology of the state and serve as Ohio's archive of geologic information. Our main office is at the ODNR campus in north Columbus. The Horace R. Collins Laboratory in Delaware County houses our core and sample archive, and the offices of the Lake Erie and seismic programs. The Survey has a full-time staff of 35 (with one current vacancy), arranged into seven groups: Geologic Mapping and Industrial Minerals, Groundwater Resources, Energy Resources, Geologic Hazards, Publications and Outreach, Library and Records Center, and Administration and Fiscal. The Survey's funding derives from severance taxes on fuel and nonfuel commodities, federal and state grants, department-allocated funds, and sales of publications and data.

GEOLOGIC MAPPING

The Geologic Mapping and Industrial Minerals Group published two new geologic maps—one statewide digital map compilation and one annual report between July 2022 and June 2023. A new county-scale (1:62,500) Quaternary geology map of Fayette County was published with partial funding from a USGS NCGMP Great Lakes Geologic Mapping Coalition (GLGMC) grant. This map was the second Quaternary geology map produced by the Survey since 2020, and the first publication under the QG-2 series designation. This follows a new long-term plan to publish detailed Quaternary geology maps at the county scale. All new QG-2 map products follow the GeMS framework and digital data is stored in a single statewide database to facilitate future statewide mapping products.

Quaternary geology mapping in Fayette County led to a better understanding of two glacial advances that occurred regionally during the late Wisconsin Glaciation. These advances were separated by an interstadial period sometimes represented in the stratigraphic record by a paleosol which dates to about 22 ka. Cross-cutting relationships between glacial landforms also support these multiple advances.

The Survey published the final statewide compilation of all surficial "stack" maps at a 1:24,000 scale with GLGMC funding. This mapping began in 1997 and culminated with the release of a digital database that is easily accessible on Ohio's Interactive Geology Map (https://gis.ohiodnr.gov/ website/dgs/geologyviewer) and that may also be downloaded directly from our website. Throughout the compilation process, about 30,000 unit contacts were revised, equating

to nearly half of the entire dataset. This revision process was documented and released as Open File Report (OFR) 2023-1.

The Survey published a bedrock topography map of the western portion of Champaign County, which was partially funded by the USGS NCGMP STATEMAP program. Over 1,200 passive-seismic, horizontal-to-vertical spectral ratio (HVSR) data points were acquired to constrain the location and morphology of the Teays River Valley, a pre-glacial drainage system buried under a maximum of about 750 feet of unconsolidated Quaternary sediments. Results indicate that the buried valley is narrower and more sinuous than previously mapped. Quaternary valley fill contains highly productive aquifers but is poorly understood near the base of the valley. Typically, residential and municipal water wells are developed within 200 feet of the surface, leaving more than 500 feet of potential aguifers undeveloped within the deepest portions of the buried valley.

The Survey continues to assess geologic hazards through the karst inventory mapping program. Potential karst features of Hamilton County (Greater Cincinnati metropolitan area) were identified via remote sensing and digital mapping techniques before being field verified. During the field season, 268 new karst features were added to the statewide inventory. Of these 268 karst features, 257 were field visited. Karst inventory mapping is crucial to the sustainable development of Hamilton County, as population growth leads to new construction in areas where karst features are active. The Survey keeps a karst features database with more than 20,000 mapped features linked directly to a publicly available interactive map. Yearly updates to this database are now detailed in an annual report that describes the mapping results and updates the status of the karst mapping program.

Figure 1. The Ohio Geological Survey studied a till outcrop that preserves a sheared transitional contact between the Darby Till (Dmm3/Dmm2) and the Caesar Till (Dmm1). This outcrop helps confirm the deposition of glacial till during two distinct advances around 27-25 ka (Caesar Till) and 22

ka (Darby Till).



Ohio

OTHER PROGRAM HIGHLIGHTS

The Survey provided funding and design input for capital improvements at the Kelleys Island Glacial Grooves Geological Presverve that were completed during the reporting period. Improvements included preservation work on the grooves and bedrock, new interpretive signage and exhibits based on the most recent science, and improved accessibility. The Horace R. Collins Laboratory and Core Repository, where the Geologic Hazards Group is housed, also completed major capital improvements during the period, improving lighting and adding core storage space, office space, and working space for OhioSeis, the seismic group. OhioSeis recorded several minor earthquakes, some felt, during the reporting period. These were mostly centered in Ohio's known seismic zones-the Anna Seismic Zone and the Northeast Ohio Seismic Zone. Efforts to install and activate the program's new generation of guiet and reliable borehole seismic stations, begun in 2021, continued during the reporting period.

The Groundwater Resources Group continued its statewide aquifer yield mapping effort, adding about 10,500 square miles of mapping to the project, which is scheduled to be released in 2024. About 11,154 water well records (sealing reports, boring logs, etc.) were recorded, over 200,000 data points were added to the hydraulic conductivity database, and slug testing of the state's 139 groundwater observation wells continued. A groundwater conflict was investigated, and the group provided expertise and support to agencies at the local, county, and state level regarding issues of groundwater availability.

The Energy Resources Group continued its role in the 20-state Midwest Regional Carbon Initiative (MRCI) partnership to study carbon capture, utilization, and storage. The Group also continued work under a USGS Earth MRI grant to perform geochemical (critical minerals) reconnaissance on Pennsylvanian marine black shales.



Figure 2. Now ADA-accessible, the Glacial Grooves Geological Preserve on Kelleys Island (Lake Erie) reopened after a \$2.27 million renovation funded by the Ohio Geological Survey.

The Publications and Outreach Group reached an estimated 17,000 people at 93 events, and revised four educational publications on the topics of dimension stone, sand and gravel, placer gold, and concretions. Finally, the Pauline Smyth Geological Library and Records Center launched an online geologic library catalog using EOS.Web, the result of five years of identifying and describing more than 17,000 publications, maps, datasets, and field notes documenting Ohio's geology. Additional items are added daily and the catalog is accessible to the public.



Figure 3. The Groundwater Resources Group conducts slug testing.

OREGON

OREGON DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES

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RATING F GEOLOGY RATING REAL REPAIR RATING R

The Oregon Department of Geology and Mineral Industries (DOGAMI), established in 1937, increases understanding of Oregon's geologic resources and hazards through science and stewardship. The agency's mission is to provide earth science information and regulation to make Oregon safe and prosperous. Our Geological Survey & Services program develops maps, reports, and data to help Oregon manage natural resources and prepare for natural hazards such as earthquakes, tsunamis, landslides, floods, volcanoes, and coastal erosion. Our Mineral Land Regulation & Reclamation program oversees the state's mineral production and works to minimize impacts of natural resource extraction and to maximize the opportunities for land reclamation. As an independent executive agency of the State of Oregon, DOGAMI assists in the development of state policy related to geologic materials; natural resources and hazards; mining; oil, gas and geothermal exploration and production; conservation; and reclamation. DOGAMI's current funding supports 42 positions across our two programs.

GEOLOGIC MAPPING

Bedrock Mapping

DOGAMI conducts geologic mapping, creates and maintains digital geologic databases, and collects aerial lidar to characterize the state's unique geology and to enhance our understanding of the state's geologic resources and hazards. Targeted new mapping updates the geologic framework of these areas, and places an emphasis on digital map products and derivatives that are accessible and usable by the public. DOGAMI geologic mapping projects between July 2022 and June 2023 have focused along the South Coast, the Walla Walla basin of northeast Oregon, and the Harney Basin of southeast Oregon. This geologic mapping, supported by grants from the STATEMAP component of the USGS National Cooperative Geologic Mapping Program, was a high priority of the Oregon Geologic Map Advisory Committee. Focus topics for DOGAMI included understanding the stratigraphic and structural controls on groundwater; mineral resource potential;, areas of geologic hazards such as earthquakes and landslides; and rock resources. DOGAMI also used these STATEMAP projects to build and refine agency capabilities to consistently produce new geologic maps in a digital format compliant with the USGS NCGMP GeMS level 3 Geologic Map Schema. The Geologic Map of the Athena 7.5-minute quadrangle, published from these mapping efforts, is an example of the utility of a comprehensive GeMS level 3 database used for both surficial and bedrock geologic maps (Figure 1; https://pubs.oregon.gov/dogami/gms/p-GMS-129. <u>htm</u>).



Figure 1. Geologic Map of the Athena 7.5-minute quadrangle, Umatilla County, Oregon.

Surficial Mapping

Landslides are common throughout Oregon due to high precipitation, steep slopes, landslide-prone geologic units, and frequent earthquakes. In June 2020, DOGAMI received a grant from the Federal Emergency Management Agency (FEMA) through the Risk Mapping, Assessment, and Planning (MAP) program as a Cooperating Technical Partner (CTP) to perform regional landslide inventory mapping of the north and central portions of Wasco County, Oregon (Figure 2). A share of this funding was passed through to Wasco County Planning and Oregon Department of Land Conservation and Development (DLCD) to work on risk reduction activities. The purpose of this project was to provide detailed information about landslide hazards in this area and to perform continued landslide risk reduction. As a result of the study, published early in 2023, DOGAMI mapped 2,693 landslide deposits in the project area—536 deep-seated landslides, 214 rockfall deposits, 1,653 debris flow deposits, and 290 shallow-seated or unclassified landslides (Figure 2; https:// pubs.oregon.gov/dogami/ofr/O-23-02/p-O-23-02.htm). Risk reduction strategies include increasing public awareness, planning and zoning approaches, and emergency response considerations. The approach for landslide risk reduction in this project focused on community needs, as relayed by community stakeholders, in combination with established recommendations from reports.

3D Mapping

Airborne lidar-based three-foot Digital Elevation Models (DEMs) and derivatives (slopeshade, hillshade, contours) are a fundamental three-dimensional base data set used for geo-



Figure 2. Landslide inventory overview map of the Wasco County project area.

logic mapping by DOGAMI. As of June 2023, over 41 million acres of lidar data were publicly available, covering over 98 percent of the state's population; 67 percent of the state is now mapped at USGS quality level 1 or better, equivalent to one-foot contour accuracy. Data have been collected for the remaining areas of the state and are in various stages of processing, with public release in the coming months to years. Repeat lidar acquisitions are also providing measurements of topographic change related to landslides, and coastal and fluvial erosion and deposition. During 2023, DOGAMI invested in our agency's first geophysical data collections, acquiring high-resolution aeromagnetic and radiometric data over geologic mapping targets in eastern Oregon.

OTHER PROGRAM HIGHLIGHTS

Coastal Geologic Assessment

DOGAMI took on a major cross-disciplinary project in 2022–2023, in collaboration with the Oregon Department of Land Conservation and Development (DLCD), to analyze the geology of the Oregon coastal zone and assess the siting potential of landing sites for undersea cables. Seafloor cables are important infrastructure, used for communication and power transmission from offshore wind or wave energy generating equipment. The locations where cables come



Figure 3. Map of existing cable landings and cables along the Oregon Coast.

onshore are critical parts of these systems, as the cables cross shallow water of the coastal zone where human interaction is more likely and where dynamic geologic processes are active. The nearshore terrestrial areas where submarine cables land also host many human communities and sensitive environments with potential for negative effects during construction activities. A systematic coastwide assessment of the suitability of cable landing sites along the Oregon coast was achieved by leveraging staff expertise and by compiling and interpreting geospatial data layers produced in this project and obtained from published sources. The results of DOGAMI's work are now published in Special Paper 54, which provides a consistent, regional-scale view of where future cable landings can be built with fewer construction complications and fewer impacts on the environment and communities (Figure 3; https://www.oregon.gov/dogami/ pubs/Pages/sp/SP-54.aspx). Detailed, site-specific investigations of geologic, environmental, and cultural factors are needed to bridge between this coastwide reconnaissance effort and successfully completed projects.

Tsunami evacuation

DOGAMI continues to map, research, and educate the public about earthquake and tsunami hazards along the Oregon coast. Current research indicates a locally generated tsunami from a Cascadia subduction zone earthquake will inundate the Oregon coast within tens of minutes. To prepare for this event, DOGAMI has created a series of "Beat the Wave" maps to help residents and visitors evacuate during an earthquake/tsunami event. For most of the population, spontaneous evacuation on foot will be the only effective means of limiting loss of life, because vehicle evacuation would be quickly compromised by traffic congestion and road blockages. DOGAMI's "Beat the Wave" series evaluates tsunami evacuation difficulty during a major earthquake/ tsunami event by providing estimates of evacuation travel times to safety, accounting for the different evacuation speeds required to reach safety, considering route characteristics, and including knowledge of the wave arrival times. Evacuation routes are restricted to roads and trails to enable more informative maps, and to remove the complications of crossing private property and the unknowns of traveling off-road. As a result, the "Beat the Wave" approach accomplishes in a single map what would require multiple maps in other approaches. With the recent release of evacuation maps for the Bandon area, DOGAMI has nearly completed production of evacuation maps for the entire Oregon coast (https://www.oregon.gov/dogami/pubs/Pages/ofr/p-O-23-04. aspx).
PENNSYLVANIA

BUREAU OF GEOLOGICAL SURVEY

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While we are commonly known as the Pennsylvania Geological Survey (PaGS), our official title is the Bureau of Geological Survey, a bureau within the Pennsylvania Department of Conservation and Natural Resources (DCNR). PaGS has been examining Pennsylvania's geology since 1836 under various organizational structures. The present organization dates to 1919, when PaGS was authorized by the General Assembly "to serve the citizens of Pennsylvania by collecting, preserving, and disseminating impartial information on the Commonwealth's geology, geologic resources, and topography in order to contribute to the understanding, wise use, and conservation of its land and included resources."

At the end of this reporting year, the bureau's staff complement is 35 comprised of 26 geologists plus two vacant geologist positions, one geospatial specialist, four administrative/clerical staff plus one vacant administrative position, and one librarian. Six positions were filled or added during the reporting period.

GEOLOGIC MAPPING

Bedrock and Surficial Mapping

New 1:24,000-scale bedrock and surficial mapping was initiated in the Catawissa 7.5-minute quadrangle in east central Pennsylvania. This new mapping aims to assess aggregate and aquifer potential within the area, and to reconcile stratigraphic inconsistencies within the Devonian Catskill Formation.

PaGS delivered 1:50,000-scale surficial maps of Pike and Wayne Counties in glaciated northeastern Pennsylvania as part of the STATEMAP 2021 requirements. Both counties had been mapped pre-lidar and required digitization, compilation of 1:24,000-scale maps, adjusting to a new lidar-derived base map, and field checking. The new maps use standard glacial/landscape feature definitions and naming across both counties. Mapping will support hydrologic modeling in the Delaware River basin.

Compilation of nine 7.5-minute quadrangles in central Pennsylvania was initiated as part of STATEMAP 2022. Mapping efforts are focused on the reconciliation of stratigraphic and structural discrepancies, nomenclature, and edge-matching issues of open-file bedrock maps published between 2004 and 2011.

3D Mapping

PaGS delivered drift-thickness and depth-to-bedrock maps of four 7.5-minute quadrangles in Butler and Lawrence Counties in northwestern Pennsylvania as part of Great Lakes Geologic Mapping Coalition 2022 deliverables. These products highlight the lithologic variability and sequence of glacial tills in the subsurface, and locations of buried valleys. Using results from these and similar quadrangle maps developed over the past ten years, as well as relevant water-well records, PaGS developed a 100-meter statewide bedrock elevation raster dataset depicting the total unconsolidated sediment cover thickness of Pennsylvania. The results of this project directly contribute to Pennsylvania's overall strategy to develop a statewide three-dimensional approach to geologic mapping. The methodology developed for modeling the unconsolidated sediment cover thickness will support future PaGS work and goals of the US GeoFramework Initiative.

Other Maps

PaGS created an updated bathymetry map for Chapman Lake in Chapman State Park in northeastern Pennsylvania. This map is one of a series of bathymetry maps of state park lakes. These maps are used by anglers and boaters for navigational purposes and are one of the most popular map products requested by park visitors.

PaGS published a 1:50,000-scale karst feature density map of Mifflin County in central Pennsylvania. This map was created using a modified automated closed depression methodology developed by the USGS supplemented by traditional field mapping techniques. The final map product intuitively highlights the areas with the greatest density, and likely susceptibility, of karst features within the county.

OTHER PROGRAM HIGHLIGHTS

Rock Sample Library

PaGS has begun preliminary design of a new rock sample storage facility to more than double the current capacity to store, catalog, and analyze the Survey's collection of core, cuttings, and hand samples. Construction of the new facility is funded through a \$6 million investment from the Department of Conservation and Natural Resources.

Earth MRI

PaGS is part of a multi-state aeromagnetic and radiometric survey extending across the borders of south-central Pennsylvania, Maryland, Virginia, West Virginia, and a swath extending northward along the Allegheny Mountains. The survey has provided high-quality, detailed magnetic anomaly maps of the Mesozoic magnetite-skarns and diabase, help in locating hidden fault zones, and insights into the distribution and relative enrichment of uranium, thorium, potassium, and critical minerals in sedimentary strata.

PaGS has received funding to pursue geochemical analysis of Devonian shales across Pennsylvania, West Virginia, and Maryland to explore vanadium, molybdenum, and rare earth element mineralization and to further information on variations of bulk geochemistry of these units across this region. This project will also include detailed isotopic study to assess the distribution and migration of these elements within target units.

Carbon Management

PaGS leads the commonwealth's Inter-Agency CCUS Work Group, which has developed concerted technical, regulatory, and economic approaches to facilitate and support the deployment of carbon capture, utilization, and storage (CCUS) in Pennsylvania. Within the past year, PaGS employee and Work Group lead, Kristin Carter, was announced as a member of the Biden-Harris Administration's CCUS Non-Federal Lands Task Force, and the Work Group has begun to engage community partners from the private and public sectors to evaluate the necessary content for a state-specific carbon management policy document to guide CCUS efforts in Pennsylvania.

PaGS has received an approximately \$1 million award from the U.S. Department of Energy to complete the Central Appalachian Partnership (CAP) for Carbon Storage Deployment Project. This effort will (1) apply the existing expertise of the Pennsylvania and West Virginia Geological Surveys with respect to oil, gas, and subsurface geology conditions in the Appalachian basin; (2) build on current collaborative relationships and the regional knowledge base resulting from two decades of regional characterization efforts; (3) frame and focus efforts to address data needs not currently being tackled through other proposed efforts for the greater Appalachian region; and (4) aggregate the most pertinent geologic and geospatial datasets to construct a free, public-facing Web-Based Tool with comprehensive datasets and information needed to inform Underground Injection Control Class VI injection permitting efforts. No such tool is currently available for either state.

PaGS is collaborating with the Mid-Appalachian Carbon Ore, Rare Earth and Critical Minerals (MAPP-CORE) Initiative to provide volumetric estimates of selected rare earth elements and critical minerals contained in multiple potential sources from the central Appalachian coal basin. Coal resource assessments are ongoing and will be reported with the work team's other findings after the project closes in March 2024.



SOUTH DAKOTA GEOLOGICAL SURVEY

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The South Dakota Geological Survey (SDGS) is a program in the South Dakota Department of Agriculture and Natural Resources. The SDGS performs surface and subsurface geologic mapping throughout the state. Aquifer mapping and modeling is also a significant part of the activities at SDGS. With two agency-owned drill rigs, the SDGS collects a wealth of subsurface and hydrogeologic information to produce maps and reports used by both the public and private sector. The SDGS also maintains a statewide groundwater monitoring network that is sampled regularly to measure water quality of major surface aquifers.

The SDGS has 22 full-time employees that consist of geologists, hydrogeologists, technicians, drillers, and other support staff. In addition, the SDGS hires several geology interns each year to assist with drilling test holes, installing observation wells, ground water sampling, and GIS-based aquifer mapping.

GEOLOGIC MAPPING

The SDGS is producing 1:24,000-scale geologic maps in the Black Hills region. South Dakota's flagship state park—Custer State Park in the heart of the Black Hills—is currently one of the areas SDGS is mapping.

The primary use of these maps is to:

- Address concerns regarding quantity and quality of water in the aquifers in the Black Hills region.
- Properly address issues related to geologic hazards, floodway analysis, and mining.
- Understand the development of caves in the Black Hills and to protect the cave resources, such as Wind Cave National Park and Jewel Cave National Monument.
- Allow sound development practices to be implemented and wise land management decisions to be made.



Figure 1. Portion of a published aquifer map.

One geologic quadrangle map was published in FY23. A status graphic of geologic mapping in the Black Hills and links to the published maps are available at <u>https://bit.ly/3Ab-dvpd</u>. The SDGS is also publishing 1:250,000-scale geologic maps in western South Dakota. Each map covers a large area and can be used for regional and statewide planning. These maps are beneficial for land use decisions such as suitability for development, planning major construction projects, and identifying groundwater and mineral resources. One map of this series was published in FY23. A status graphic of this series, along with links to the published maps, are available at <u>https://bit.ly/3iOrREV</u>.

OTHER PROGRAM HIGHLIGHTS

Mapping Ground Water Resources

Work related to understanding and documenting groundwater resources in the glaciated part of South Dakota continues to be a primary focus for the SDGS. Drilling resources were used to drill test holes and to install observation wells in multiple aquifers this past year. New data generated from this drilling program, as well as review of historical data, are used in the interpretation of aquifer occurrence. Products that come from this effort are:

- Aquifer extent maps
- Depth to aquifer maps
- Revised bedrock geologic maps
- Revised surface geologic maps

New Drill Rig

The SDGS acquired a new Mobile B58 drill rig in 2023. This rig replaces an older Mobile drill rig that served us well for many years. The new rig can drill using mud rotary, hollow stem auger, and continuous coring technologies. It will be used to acquire subsurface geologic data for our geologic and groundwater resources mapping program, as well as to install observation wells for our water level and water quality monitoring networks. The new drill rig joins an existing Enid drill rig that we have owned for about 15 years.



Figure 2. SDGS drill rigs.

TEXAS

BUREAU OF ECONOMIC GEOLOGY

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The Bureau of Economic Geology (Bureau) is the State Geological Survey of Texas and the oldest organized research unit at The University of Texas at Austin. The Bureau is one of three units in the Jackson School of Geosciences at UT Austin.

Bureau researchers spearhead basic and applied research projects globally in energy resources, technologies and economics, coastal and environmental studies, land resources and use, geologic and mineral mapping, hydrogeology, geochemistry, and subsurface nanotechnology. Our staff of more than 200 includes scientists, engineers, economists, and graduate students, representing 27 countries, often working in integrated, multidisciplinary research teams.

The Bureau's facilities and state-of-the-art equipment are world-class, and they include 19 individual laboratories hosting researchers investigating many topics, from nanoparticles to shale porosity and permeability. The Bureau also maintains three major well core research and storage facilities, in Houston, Austin, and Midland—together believed to be the largest archive of subsurface rock material in the world—as well as the state's wireline log library.

GEOLOGIC MAPPING

Increases in National Cooperative Geologic Mapping Program (NCGMP) funds continue to expand coastal-, groundwater-, geohazards-, and minerals-related geologic mapping in Texas under the STATEMAP program. These funds have supported hiring of geologists for the expanded mapping program, new mapping in a critical minerals-focused project area, and preparation of maps in the USGS/AASG Geologic Map Schema (GeMS). In addition, a cooperative Earth MRI project comprising the USGS, the New Mexico Bureau of Geology & Mineral Resources, and the Bureau focuses on critical minerals hosted in igneous rocks in the Trans-Pecos region.

Between July 2022 and June 2023, Bureau researchers completed seven new quadrangle-scale Open-File Maps (OFM), two GeMS conversion maps, and two multiquadrangle GeMS compilation maps as part of the STATEMAP and state-funded STARR programs.

Map Citations

- Caudle, T. L., and Paine, J. G., 2022, Geologic map of the Mud Lake quadrangle, Texas Gulf of Mexico Coast: The University of Texas at Austin, Bureau of Economic Geology, Open-File Map No. 265, map scale 1:24,000.
- Caudle, T. L., Paine, J. G., and Andrews, J., 2022, Geologic map of the High Island quadrangle, Texas Gulf of Mexico Coast: The University of Texas at Austin, Bureau of

Economic Geology, Open-File Map No. 256, map scale 1:24,000.

- Hunt, B. B., Andrews, J. R., and Barnes, V. E., 2022, Geologic map of the Pedernales Falls, Johnson City, Howell Mountain, Round Mountain, Rocky Creek, Cave Creek School, Blowout, and Willow City quadrangles, Blanco, Gillespie, and Burnet Counties, Texas: The University of Texas at Austin, Bureau of Economic Geology, GeMS Level 3 geodatabase.
- Hunt, B. B., Johnson, B., Helper, M., and Droxler, A., 2022, Geologic map of the Mason quadrangle, Mason County, Texas: The University of Texas at Austin, Bureau of Economic Geology, Open-File Map No. 259, map scale 1:24,000.
- Hunt, B. B., Johnson, B., Helper, M., and Droxler, A., 2022, Geologic map of the Turtle Creek quadrangle, Mason County, Texas: The University of Texas at Austin, Bureau of Economic Geology, Open-File Map No. 260, map scale 1:24,000, 1 sheet.
- Paine, J. G., and Costard, L., 2022, Geologic map of the Palacios NE quadrangle, Texas Gulf of Mexico Coast: The University of Texas at Austin, Bureau of Economic Geology, Open-File Map No. 257, map scale 1:24,000.
- Paine, J. G., Collins, E. W., and Costard, L., 2022, Geologic map of the Kamey, Point Comfort, Olivia, Port Lavaca West, Port Lavaca East, Keller Bay, Seadrift, Seadrift NE, and Port O'Connor quadrangles, Texas coastal plain:



Figure 1. Mapping project areas

The University of Texas at Austin, Bureau of Economic Geology, GeMS Level 3 geodatabase.

- Paine, J. G., Costard, L., and Caudle, T. L., 2022, Geologic map of the Palacios SE quadrangle, Texas Gulf of Mexico Coast: The University of Texas at Austin, Bureau of Economic Geology, Open-File Map No. 258, map scale 1:24,000.
- Woodruff, C. M., Jr., and Costard, L., 2022, Geologic map of the Creedmoor quadrangle, Texas: The University of Texas at Austin, Bureau of Economic Geology, Open-File Map No. 261, map scale 1:24,000.

OTHER PROGRAM HIGHLIGHTS

At the request of the Liberty County, Texas, Office of Emergency Management, a Bureau of Economic Geology hazard assessment team consisting of researchers Jeff Paine, John Andrews, Jennifer Morris, and Kutalmis Saylam visited the new Daisetta sinkhole on April 8, 2023. Data from the site visit will provide critical information on the sinkhole to emergency responders and to the public. Studies at the site are supported by the Bureau's <u>State of Texas Advanced Resource</u> <u>Recovery (STARR) program</u>. The citation for this study is:

Paine, J. G., Andrews, J. R., Morris, J. N., Saylam, K., and Kyle, J. R., 2023, Airborne and ground surveys of the April 2023 Daisetta sinkhole, Liberty County, Texas: The University of Texas at Austin, Bureau of Economic Geology, Open-File Report 23–1, 16 p. doi: <u>doi.org/10.23867/</u> <u>OFR23-1</u>.

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Bureau staff made a trip to the Asian island nation of Timor-Leste. The country's national oil and gas company, Timor Gap, has sought Bureau assistance in characterizing and developing the nation's significant natural gas reserves and in exploring its potential to develop other technologies such as CO_2 and hydrogen storage in depleted reservoirs. The team included Bureau researchers Robin Dommisse, Dallas Dunlap, Jay Kipper, Toti Larson, and Hongliu Zeng, as well as Mojdeh Delshad from the UT-Austin Department of Petroleum and Geosystems Engineering.

In artificial intelligence (AI) and deep learning, progress is recognized through competitions. The Bureau's Yangkang Chen recently led a team, including Alexandros Savvaidis, Sergey Fomel, Dino Huang, and researchers from other institutions, that won first place among 600 international teams in the 2022 AETA Earthquake Prediction AI Algorithm Competition, hosted by Peking University's Shenzhen Graduate School in China.

The Bureau entered a new publishing partnership with the distinguished online Texas Water Journal (TWJ), a peer-reviewed, indexed, web-based, and multidisciplinary publication on water resources management, research, and policy.



Figure 2. Oblique drone image of the 2008 and 2023 sinkholes in Daisetta, Texas, acquired on April 8, 2023. "F" denotes areas of prominent concentric cracks, fissures, and scarps. View to the northeast.

Awards

- Bureau Director Scott W. Tinker received both the Ben H. Parker Memorial Distinguished Service Medal from the American Institute of Professional Geologists (AIPG) and the President's Award from Energy GeoAlliance (EnerGeoAlliance).
- Bridget Scanlon was selected by the American Geophysical Union (AGU) to be the lecturer for the 2022 William Bowie Lecture.
- Stephen Laubach was named an Outstanding Reviewer by the American Geophysical Union (AGU).
- Rich Kyle received the 2023 Hal Williams Hardinge Award, as well as the 2023 Mineral Industry Education Award, at the annual meeting of the Society for Mining, Metallurgy, & Exploration (SME).
- Charles Kerans received the 2022 Robert R. Berg Outstanding Research Award from the American Association of Petroleum Geologists (AAPG).
- Sergey Formel received Honorary Membership in the Society of Exploration Geologists (SEG).
- Shuvajit Bhattacharya received the 2022 J. Clarence Karcher Award from the Society of Exploration Geophysicists (SEG).

UTAH

UTAH GEOLOGICAL SURVEY

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In 1949, the Utah Geological and Mineralogical Survey was created within the University of Utah's State School of Mines and Mineral Industries. Today, the Utah Geological Survey (UGS) is a state executive branch applied science agency within the Utah Department of Natural Resources (DNR). Our mission is to provide timely scientific information about Utah's geologic environment, resources, and hazards. The UGS comprises six technical programs: Data Management, Energy & Minerals, Geologic Hazards, Geologic Information & Outreach, Geologic Mapping & Paleontology, and Groundwater & Wetlands. Additionally, we operate the Utah Core Research Center and Natural Resources Map & Bookstore retail outlet. Most of our approximately 90 employees work out of our main office in Salt Lake City, and four staff work out of our satellite office in Cedar City.

Among our current priorities is research related to Great Salt Lake. Persistent drought has contributed to historically low lake levels, which in turn pose a threat to the lake's mineral industries, migratory bird habitat, microbialite viability, recreation, and air quality. UGS research is focused on characterizing wetlands and hydrologic systems related to the lake—in particular, developing an updated groundwater model—as well as studying salt flux and lithium resource potential.

GEOLOGIC MAPPING

Our geologic mapping team produces print-on-demand and digital GIS geologic maps at multiple scales (30- x 60-minute guadrangles at 1:62,500 to 1:100,000 scale and 7.5-minute guadrangles at 1:24,000 scale). Two decades ago, the Utah State Mapping Advisory Committee (SMAC) set goals to complete geologic mapping of the entire state at intermediate scale to meet regional land management, resource exploration, scientific research, and other objectives. They also set goals to map the entire state in high detail, with shorter-term goals focused on geologic hazard, geotechnical, industrial mineral, and water issues associated with Utah's large population centers, high-growth areas, major transportation corridors, and high-recreation-use areas. Thanks to recently increased National Cooperative Geologic Mapping Program (NCGMP) funding, our current geologic mapping projects have significantly expanded and now include work focused on GeMS GIS conversions of published maps, regional stratigraphic studies, and three-dimensional geologic data creation including cross sections. In conjunction with the newly increased work tasks, we have a largely new staff following significant staff retirements.

We are working on numerous projects, including detailed mapping of 7.5-minute quadrangles in the Wasatch Urban Growth area, regional mapping of 30- x 60-minute quadrangles across the state, improvement of the state 1:500,000-scale geologic map and three-dimensional state geologic map cross sections, regional stratigraphic studies, and contributions to national databases. We continue to conduct projects on older maps to temporarily fill holes in our 30- x 60-minute series GIS database coverage pending future new mapping projects. Currently, about 80% of the state has at least preliminary geologic map coverage and about 70% has intermediate-scale GIS coverage. We are working on four 30- x 60-minute quadrangles across the state. The mapping group is also working toward finalizing changes to the Utah geologic map schema to make it fully GeMS compliant.

We are now in the tenth year of a SMAC priority emphasis to significantly increase detailed mapping of 7.5-minute quadrangles in the Wasatch Front area, the most populated part of the state. We are working on seven quadrangles as STATEMAP projects in this area and one geologic map in southwestern Utah's high growth and urban development area. One of these new 7.5-minute quadrangles (Dromedary Peak), in the central Wasatch Range near Salt Lake City, is being used to train new staff, with the goal of developing new mapper skills and increasing collaboration among the mapping group.

Utah currently has a total of four active EDMAP (The Educational Component of the National Cooperative Geologic Mapping Program) projects. We continue to actively support and encourage EDMAP mapping projects.

OTHER PROGRAM HIGHLIGHTS

Our Energy & Minerals Program continued investigating critical minerals, oil and gas potential in the northern Paradox Basin, geothermal resources in the West Desert, and carbon storage opportunities across the state. Earth MRI funding facilitated lidar acquisition for all areas of the state lacking existing coverage, as well as acquisition of aeroradiometric and aeromagnetic data across a large swath of the West Desert. Earth MRI also funded UGS research on the unique West Desert indium deposit, the only established resource of indium in the U.S. Work continued on a project in the Iron Mountain area west of Cedar City to characterize possible reservoirs suitable for CO₂ sequestration; this project is a partnership with New Mexico Tech, Energy & Geoscience Institute at University of Utah, Los Alamos National Laboratory, and the Oklahoma Geological Survey. We also continued work on an evaluation of REEs and critical minerals in coal and coal-adjacent strata, in partnership with the University of Utah and funded by the Department of Energy's Carbon Ore, Rare Earth, and Critical Minerals (CORE-CM) Initiative.

Our Geologic Hazards Program organized and hosted the 2022 Basin and Range Earthquake Summit (BRES22). About 100 attendees from across the western U.S. participated in discussions on earthquake geology, seismology, Earthquake Early Warning, and emergency management. We also began work on an Earthquake Early Warning feasibility study, in

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partnership with the University of Utah Seismograph Stations and Utah Division of Emergency Management. Stemming largely from UGS-led field trips for legislators and water district managers, the Utah Legislature authorized \$50 million to improve the seismic resilience of water-supply aqueducts that cross the Wasatch fault. A National Earthquake Hazards Reduction Program (NEHRP)-funded paleoseismic-trenching study on a strand of the West Valley fault zone will help refine models of seismic hazard in the densely populated Salt Lake Valley. In addition to earthquake hazards, landslides became an emergency response focus. Utah experienced its busiest landslide season in over a decade as record winter snowpack melted in the spring. We investigated a large percentage of the over 250 landslides that occurred.

Our Groundwater & Wetlands Program worked on expanding the Utah Flux Network in the Colorado River Basin, funded by the Colorado River Authority of Utah, for evapotranspiration measurements to calibrate remote sensing data. Our Paleontology Section continued a paleontological resource assessment of the Island in the Sky and Maze districts of Canyonlands National Park, and joined National Park Service staff and others in assessing potential fossil resources exposed due to unusually low water levels at Glen Canyon National Recreation Area. We also organized and hosted the 14th Mesozoic Terrestrial Ecosystems paleontology conference, which was held in the U.S. for the first time. This international conference was attended by nearly 180 participants from nine countries..

After a two-year hiatus due to the COVID-19 pandemic, our Geologic Information & Outreach Program once again hosted Earth Science Week activities, attended by nearly 700 students. New this year was an earthquake activity station illustrating Utah's seismic hazard and risk and how to prepare for "the big one".

Figure 1. Drone-sourced data collection methods are facilitating UGS geologic mapping and analysis of features such as the Gad Valley rock glacier, at the Snowbird ski resort in the central Wasatch Range.

Figure 2. High-resolution, drone-based, lidar-generated digital elevation model of the Gad Valley rock glacier. Repeat imaging enables precise measurement of changes in the glacier's volume, movement, and structural integrity over time, which is crucial for assessing its potential impact on the surrounding environment, infrastructure, and ski resort operations.





VIRGINIA

GEOLOGY AND MINERAL RESOURCES PROGRAM

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The Geology and Mineral Resources Program (GMR) is part of the Department of Energy (DE), a Commonwealth of Virginia agency whose mission is to "lead the Commonwealth to a reliable and responsible energy future." The GMR serves as Virginia's geological survey. Located in Charlottesville, the GMR performs geological and mineral resource investigations aimed at reducing the risk from geologic hazards and encouraging sustainable economic development through the wise use of mineral, land, water, and energy resources. Program staff include 16 full-time geoscientists, one full-time support staff, and several external contractors. In FY 2022, funding for the GMR came from state-appropriated recurring general funds (60%) and federal grants (40%).

GEOLOGIC MAPPING

Most of the GMR's geologic mapping is conducted under the STATEMAP program, funded by the U.S. Geological Survey's (USGS's) National Cooperative Geologic Mapping Program. Projects are prioritized pursuant to the Program's long-range mapping plan and approved by our Geologic Mapping Advisory Committee, a panel composed of representatives from the mining industry, academia, the consulting community, land-use planners, and state and federal agencies. Two continuing mapping projects are underway along the Interstate 81 corridor and in the Richmond Metropolitan Statistical Area (MSA). In the past year, the GMR performed geologic mapping in the Bland, Crockett, Fosters Falls, Long Spur, and Rural Retreat guadrangles in the Interstate 81 corridor (Figure 1). In the Richmond MSA, geologic mapping was performed in the Dabneys, Dinwiddie, Fine Creek Mills, Hylas, and Winterpock quadrangles. All mapping was at 1:24,000 scale and compiled in ArcGIS using the Geologic Map Schema (GeMS) geodatabase data model. Major map compilation efforts during the year were updating the Virginia portions of six 30- x 60-minute quadrangles at 1:100,000

scale: Buena Vista, Charlottesville, Danville, Fredericksburg, Front Royal, and Radford. Lidar data were used to improve bedrock geology and to map surficial deposits and landslides. In addition, we delivered the first phase of a derivative mapping project along Interstate 81 providing simplified and targeted geologic map information along with lidar-derived sinkhole data.

Rain-induced landslide events continue to be Virginia's single greatest geologic hazard in terms of potential loss of life and infrastructure. With a Pre-Disaster Mitigation Grant from the Federal Emergency Management Agency, GMR geoscientists are currently mapping prehistoric and historic landslides in Albemarle and Nelson Counties, two of the more populous counties in the Blue Ridge. Our geoscientists continue to work with emergency responders, local government, and the Virginia Department of Emergency Management to update regional hazard mitigation plans to address geologic hazards.

OTHER PROGRAM HIGHLIGHTS

The USGS Earth Mapping Resources Initiative (Earth MRI) provides continuing support for activities conducted by the Applied Geology Section. A second phase of geologic mapping and geochemical investigation of heavy mineral paleo-placer occurrences in the Fall Zone of Virginia is presently underway. This project leverages newly available, high-resolution airborne geophysical data collected in 2021. Mapping and sampling are focused in five 7.5-minute quadrangles in the Fall Zone, assessing potential source rocks for heavy minerals and heavy mineral sands containing critical minerals in the adjacent Coastal Plain sediments.

Virginia Energy (VE) is partnering with the U.S. Bureau of Ocean Energy Management (BOEM) to assess the feasibility of extracting economic minerals from sand deposits located on the outer continental shelf (OCS) offshore of Virginia. Our study is evaluating alternative methods for the separation and recovery of heavy minerals containing critical elements, ideally as an integral part of coastal remediation projects.



Figure 1. A portion of the Fosters Falls geologic map completed through the STATEMAP Program, showing the spatial association of sinkholes, zinc mineralization, and older terrace deposits (t3-t5).

With funding from the USGS through the National Geological and Geophysical Data Preservation Program (NGGDPP), our Applied Geology Section digitized more than 10,000 photographs, field maps, notebooks, logs, and analyses; and photographed and preserved more than 1,800 fossil specimens (Figure 2). Staff also participated in the Critical Minerals Workshop and completed updates to our critical mineral webpages. In addition, we created a story map for the <u>Morefield Gem Mine</u>.

Virginia



Figure 2. An example fossil photograph for specimens in VE's repository. More than 1,800 fossils were photographed and preserved during the year with funding from the NGGDP Program.

WASHINGTON

WASHINGTON GEOLOGICAL SURVEY

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Since 1890, the Washington Geological Survey (WGS) has provided geological data and services that benefit the people of Washington. The Survey's vision is to foster a safer, more productive, and resilient society that incorporates geology into its regular thought and decision-making processes. WGS is Washington's primary state science agency for earthquake, tsunami, and landslide research; environmental geology; geologic mapping; lidar acquisition; and earth resources. Its mission is to collect, develop, use, distribute, and preserve geologic information to promote the safety, health, and welfare of the people of Washington, protect the environment, and support the economy of the state.

To carry out its responsibilities during the period of July 2022 to June 2023, WGS employed more than 55 full-time staff. The Survey consists of the Geologic Hazards Group, the Landslide Hazard Program, the Geologic Mapping Program, the Surface Mine Reclamation Program, the Washington Geology Library, the Washington Lidar Program, the Publications Group, and the Earth Resource Program.

GEOLOGIC MAPPING

The Survey's Geologic Mapping Program consists of five fulltime mappers, four seasonal field assistants, and a mapping supervisor/mapper. From July 2022 to June 2023, the group continued its participation in the STATEMAP program and mapped four 1:24,000-scale quadrangles in the southeast Puget Lowland near Eatonville, the Cascade Foothills near Enumclaw, and in Kittitas Valley near Ellensburg. Two additional quadrangles were mapped in northeastern Washington, under the EarthMRI program. The group published three-and-a-half quadrangles of new geologic mapping at 1:24,000 scale in the southeast Puget Lowland and in Kittitas Valley.

Several other publications were released, including a new aggregate resources database to accompany an aggregate inventory of Kitsap County in the Puget Lowland. An update to the Survey's compilation of statewide 1:24,000-scale mapping database was also released, along with an update to the intermediate-scale legacy geologic map database, containing geologic mapping digitized from existing paper maps at scales between 1:24,000 and 1:100,000.

OTHER PROGRAM HIGHLIGHTS

The Geologic Hazards Program released several new tsunami products, including a major publication presenting tsunami inundation and current speed maps for a modeled Seattle Fault earthquake impacting Puget Sound. This release was accompanied by tsunami simulation videos for King County, including parts of downtown Seattle. Three tsunami evacuation walk time maps were released for communities on Washington's outer coast.

The Landslide Hazards Program released a new landslide inventory for parts of Snohomish County, as well as an alluvial fan inventory and accompanying Esri Experience for Klickitat County that highlights the interaction of wildfires and landslides. The Program completed two post-wildfire debris flow assessment rapid reports, documenting potential landslide hazards in areas recently burned by wildfires.

The Earth Resource Program developed several grant proposals, leading to a key partnership on three Department of Energy grants and a lead role on a seismic data acquisition grant. Team members also hosted a "Big Questions" workshop that brought together participants from state and federal agencies, universities, and industry to discuss important research and data goals to advance knowledge of groundwater, geologic structure, geothermal resources, and carbon sequestration in the Columbia Basin. Additionally, the Program presented important carbon sequestration and groundwater chemistry data at professional conferences, developed programmatic fact sheets, and prepared a major



Figure 1. Map sheet for the first of a new series of aggregate resource inventories, intended to eventually cover all counties in the state to assist local communities in mineral resource land designations.

Washington



Figure 2. Screenshot of the starting screen for a tsunami simulation video for King County, showing inundation from a Seattle Fault earthquake for the Seattle waterfront.

data product on groundwater chemistry in the Columbia Basin for eventual release with a companion technical report.

The Publications Group worked with other programs across the Survey to update several databases, including an update and complete revamp of the Mining and Minerals database, a major update to the Subsurface Database with data compiled as part of a National Geological and Geophysical Data Preservation Program (NGGDPP) grant, and the release of a comprehensive new Geophysical Database containing data compiled from external sources as well as data collected by Survey geophysicists. Many of the Survey's hazard booklets as well as several fact sheets were translated into Spanish to serve more communities in Washington. The Lidar Program set out to collect critical gaps in state coverage, resulting in an ambitious one-year collection covering over 10,000 square miles. These projects covered the southeastern portion of the state, as well as technically challenging areas over the Olympic and Cascade mountains, including Mount Rainier.

Participation in the USGS 3D Elevation Program (3DEP) continued with three projects, two in the central and northern portions of the state that are currently in the final stages of acceptance, and one over the eastern Cascade mountains that is now available on the Washington Lidar Portal. The WGS Lidar Program also completed a bathymetric lidar project over the Entiat River. Bathymetric lidar continues to be a critical need for many of our partners, and we are looking forward to more bathymetric projects in the next year.



Figure 3. Combination Esri Experience and Story Map informing the public about the intersection of wildfires and alluvial fans in Klickitat County in southern Washington.

WISCONSIN

WISCONSIN GEOLOGICAL AND NATURAL HISTORY SURVEY

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Wisconsin

INTRODUCTION

The Wisconsin Geological and Natural History Survey (WGNHS) provides objective information about Wisconsin's geological, mineral, and water resources. The WGNHS was created by the Wisconsin Legislature in 1897, with earlier state surveys in Wisconsin dating back to 1854. The Survey is part of the Division of Extension at the University of Wisconsin-Madison. For July 2022 to June 2023, the staff of the WGNHS consisted of 30 science and support staff and a number of students. They were involved in a variety of mapping, research, and educational projects in the areas of geology, hydrogeology, and mineral resources.

WGNHS completed several successful searches at the end of 2022, resulting in the hire of four new people starting in early 2023. This includes our Editor, two Hydrogeologists, and a Financial Specialist. Dr. Eric Carson served a one-year term as Interim Director and State Geologist following the retirement of Dr. Ken Bradbury in July 2022 and during the search for a new Director and State Geologist in 2023. Dr. Sue Swanson started as WGNHS Director and State Geologist in September 2023.

GEOLOGIC MAPPING

Bedrock Mapping

The WGNHS completed a 1:100,000-scale bedrock geologic map for Jefferson County, which underwent peer review and is now in production for publication. In this part of southeastern Wisconsin, the bedrock consists of a Precambrian surface characterized by regional-scale folding and topographic relief overlain by upper-Cambrian siliciclastics and Ordovician through Silurian dolostone and siliciclastics. In addition to providing baseline geologic data, this map clarifies the stratigraphy of the Cambrian Tunnel City Group.

In a related effort, geologists completed a regional compilation of the Precambrian bedrock surface elevation in south-central Wisconsin. The resulting publication includes a GIS database with elevation contours, bedrock faults, Precambrian outcrops, groundwater wells that intersect the Precambrian surface at depth, and historic drill records:

Elevation contours of the Precambrian surface of south-central Wisconsin, WGNHS Data Series 001.

WGNHS bedrock geologists also continued 1:100,000-scale mapping in Grant, Iowa, and Lafayette counties in southwestern Wisconsin. This area comprises the historic Lead-Zinc Mining District of Wisconsin. Associated mapping at 1:24,000 scale assesses small-scale bedrock structures and mineralization associated with the Lead-Zinc District. This detailed mapping will be combined with similar mapping conducted by the USGS in the mid-20th century to produce complete 1:100,000-scale maps of these counties. The following 1:24,000 scale maps were completed and published in the Fall of 2022.

Geologic map of the Castle Rock and Long Hollow 7.5-minute quadrangles, Grant County, Wisconsin, WGNHS Open-File Report 2022-01

Geologic map of the Bloomington and part of the Brodtville 7.5-minute quadrangles, Grant County, Wisconsin, WGNHS Open-File Report 2022-03

OTHER PROGRAM HIGHLIGHTS

Agriculture and Groundwater Contamination

The WGNHS evaluated the ties between local landscape, neonicotinoid concentrations, and groundwater-surface water within the Central Sands region of Wisconsin and published an associated database of over 100,000 measurements of nitrate and neonicotinoid concentrations in groundwater from wells across Adams, Juneau, Marquette, Portage, Waushara, and Wood Counties. The main research objective was to improve understanding of temporal and spatial dynamics of agricultural insecticides in groundwater and streams. Applied groundwater modeling using particle tracking to delineate watershed- to subwatershed-scale contributing areas to



Figure 1. Side-view of a drumlin—a glacially streamlined hill—near the city of Waterloo in Jefferson County, Wisconsin.

streams and wells is of broad interest. Field-based sampling and synoptic stream surveys of NO₃/neonicotinoids have provided real-world methods to anchor modeled simulations and guide stakeholder discussions.

WGNHS staff also completed the Southwest Wisconsin groundwater and geology study, which sampled private wells in three southwestern counties (lowa, Lafayette, and Grant) for agricultural contaminants and pathogens in groundwater. The published report characterizes the types of contamination in those wells, describes sources of contamination, and identifies multiple factors that influence groundwater quality in this region. The age and depth of a well, the local geology, and the nearby land use all affect the probability that groundwater is contaminated. This work resulted in the following publications:

- Central Sands nitrate and neonicotinoids database, WGNHS Data Series 002
- Assessing private well contamination in Grant, Iowa, and Lafayette counties: The southwest Wisconsin groundwater and geology study, WGNHS Open File Report 2023-02

Groundwater-Surface Water Interactions

WGNHS hydrogeologists completed an inventory of flowing artesian wells in Bayfield County, on the south shore of Lake Superior (Figure 2). The information from this study will be used by the county to establish protection zones that will be incorporated into a county zoning ordinance.

The WGNHS continued several groundwater studies in the nearby Chequamegon-Nicolet National Forest. WGNHS hydrogeologists completed and published a study of the sandy uplands of the Bayfield Peninsula. The sandy uplands are primary contributors to regional groundwater recharge and provide baseflow to streams in the area. Data from two new cores and wells, from one existing well, and from a lake in the sandy uplands provided information about the local hydrogeology and contributed to the understanding of the regional groundwater system. The WGNHS also continued a project along the North Fork of the Yellow River in Taylor County to improve understanding of the local hydrogeology and to document baseline water chemistry. This project addresses a need for local hydrogeological characterization in the immediate vicinity of the Bend Copper-Gold Deposit where there has been a history of proposed mineral exploration or mining.

Hydrogeology of the sandy uplands of the Bayfield Peninsula, Wisconsin, WGNHS Open File Report 2022-04



Figure 2. A flowing artesian well in Bayfield County, on the south shore of Lake Superior.

AWARDS

FRYE AWARD

Environmental geology has steadily risen in prominence over recent decades, and to support the growth of this important field, the John C. Frye Memorial Award was established in 1989 by the Geological Society of America (GSA) and AASG. John C. Frye (1912–1982) joined the U.S. Geological Survey (USGS) in 1938. He went to the Kansas Geological Survey in 1942 and was its Director from 1945 to 1954. He was Chief of the Illinois State Geological Survey until 1974 and GSA Executive Director until his retirement in 1982, shortly before he passed away. John was active in AASG and on national committees and was influential in the growth of environmental geology. The John C. Frye Memorial Award is given each year to a nominated environmental geology publication released in one of the three preceding calendar years, either by GSA or by a state geological survey.

The nominated publications identify a geologically based environmental issue, provide sound and substantive information pertinent to the problem, relate geology to the issue, and present information directly usable by geologists, by other professionals such as land-use planners and engineers, and ideally by informed laypersons. The Selection Committee assesses the uniqueness, significance as a model, and overall worthiness of the publication.

The 2023 award was presented to Nelia Dunbar, David Gutzler, Kristin Pearthree, Fred Phillips, Paul Bauer, Craig Allen, David DuBois, Michael Harvey, J. Phillip King, Leslie McFadden, Bruce Thomson, and Anne Tillery of the New Mexico Bureau of Geology and Mineral Resources for the report entitled Climate Change in New Mexico Over the Next 50 Years: Impacts on Water Resources (2022, New Mexico Bureau of Geology and Mineral Resources Bulletin 164, 218 p).

MANKIN AWARD

Geological survey agencies play an essential role in the provision of comprehensive, jurisdiction-wide geoscience information. Whereas the Frye Award recognizes work on environmental geology issues, such as water resources, engineering geology, and hazards, the Mankin Award recognizes state geological survey publications in regional, energy, or mineral resource geology, with an emphasis on



Figure 1. AASG 2023 annual meeting field trip stop near Glenwood Springs, Colorado

surface or subsurface geologic mapping, compilations, and associated reports.

Charlie Mankin (1932–2012) earned a Ph.D. from the University of Texas in 1958. He joined the University of Oklahoma in 1959 and was Director of the Oklahoma Geological Survey from 1967 to 2007. He was AASG President in 1975–1976, American Geosciences Institute (AGI) President in 1978–1979, and Campbell Medalist in 1987. Charlie played a key role in establishing STATEMAP, a program crucial to the state geological survey role in geologic mapping. The Mankin Award is given each year to a nominated geologic map, compilation, or report on regional, energy, or mineral resource geology published in the current year or one of the three preceding calendar years by a state geological survey.

The winners of AASG's 2023 Charles J. Mankin Memorial Award were Stephen C. Ruppel and coauthors of the Texas Bureau of Economic Geology for their publication entitled Anatomy of a Paleozoic Basin: The Permian Basin, USA (2019, Texas Bureau of Economic Geology Report of Investigations 285 and AAPG Memoir 118).

PICK AND GAVEL AWARD

The Pick and Gavel Award was initiated by the AASG in 1999 to recognize distinguished friends of geology who have made or are making major contributions to advancing the role that geoscience plays in our society. The Pick and Gavel Dinner is held in Washington, D.C., in late February at the Cosmos Club, whose history is steeped in geology. One of its founders and first presidents was John Wesley Powell, 1881–1894, USGS Director and explorer of the Grand Canyon, and its membership has included many renowned geologists. The Award consists of a mounted mineral, fossil, or rock with a symbol that includes a geologist's pick, a policy maker's gavel, and the Capitol, where geologists and policy makers work together to respond to the needs of the nation.

The 2023 Pick and Gavel Award was presented to Senator Catherine Cortez Masto of Nevada for her enthusiastic support of geoscience and the environment, her steadfast support for renewable energy, her ongoing interest in science and technology, and her encouragement of partnerships among state, local, tribal, and federal governments. She serves on the Committee of Energy and Natural Resources, chairing the Subcommittee on Public Lands, Forests, and Mining and serving on the Subcommittee on Energy. Her sponsored legislation has included water, mineral, and energy resources, tribal lands, science, business, and geoscience. She has consistently supported major programs critical to State Geological Surveys and AASG, including the EarthMRI and National Cooperative Geological Mapping Programs. She has been dedicated to addressing the nation's energy and mineral resource needs, responsible use of our public

lands, and scientifically informed public policy. AASG greatly appreciates the Senator's support in these areas.

DISTINGUISHED SERVICE AWARD

The AASG Distinguished Service Award is presented to particularly deserving living, retired, or retiring State Geologists, Associates, and Honorary Members, other than current officers, who deserve to be recognized for the excellence of their efforts over the long term, in particular through AASG. The award honors those who take pride in advancing our science and its application, in improving the work of state geological surveys, in improving dissemination of the knowledge that we produce, in achieving effective coordination with partner agencies, and in promoting camaraderie among the membership of AASG. Four retired State Geologists were honored in 2023.

- Karen Berry was State Geologist of Colorado from 2013 to 2022; AASG Vice President, 2016–2017; AASG President Elect, 2017–2018; AASG President, 2018–2019; AASG Past President, 2019–2020.
- Joe Gillman was State Geologist of Missouri from 2008 to 2022; AASG Annual Meeting Host, 2017; AASG Vice President, 2013–2014; AASG President Elect, 2014–2015; AASG President, 2015–2016; AASG Past President, 2016–2017; AASG Secretary, 2011–2013.
- Steve Masterman was State Geologist of Alaska from 2014 to 2022; AASG Annual Meeting Host, 2016; AASG Vice President, 2015–2016; AASG President Elect, 2016–2017; AASG President, 2017–2018; AASG Past President, 2018–2019.
- David Spears was State Geologist of Virginia from 2009 to 2022; AASG Vice President, 2014–2015; AASG President Elect, 2015–2016; AASG President, 2016–2017; AASG Past President, 2017–2018; AASG Secretary, 2013–2014; AASG Editor, 2012–2013.

PRESIDENTIAL AWARD

The AASG Presidential Award is presented by the AASG President to particularly helpful, constructive, and worthy members or friends of AASG for extraordinary service to the objectives of AASG. In 2023, AASG President James Faulds presented the AASG Presidential Award to three very deserving individuals: (1) Warren Day of the USGS; (2) Elizabeth Duffy, AASG's Federal Affairs Specialist; and (3) Dick Berg, State Geologist of Illinois.

 Warren Day has provided strong leadership for the EarthMRI program, serving as its Science Coordinator since its inception. He was instrumental in the successful deployment of the program, effectively seeking input from State Geological Surveys on how best to carry out assessment of critical minerals throughout the nation through a combination of regional geophysical surveys and detailed analyses of highly prospective areas. We were lucky to have Warren in this position at such a critical juncture.

- Elizabeth Duffy has been a great asset for AASG over the past several years serving as our government affairs liaison in Washington, DC. She has helped hone our message to Congress. She has also provided critical oversight in scheduling meetings with congressional staffers at the liaison meetings, focusing on enhancing long-term strategic relationships with key members of Congress, as well as establishing relationships with new members who have been appointed to important committees. All of this has resulted in significant increases in funding for several key programs (e.g., NCGMP and NGGDPP) and initiation of other programs (e.g., EarthMRI).
- Dick Berg has continued to contribute enormously to many facets of AASG. He has co-led the Liaison Committee for the past several years, carefully monitoring federal legislation and appropriations while helping to develop the annual request sheet. In addition, he has served effectively as Chair of the Minerals Committee. He has also played a key role in co-leading the Cost Benefit Analysis of Geological Mapping project, which will be completed in 2024.

The list of Presidential Awards can be found at <u>www.</u> <u>stategeologists.org/award/presidential</u>.

ADDITIONAL AWARDS

The Ian Campbell Medal is presented each year by the America Geosciences Institute to a nationally recognized, living statesperson with a distinguished record of significant achievements in science, education, and administration, in support of the profession of geology and its role in society. The 2023 Ian Campbell Medal was awarded to Vicki S. McConnell, former State Geologist of Oregon.

The Heroy Award is in recognition of exceptional and beneficial long-term service to the American Geosciences Institute. The Institute gave the 2023 Heroy Award to Rodney Ewing.