



Biennial Report of Activities and Programs

July 1, 2022 to June 30, 2024



A department of Montana Technological University

DIRECTOR'S INTRODUCTION



Photo by Lisa Wareham

The Montana Bureau of Mines and Geology biennial report is our opportunity to reflect on the many and varied achievements of a unique group of scientists, engineers, staff, and students.

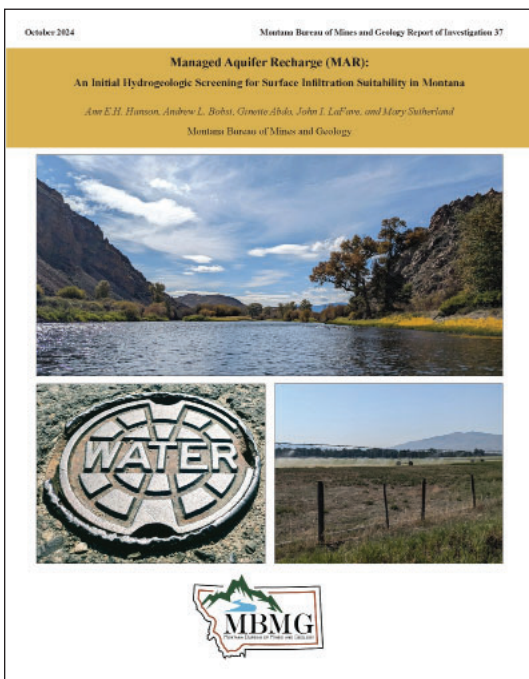
Our mission is to provide information for the sound use of Montana's geological and water resources. Our vision is to be Montana's lead source of geologic and water information.

As a non-regulatory State agency within the Montana University System, we serve as Montana's geologic survey, addressing topics ranging from earthquake monitoring and geologic mapping to energy development and groundwater. We are housed on the campus of Montana Technological University and maintain a fully staffed office in Billings.

Our geologic mapping program, supported by both State and competitive Federal funding, continues its work on the complex geology of western Montana; during this biennium we released several new maps, including collaborative maps with the Idaho Geologic Survey. The demand for critical mineral commodities (commonly referred to as critical minerals) has increased dramatically over the past few years; likewise, demand for information related to those resources in Montana.

The Earth Mineral Resource Initiative (Earth MRI), hosted by the U.S. Geological Survey, provides funding for mapping and assessment of critical minerals—a task for which Montana and the MBMG are well suited. Funding has been secured for mapping economic mineral deposits, primarily in western Montana; several publications based on this new work are in process.

As is our tradition, the MBMG publishes high-quality, reviewed publications for both scientists and the public. In the 2020-2022 biennium we published 88 maps and reports, including many fact sheets on critical minerals. As we migrate away from paper, our online (free) downloads rapidly increase—this past biennium we provided more than 2,250 digital maps and reports.



MBMG staff sampling for rare earth elements near Flat Creek, Mineral County.

The MBMG has recently published a screening study on the potential for managed aquifer recharge (MAR) in Montana. This study determines locations across the State that appear suitable for MAR surface infiltration methods based on the hydrogeology.

GROUND WATER ASSESSMENT PROGRAM

Groundwater, often called the “hidden resource,” is one of Montana’s most valuable natural assets, supplying domestic and municipal drinking water, irrigation and stock water, and sustaining streams and wetlands. The Montana Ground Water Assessment Program is designed to improve the understanding of Montana’s groundwater resources by collecting, interpreting, and disseminating essential groundwater information. This information is vital for making science-based management decisions.

There are three parts to the program:

- **Ground Water Monitoring**—to produce and maintain long-term water-level and water-quality records
- **Ground Water Characterization**—to systematically assess and document the hydrogeology and quality of the State’s major aquifers
- **Ground Water Information Center (GWIC) database**—to make groundwater information widely available

An interagency Steering Committee selects study areas, coordinates groundwater research among State, Federal, and local government units, and oversees Assessment Program progress.

Ground Water Monitoring

The Ground Water Monitoring Program collects water-level measurements and water-quality samples from strategically located wells across the State. Long-term groundwater-level records are the only direct measure of how Montana’s aquifers respond to seasonal, climatic, developmental, or land-use factors.

Since 1993, the MBMG has been collecting systematic groundwater-level data from an 800+ well statewide network that covers the State’s major aquifers; some wells have been regularly monitored since the 1950s. Several partners maintain local groundwater-level networks and share their data with the MBMG.

Cooperators include:

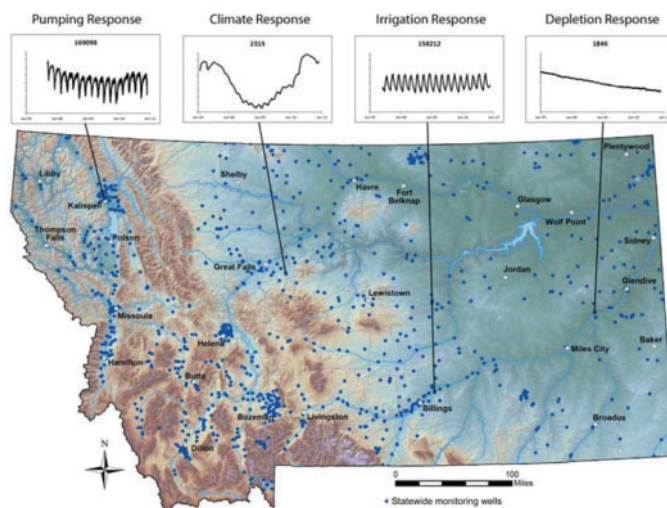
- Confederated Salish Kootenai Tribes Water Resources
- Gallatin Local Water Quality District
- Missoula Valley Water Quality District
- Lewis and Clark Water Quality Protection District
- Sheridan County Conservation District
- Yellowstone National Park

During the biennium, new monitoring sites were added to the statewide network in the Tobacco Valley near Eureka, Montana and along the Big Hole River near Glen. The MBMG also continued to partner with the National Ground Water Monitoring Network (NGWMN), obtaining funding to install three monitoring wells on the Fort Peck Reservation. These monitoring wells will be constructed in late 2024 or in 2025, and two of the wells will be co-located with Montana

Climate Office Mesonet stations. Data from these wells will help characterize the groundwater quality in aquifers on the Reservation, and monitor the effects of development, droughts, and other climate variability on groundwater levels.

Since 2006 the MBMG has been collaborating with Yellowstone National Park and the Montana DNRC to continue groundwater monitoring in the Yellowstone Controlled Groundwater area, which encompasses almost 1,200 mi², surrounding Yellowstone National Park. Monitoring efforts are focused around the towns of Cooke City, Silver Gate, Gardiner, and West Yellowstone, and along the upper Gallatin River from the Big Sky area southward. The monitored sites include wells, springs, spring creeks, and a few geothermal features. Data collected included groundwater levels, spring discharge rates, water temperatures, and water chemistry.

The Ground Water Monitoring Program has also continued a partnership with the Richland County Conservation District to provide technical oversight and assist with data management for a groundwater monitoring network in the West Crane aquifer near Sidney, Montana. This “buried valley” aquifer was formed when glacial deposits filled in an ancient river valley eroded into the Fort Union bedrock. Its existence was unknown 15 years ago, but now it supplies more than a dozen high-capacity irrigation wells. The monitoring efforts are providing data for developing long-term aquifer management strategies.



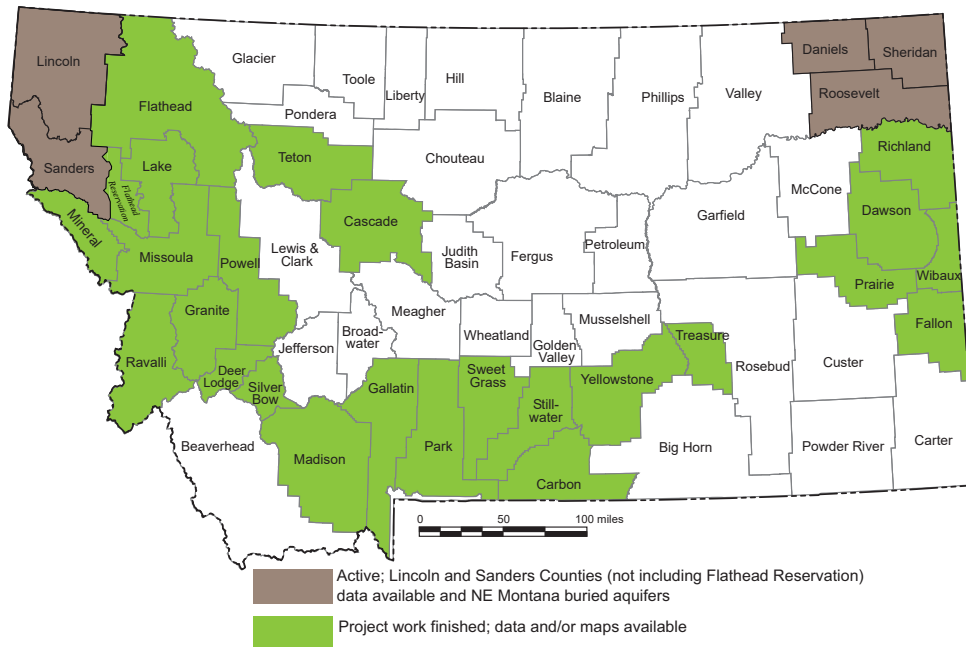
Locations of Statewide Monitoring Network wells and examples of different types of hydrographs.



Drilling crew constructing monitoring wells for the NGWMN.

Ground Water Characterization

The Ground Water Characterization Program provides basic information about aquifers across the State. Work is completed in specific areas as prioritized by the Ground Water Assessment Steering Committee. To date, more than 9,800 wells have been visited and about 3,500 groundwater samples have been collected. These data have been used to compile over 78 maps and reports that describe specific aspects of Montana's aquifers, groundwater flow systems, and groundwater quality.



GWCP project area status map.

During the biennium, fieldwork was completed in the Lincoln and Sanders Counties characterization area in northwestern Montana, including additional, focused work in the Tobacco Valley, around Eureka. Fieldwork was also started in northeastern Montana (Daniels, Sheridan, and Roosevelt Counties) to characterize “buried valley aquifers,” formed when continental ice sheets advanced into Montana from Canada during the last ice age. The ice sheets overran the former Missouri River drainage, forcing the river system southward and covering the old drainage system with glacial deposits. This initial fieldwork involved working with University of Montana Western faculty and students to test geophysical methods for locating the buried valley aquifers.

The Characterization Program also published the following reports and maps from previous field areas during the biennium:

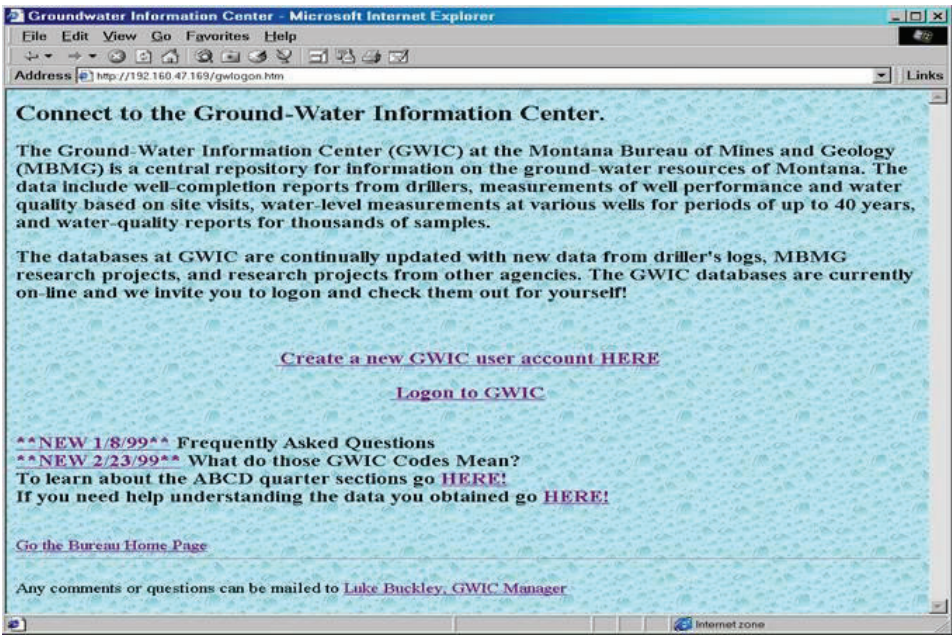
- Groundwater quality of Carbon and Stillwater Counties, south-central Montana https://www.mbmgt.mtech.edu/mbmgcat/public/ListCitation.asp?pub_id=32431
- Potentiometric surface in Gallatin, Lower Madison, Lower Jefferson, and Upper Missouri River Valleys within parts of Madison and Gallatin Counties, Montana https://www.mbmgt.mtech.edu/mbmgcat/public/ListCitation.asp?pub_id=32433
- Potentiometric surface in the Madison, Upper Jefferson, Beaverhead, Big Hole, and Ruby River Valleys within Madison County, southwest Montana https://www.mbmgt.mtech.edu/mbmgcat/public/ListCitation.asp?pub_id=32574
- Hydrogeologic framework of the upper Yellowstone River Valley, Park County, Montana https://www.mbmgt.mtech.edu/mbmgcat/public/ListCitation.asp?pub_id=32644
- Data for water wells visited during the Park–Sweet Grass ground water characterization study https://www.mbmgt.mtech.edu/mbmgcat/public/ListCitation.asp?pub_id=32728

The Characterization Program also continued collaboration with the USDA Natural Resources Conservation Service (NRCS) to prepare hydrogeologic reports for proposed stockwater wells, as part of an NRCS cost-share program for agricultural producers. About 60 hydrogeologic reports are prepared each year to assist NRCS with evaluation of proposed well sites. Staff also continued to collect water-isotope samples from precipitation and snowpack as part of a collaborative effort to develop a Montana Precipitation Isotope Network (MTPIN). A data report on a 4-year pilot network is scheduled for release in the 2025 fiscal year.



Characterization Program staff and University of Montana Western students testing geophysical equipment for use in locating buried valley aquifers.

Ground Water Information Center



Screenshot of the first GWIC website homepage.

A New Look

The flagship database for the MBMG, GWIC is debuting its 12th version in December 2024, which will give the site a much-needed update and incorporate many new elements, including a cleaner look and responsive design for all screen sizes.

GWIC serves its population 24 hours a day and shows the reach of the scientific community and their demand for data (see table 1). GWIC offers some datasets to the general user, but some datasets require a login to access. The statistics reported in table 1 include all users.

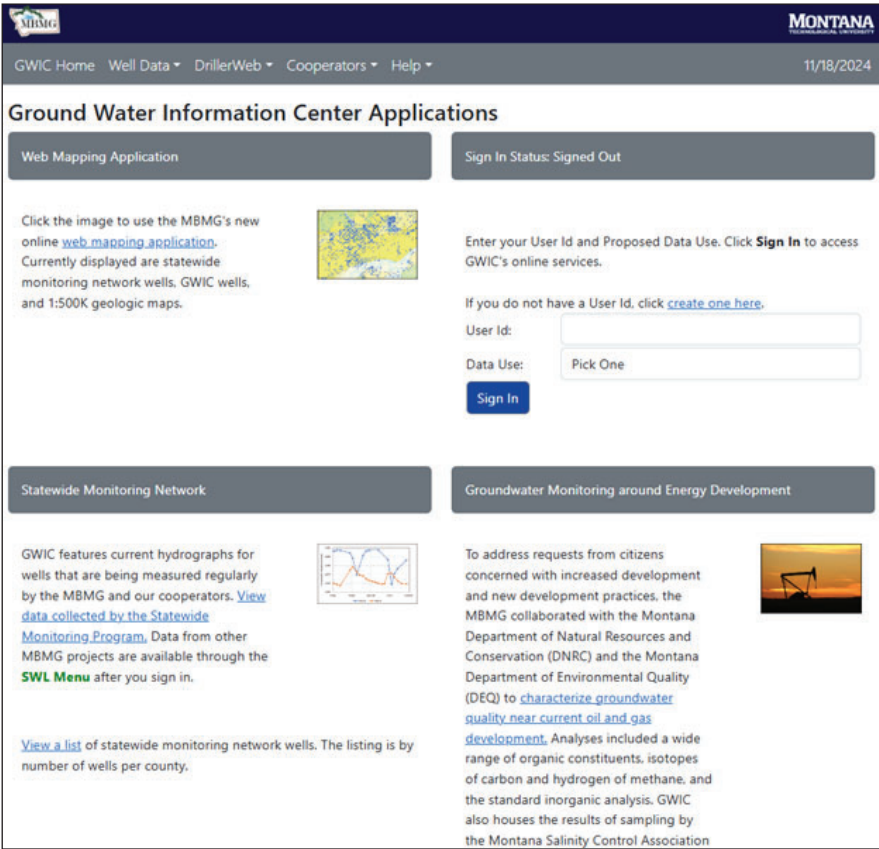
Table 1. GWIC online metrics.*	
Metric	Statistic
Years in service	25
Countries served	58
States/provinces served	339
Total unique users	368,290
Total unique queries	15,128,639
Total downloaded records	8,193,583,885
Average yearly logins	40,862
Average yearly queries	604,532
Average yearly downloads	327,743,355
Total website hits**	50,595,147
5-year-average website hits**	4,038,278

*Analysis performed January 2024.
**Statistics only available from calendar year 2006.

On January 4, 2024, a major milestone for the Ground Water Information Center (GWIC) website quietly slipped in with the new year. This day marked 25 years of providing online access to the Montana Bureau of Mines and Geology’s water-well and associated data to the public through our website at <https://mbmggwic.mtech.edu>

A Bit of History

After a 2-year development cycle, the GWIC website went online January 4, 1999, and quickly became popular among water professionals both in Montana and around the world. To date, GWIC has served a wide variety of data consumers worldwide, and usage statistics continue to climb with added products and datasets.



GROUND WATER INVESTIGATION PROGRAM

The Ground Water Investigation Program (GWIP) answers locally identified, site-specific water resource questions prioritized by the Montana Ground Water Steering Committee (MCA 85-2-525).

In Montana, groundwater is essential for safe drinking water supplies and for economic growth. In many areas of the State, groundwater is the only reliable year-round source of water for household use and for livestock. Groundwater is also used for irrigated agriculture and provides baseflow to Montana's rivers. Changing land use and demographics can alter groundwater withdrawals, potentially affecting senior water rights holders, stream flows, the availability of irrigation water, and the health of aquatic ecosystems.

With changing land use and a shift to a warmer climate, Montanans are increasingly concerned about how best to plan for future water supplies, and to ensure that water policy is based on the best available science. Future water management will reflect the increasing value of Montana's water resources and must address decisions about competing needs for water.

Current research questions include:

- Groundwater sustainability in response to increasing residential, irrigation, and commercial demands
- Effects of changing irrigation methods on groundwater recharge and surface-water baseflow
- Aquifer and stream response to changing land use from irrigated agriculture to residential development
- Changes in water quality due to increasing development

The 2022–2024 Biennium

Four new GWIP projects were started this biennium:

- *Billings area, Yellowstone County*—a groundwater budget has been developed and a groundwater flow model is being constructed to investigate groundwater availability in the thin alluvial aquifer that supplies groundwater outside of the Billings public water supply area. A water-quality report is in draft review.
- *Eureka, Lincoln County*—groundwater/surface-water interactions have been evaluated in the Tobacco River, a groundwater budget has been developed, and a groundwater flow model is being constructed to determine the effects of increased residential development on groundwater and surface water.
- *Big Hole River, Silver Bow County*—data interpretation is underway to understand water quantity and temperature influences to the Big Hole River from irrigation return flows.
- *Quantified irrigation recharge to groundwater*—data collection is ongoing at sites in the Glen and Edgar areas to determine the fate of applied irrigation water and quantify recharge to groundwater. Unsaturated zone models are being developed.

Program Products

GWIP products are designed to provide a more detailed understanding of the groundwater and surface-water systems. The information provided by GWIP can be used by regulators, senior water-right holders, new water-right applicants, and other stakeholders to make informed water management decisions and to help anticipate hydrogeologic effects from land use changes. Program products include:

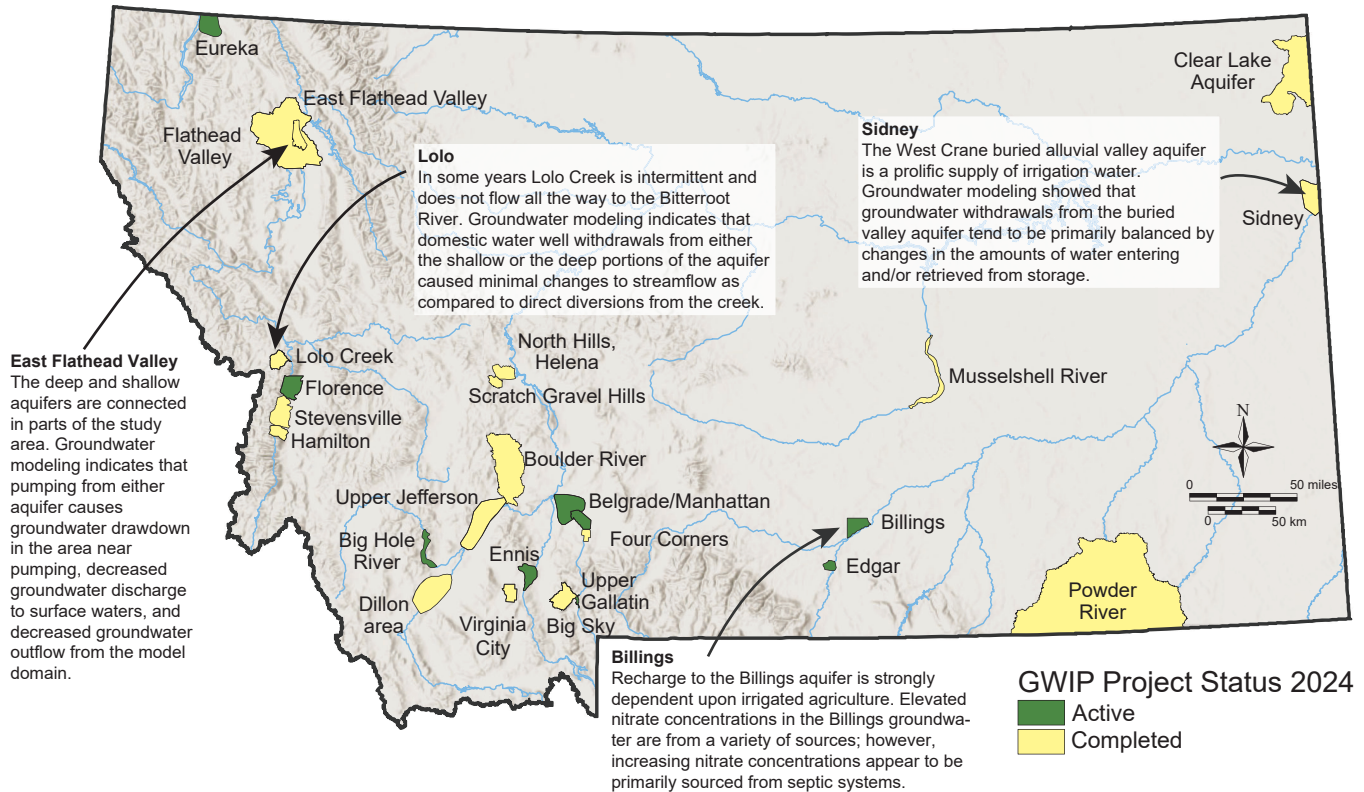
- ✓ A report on the hydrogeologic responses to current and anticipated stresses
- ✓ Groundwater models available to users that simulate hydrogeologic response to different stresses
- ✓ A comprehensive set of hydrogeologic data for each project, permanently available online through the Ground Water Information Center (<http://mbmggwic.mtech.edu/>)

GWIP personnel led a field trip for the Water Policy Interim Committee highlighting some results of the Big Hole River investigation, Glen area.



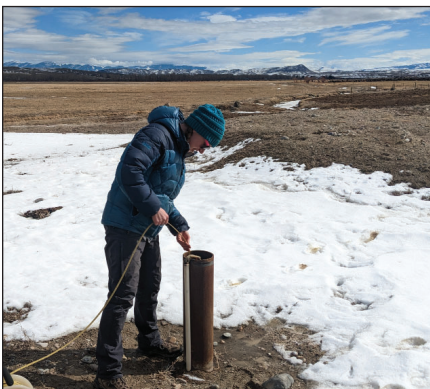
Program Status

To date, over 120 projects have been nominated and prioritized by the Ground Water Steering Committee. In 2025, we will be working with the Greenfields Irrigation District (Fairfield) evaluating the effects of improving their irrigation infrastructure on groundwater and surface water, and with the Big Hole Watershed Committee to investigate the potential for Managed Aquifer Recharge (MAR) in the upper Big Hole watershed for improving late season stream flows. The map below shows the location of GWIP active and completed investigations.



Publications Released in 2022–2024

- Three aquifer tests in the Tobacco Valley, near Eureka, Montana, 2024, Open-File Report 764.
- Analyses of three constant-rate aquifer tests, East Flathead Valley, northwest Montana, 2024, Open-File Report 757.
- A groundwater flow model for the East Flathead Valley, Flathead County, Montana, 2024, Report of Investigation 36.
- Groundwater inputs to rivers and streams: Using temperature and visual cues on the Big Hole River, southwestern Montana, 2024, Information Pamphlet 17.
- Analyses of constant-rate aquifer tests in the Quaternary-Tertiary basin-fill sediments and the Tertiary-Archean fractured bedrock near Ennis, Montana, 2024, Open-File Report 763.
- Sources of salinity to the Musselshell River: Executive summary, 2023, Information Pamphlet 15.
- Hydrogeology and irrigation potential of the West Crane aquifer, Richland County, 2023, Open-File Report 760.
- Groundwater/surface-water study in the Upper Jefferson Valley, 2023, Information Pamphlet 14.
- Analyses of three constant-rate aquifer tests, East Flathead Valley, 2023, Open-File Report 757.
- Groundwater quantity and quality near Hamilton, Montana, 2023, Open-File Report 759.
- Hydrogeologic investigation of the Belgrade-Manhattan area, Gallatin County, Montana: Superposition groundwater modeling report, 2023, Open-File Report 754.
- Sources of salinity to the Musselshell River, Musselshell County, Montana, 2023, Report of Investigation 35.
- Investigation of the inorganic groundwater quality in the West Yellowstone Basin, Gallatin County, Montana, 2023, Open-File Report 755.



Measuring water levels in the Big Hole River Valley.

MANAGED AQUIFER RECHARGE



Pivot irrigation field near Melrose.

Managed aquifer recharge (MAR) is the purposeful addition of water to aquifers for storage and later use and/or ecological benefit. Surface infiltration is a common MAR method in which water infiltrates through the unsaturated zone to recharge the aquifer below. An initial screening tool was developed to identify areas in Montana that may be appropriate for surface infiltration based on hydrogeologic information. This suitability analysis focused on unconfined basin-fill and alluvial surficial aquifers.

Four hydrogeologic criteria were rated statewide and geographically combined. Criteria included:

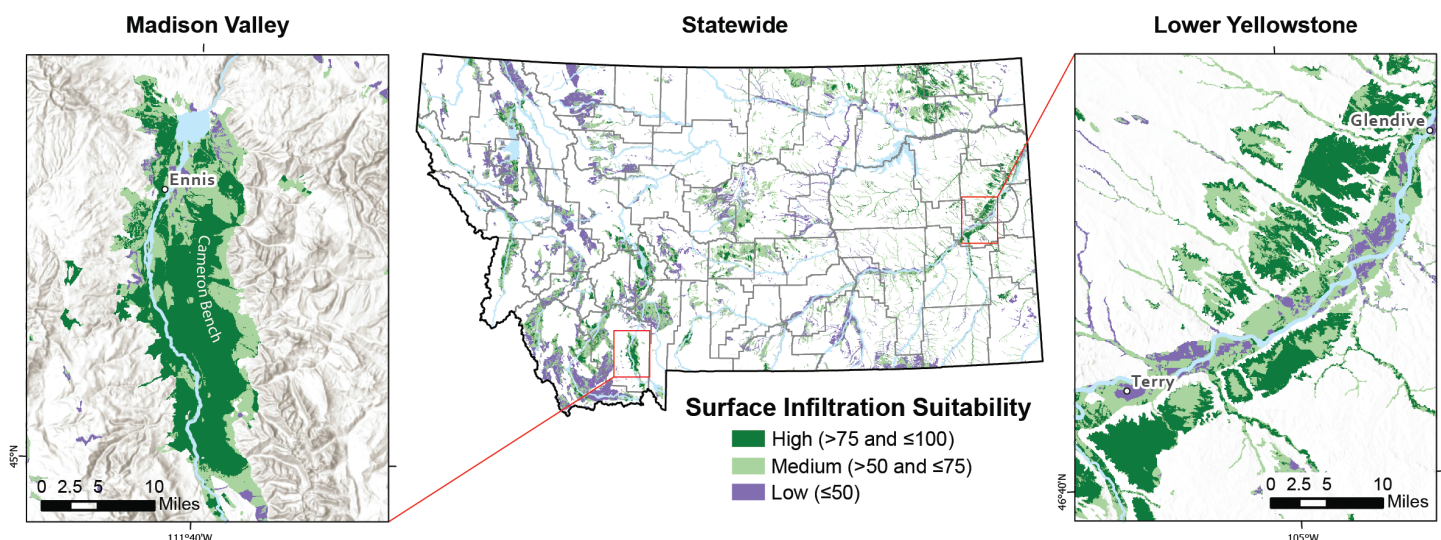
- Geologic/aquifer properties,
- Depth to groundwater,
- Soil permeability, and
- Topographic slope.

Final suitability scores were grouped as “high,” “medium,” and “low.”

- 15% of the analyzed area (~2.3 million acres) is scored high and is common along, but not exclusive to, river terraces.
- 53% of the analyzed area (~8.3 million acres) is scored medium.
- 32% of the analyzed area (~5.0 million acres) is scored low and is common where fine-grained glacial or Tertiary sediments were present at the surface.

This product serves as a first-level screening tool for stakeholders to identify areas that merit a more localized and detailed suitability investigation. For additional details, the report can be found at https://www.mbmgt.mtech.edu/mbmgcat/public/ListCitation.asp?pub_id=32745.

Visit the MBMG MAR Web App to explore this study at: <https://gis-data-hub-mbmgt.hub.arcgis.com/apps/93e50821cc9c494392f238c521ef5576/explore>.



A western and eastern Montana example that showed high surface infiltration suitability. Both these areas have sand and gravel terraces that are topographically flat and above the present-day river system.

GEOLOGY PROGRAMS

Geologic Mapping

Geologic maps provide essential information for managing Montana’s water, land, mineral, and energy resources, as well as addressing geologic hazards. The Montana Bureau of Mines and Geology has maintained a rigorous geologic mapping program for decades, consistently publishing detailed geologic maps and ancillary reports annually. During the past biennium, the mapping program employed a core staff of 10 geologists and a support staff of 10 employees comprising GIS specialists, cartographers, laboratory technicians, and mapping contractors. The MBMG anticipates hiring two mapping geologists in the next biennium to facilitate program growth and to replace retiring staff.

The U.S. Geological Survey STATEMAP Program, a component of the National Cooperative Geologic Mapping Program, supported most of our geologic mapping projects during the 2022–2024 biennium. Funding for STATEMAP is awarded through competitive cost-share grants requiring matching dollars from the State. Funding support for the STATEMAP program in Montana has significantly increased recently—from an annual award of \$163,000 in 2019 to \$656,00 in 2024.

New mapping projects are prioritized by a State Mapping Advisory Committee representing Montana industries, universities, and Federal, State, and Tribal agencies. The Advisory Committee’s main priorities are to (1) complete geologic maps of all 30' x 60' quadrangles in Montana and (2) perform detailed, large-scale mapping of transportation corridors, areas with increasing land development, regions of interest for natural resource extraction, or geologic terranes with pressing scientific problems. With guidance from the advisory committee, the mapping program completed six STATEMAP projects in fiscal year 2023 and is currently working on seven projects in fiscal year 2024.

The geologic mapping group expanded its lab and analytical capabilities over the past biennium. Mapping projects were supported by a robust combination of whole-rock geochemical analyses, U-Pb zircon geochronology, fission track and (U-Th)/He thermochronology, and cosmogenic studies. The newly acquired analytical data provide age and compositional information used to correlate and map geologic units within the context of Montana’s regional geologic framework and natural resource abundances. The geologic mapping group spearheaded a new publication series, “Analytical Datasets,” to facilitate the accessibility and usability of MBMG’s growing analytical data resources. The analytical datasets, alongside geologic maps, are released now on our website as publications, and will be made available in a public web-based information portal in the next biennium.

Project Summaries—Fiscal Year 2023 Delivered for June 30, 2024 USGS submittal deadline:	Project Summaries—Fiscal Year 2024 In progress for June 30, 2025 USGS submittal deadline:
•Detailed geologic maps of the Christensen Ranch, Elk Gulch, and Home Park 7.5' quadrangles within the Dillon 30' x 60' quadrangle. •Detailed geologic maps of the Murr Peak, East Bay, and Ronan 7.5' quadrangles in the Polson 30' x 60' quadrangle. •Integration of the Wisdom 30' x 60' quadrangle into 1:100,000-scale seamless geologic map of Montana. •Surficial deposit compilation of the Havre, Harlem, Whitewater, Rocky Boy, Dodson, and Malta 30' x 60' quadrangles. •Detailed geologic map of the Lost Trail Pass 7.5' quadrangle on the Montana–Idaho border in collaboration with the Idaho Geologic Survey. •New subsurface maps of the top of the Madison Group, and Swift, Fall River, Kootenai, and Judith River formations in central and eastern Montana.	•Mapping and final compilation of the Dillon 30' x 60' quadrangle. •Detailed geologic mapping in the Polson 30' x 60' quadrangle including the North ½ of the Weeksville and the South ½ of the Loneman Creek 7.5' quadrangles, and the Shroder Creek 7.5' quadrangle. • Detailed geologic mapping of the Fort Connah 7.5' quadrangle and the southern Mission fault. •Completion and publication of Buxton and Tucker Creek 7.5' quadrangles (I-15 corridor south of Butte). •Landslide map of the historic Virginia City area, southwest Montana. •Surficial deposit compilation for the 1:100,000-scale seamless geologic map of Montana. •Subsurface mapping of the Glendive and Glasgow 1° x 2° quadrangles, northeast Montana.

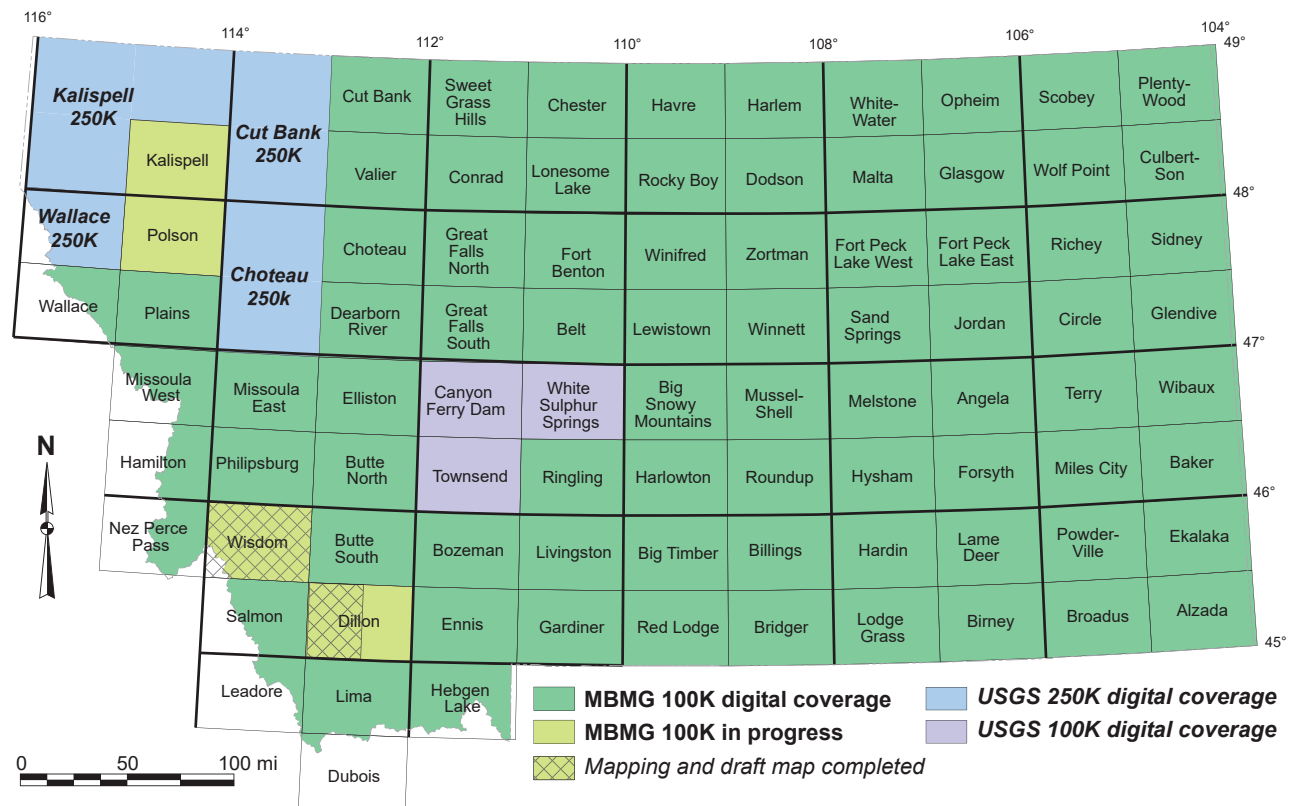
Program Status

The MBMG is winding down two long-term geologic mapping projects in southwest Montana. The Wisdom quadrangle was completed during the past biennium and is being prepared for publication in fiscal year 2024. A draft of the Dillon quadrangle will be completed in fiscal year 2024 and published the following year. Over the next biennium, new quadrangle mapping will focus on completing 30' x 60' geologic map coverage in northwest Montana. Work in the Polson quadrangle began in 2017 and will continue through the next biennium. Geologic mapping will commence in the Kalispell quadrangle in fiscal year 2025. Other miscellaneous mapping projects will focus on fault and landslide mapping in western Montana, surficial and subsurface mapping in eastern Montana, and geologic mapping along the state line in collaboration with the Idaho Geologic Survey. The MBMG joined the Intermountain West Geologic Mapping and Research Coalition in fiscal year 2024, partnering with eight states, including Arizona, Colorado, Idaho, Nevada, New Mexico, Utah, and Wyoming. The coalition anticipates the U.S. Geological Survey will establish a new funding stream supporting cross-border mapping initiatives.

In the 2022–2024 biennium, the mapping group published 15 geologic maps of 7.5' quadrangles and 6 analytical datasets, and assisted two EDMAP publications and three geohazard map publications. All published STATEMAP map products are free to download from the MBMG website, <http://www.mbmrg.mtech.edu/>.



Field trip participants inspect the 2022 flood damage to Highway 89 connecting Gardiner, Montana, and Mammoth Hot Springs at the biannual Yellowstone Volcano Observatory meeting in May 2024. Yellowstone National Park is abandoning the old highway and evaluating a new route, hindered by park restrictions, physiographic barriers, and Yellowstone's potential to generate cascading hazards. The MBMG plans to map the massive landslide complex impacting the north entrance to the park as a fiscal year 2025 STATEMAP project.



Current status of 1:100,000-scale geologic mapping in Montana.

ECONOMIC GEOLOGY

The Economic Geology program at the MBMG has undergone significant growth in the past 2 years. Almost all of our work is tied to critical minerals research in Montana. Critical minerals are mineral resources that the federal government has deemed essential to society or national defense, and of unreliable or limited supply.

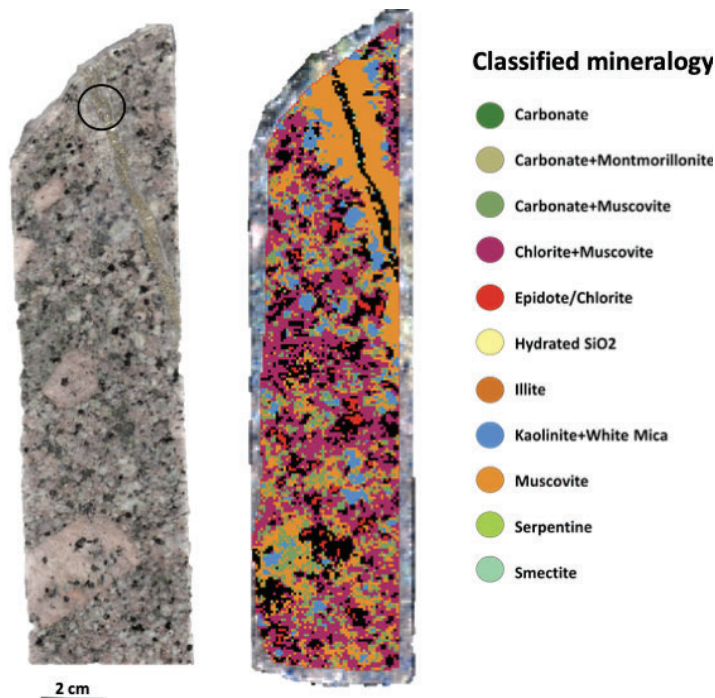
Active projects funded by the U.S. Geological Survey's Earth Mapping Resources Initiative include: mine waste characterization, REE-bearing carbonatite at Sheep Creek, magmatic-hydrothermal deposits in Radersburg, porphyry deposits near Basin, and Phosphoria Formation in southwest Montana. We have also worked with the USGS and Idaho Geological Survey to target an area along the MT-ID border, from the Bitterroot to the Tendoy Mountains, for combined airborne radiometric and magnetic surveys. These surveys will support mineral exploration and deposit delineation along this region.

The Army Research Lab (Department of Defense) is our second column of support for the program's research into critical minerals of Montana. Two ongoing grants from the ARL have funded discovery or rediscovery of important deposits of REEs, Cr, V, Co, Zn, Sb, and many other commodities over the past 2 years. These grants also support two Montana Tech M.S. students: Everett LaBudda is developing geochemical vectors to target porphyry-type mineralization in the Boulder region, and Nicholas Risedorf is investigating causes for REE enrichment in the Phosphoria Formation.

Many detailed accounts of our research were covered in the September 2023 Montana Mining and Mineral Symposium. Proceedings from this conference contain a selection of extended abstracts for review; the publication is available for free download from our website: <https://doi.org/10.59691/TTSI4436>.



Jarred Zimmerman stands in front of a roadcut that exposes skarn mineralization in Powell County, Montana. Photo by Adrian Van Rythoven.



Paired visible light (left) and infrared reflectance mineralogy (right) images of a core slab from the Boulder Porphyry Deposit, Jefferson County, Montana. Figure by Everett LaBudda. Data collected at the Center for Advancing the Science of Exploration to Reclamation in Mining (CASERM) at the Colorado School of Mines, with assistance from Miranda Lehman and Katharina Pfaff.

Active Mining and/or Mineral Processing in Montana

- Pd and Pt (with lesser Rh, Ni, and Co) are produced from the Stillwater Layered Mafic Intrusion by Sibanye—Stillwater's East Boulder and Stillwater mines in Sweet Grass and Stillwater Counties. Despite Platinum Group Elements (PGEs) being classified as critical minerals, the company laid off 450 workers this fall due to low metal prices.
- Sulfide ore from the above two mines is smelted in Columbus (Stillwater County), along with salvaged catalytic converters to produce refined metallic PGEs.
- Montana Resources produces Cu, Mo, and Ag concentrates from the Continental Pit, Silver Bow County.
- Au mining no longer occurs at Barrick's Golden Sunlight Mine in Jefferson County, but pyrite is being extracted from the tailings to remediate the risk of acid rock drainage at the site. The pyrite is then used in mineral processing at other Barrick mines outside of Montana. Fine gold within the pyrite is also recovered in this process.
- Coal mining occurs at four mines in central and eastern Montana.

- Talc is produced at three mines across Madison and Beaverhead Counties.
- Over a dozen small-scale placer mines (Au, Ag, or sapphire) operate across western and southwestern Montana.
- A small custom physical processing mill continues to operate in Philipsburg (Granite County) to produce Au and other metal ore concentrates.
- Small-scale hard rock sapphire mining continues at Yogo Gulch in Judith Basin County.
- Commercial placer mining for sapphire is conducted by Potentate Mining, LLC in Granite County.
- Mining for specimens and gem rough (amethyst, smoky quartz) is ongoing at the Little Gem Mine, Jefferson County.
- Aggregate (sand and gravel), building stone, and limestone (cement) are quarried from a handful of locations, mostly in western and central Montana.
- Imported Sb ores are refined at U.S. Antimony Corp.'s smelter in Thompson Falls in Sanders County.



Nicholas Risedorf examines an exposure of the Phosphoria Formation at the Hogback Syncline, Madison County. Photo by Adrian Van Rythoven.

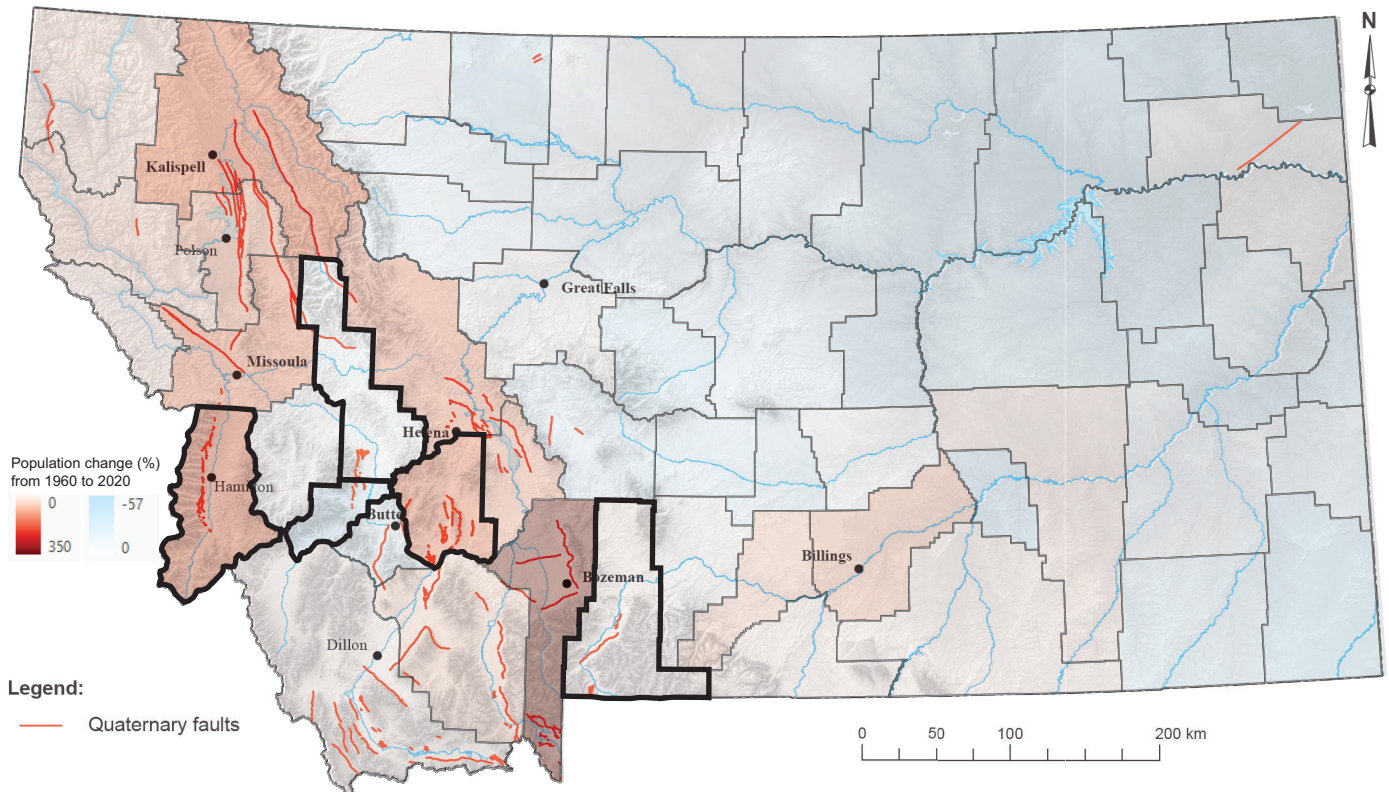
Active/Recent Exploration and Development

- Further exploration (drilling, drone geophysics) for PGEs and other associated critical minerals in the Stillwater Complex is being conducted by Stillwater Critical Minerals (formerly Group Ten Metals).
- Reflex Advanced Materials Corp. has drilled core at the Ruby Graphite Project in the vicinity of the closed Crystal Graphite Mine in Beaverhead County.
- REE and Nb-bearing carbonatite deposits at Sheep Creek in Ravalli County are being evaluated by U.S. Critical Materials Corp.
- Sandfire Resources America awaits permit-related litigation to finish before proceeding on its Black Butte Cu-Co-Ag deposit in Meagher County.
- Hecla Mining Company is evaluating the Rock Creek Ag-Cu deposit in Sanders County and the Montanore Ag-Cu deposit in Lincoln County.
- Blackjack Silver Corp. is evaluating old underground mine workings in the Walkerville neighborhood of Butte (Silver Bow County) for Ag, Zn, Cu, Au, and other critical minerals such as In, Ge, and Bi.
- Brixton Metals and Ivanhoe Electric (formerly High Power Exploration) are conducting a joint venture to evaluate the Hog Heaven Cu-Au-Ag project in Flathead County.
- American Pacific Mining Corp. continues evaluation of prior mine workings at its Cu-Au project in Madison County.
- Celerity Mineral Corp. is delineating a likely Cu porphyry deposit west of Boulder in Jefferson County.
- Falcon Copper Corp. is delineating Cu-W-Mo skarn deposits around old mines in Snowshoe Gulch in Powell County.
- Teras Resources Inc. was evaluating the Wataseca (Wataseka) Au Mine in Madison County, but the company has halted trading as of 2023 due to lack of operating capital.
- Eastern Resources Inc. continues to hold the mineral rights to the Montana Tunnels Au-Ag-Pb-Zn Mine (Jefferson County), but the company is in limbo as bankruptcy proceedings were denied in July 2024 by court order.
- Eastern Resources is also evaluating their Au skarn holdings to the east of Montana Tunnels at Golden Dream and Diamond Hill.
- W.R.H. Nevada Properties, LLC is evaluating a large swath of previously unexplored private deeded mineral estate parcels in western Montana.
- Recent claim staking on federal lands by Barrick Gold Corp. in southwest Montana.
- Part-time or independent prospecting continues throughout mostly western Montana and is supported by the MBMG as part of its mandate for responsible resource development and geologic education.

GEOLOGIC HAZARDS PROGRAM

The Geohazards Program locates and characterizes active faults, earthquakes, and landslides, and makes this information available to the scientific community, policy makers, emergency responders, and the public.

A major goal is to develop a statewide database of active faults and landslides. Grants from the Federal Emergency Management Agency (FEMA) and Montana Department of Emergency Services (DES) support active fault and landslide mapping using Light Detection and Ranging (LiDAR) in several counties. Datasets from newly available LiDAR surveys in Montana reveal numerous hazardous active faults and landslides that were previously unrecognized.

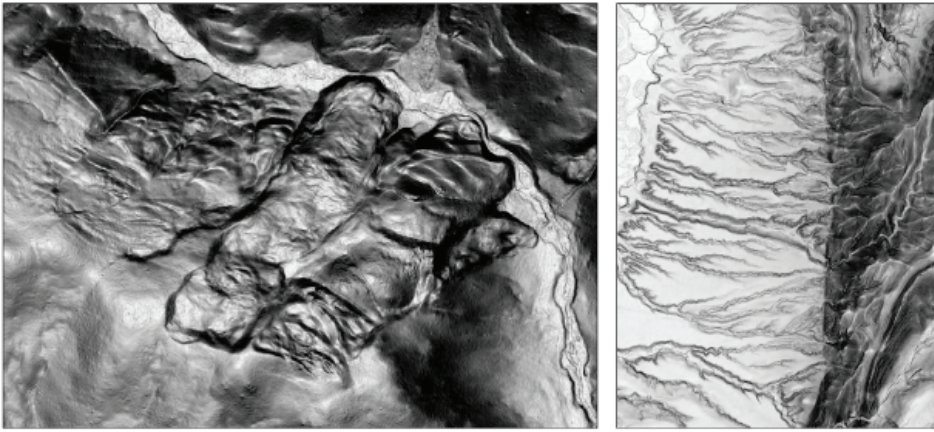


Quaternary fault database for Montana and population distribution (2020 census) showing counties (black outlines) with recent or active faults and landslides mapping projects funded by FEMA and DES using countywide new LiDAR data.

New MBMG geologic maps showing the locations of hazardous faults and landslides have been released for Jefferson and Deer Lodge Counties, and fault and landslide maps are underway for Ravalli, Park, and Powell Counties. Map data are integrated into online geodatabases of statewide active faults and landslides. The current and developing inventory of active faults will be published as geodatabases and made available through the MBMG Geohazards Portal for earthquake hazard assessments and updates to the National Seismic Hazards Model. A web mapping application will soon allow users to visualize statewide Quaternary faults



View of the East Gallatin fault–Reese Creek fault that extends along the range front and foothills of the Gallatin Range (background). In the foreground are glacial deposits with glacial boulders similar to target sites sampled for cosmogenic nuclide exposure dating.



LiDAR datasets for Jefferson County showing examples of hazardous landslides (left) and faults (right) with evidence of geologically recent displacement. Basemaps are LiDAR slopeshade DEMs.

with LiDAR data and other available geohazards information (historic earthquakes, landslide occurrences, and liquefaction susceptibility).

The Geohazards Program continues to secure funding from the U.S. Geological Survey's National Earthquake Hazards Reduction Program (NEHRP) for site-specific field investigations of active faults. Recent completion of three projects on the Bitterroot fault, an active fault located in the Bitterroot Valley, have provided results in multiple technical reports, a new 1:24,000-scale MBMG geological map, and an MBMG Bulletin. These projects

involved MBMG geologists characterizing fault traces and fault scarps using LiDAR, timing of fault activity, fault slip rates, prehistoric earthquake history, and probabilistic fault displacement hazard assessments.

Since 2023, the MBMG has partnered with the Wyoming State Geological Survey (WSGS) on a collaborative investigation of the East Gallatin fault–Reese Creek fault, a cross-border active fault in Yellowstone National Park (YNP). MBMG and WSGS geologists recently conducted field expeditions into remote areas of the YNP to map fault scarps and collect samples for cosmogenic nuclide exposure dating. This project will provide important constraints on the faulting history, timing of most recent surface-rupturing earthquakes, and fault slip rates to better characterize seismic hazards for the North Yellowstone region.

The MBMG has been leading and organizing the annual Montana Geohazards Workshop since 2022. In April 2022, the first workshop was held at Montana Technological University in Butte. In April 2023, the second workshop was held at Fort Harrison in Helena. Recently the third workshop was held at the University of Montana in Missoula on May 1–2, 2024 (<https://mbmg.mtech.edu/MontanaGeology/geohazards/MontanaGeohazardworkshop2024.asp>). These workshops bring together earth scientists, engineers, state agencies, local governments, and various asset owners and stakeholders to discuss geohazards and their potential risks to Montana and the broader Northern Rockies region. Participants included MBMG, FEMA, EERI, Montana DES, University of Montana, Montana Department of Transportation, Montana Department of Natural Resources, Montana State Library, Montana Department of Environmental Quality, Missoula and Helena Public Schools, and representatives of Montana Senators' and Representatives' offices, among others.

These meetings provide an opportunity to: present results from recent geohazards and hazards mitigation projects throughout Montana; identify research priorities and facilitate collaborative projects and synergies with partner agencies; and organize earthquake tabletop exercises and training courses. In particular, a key milestone and direct outcome of the 2024 Geohazards Workshop was the ratification of the Montana Earthquake Working Group (MEWG), with its mission and interest groups in Hazards Research, Mitigation Strategies, and Outreach. MEWG serves as a source of information for individuals and groups concerned with earthquake safety, promotes earthquake-loss-reduction measures and resilience, develops partnerships, and implements awareness campaigns in order to save lives, prevent injuries, protect property, and reduce social and economic disruption from the effects of earthquake-related activity in Montana. An example of a success story through the MEWG partnership is the Helena School District seeking FEMA funding to develop a school inventory for seismic retrofit.



Drone photo of Bitterroot fault within a residential area near Hamilton in the Bitterroot Valley. View is to the north showing an example of a fault scarp (red line) that vertically offset glacial deposits from the last major glaciation (15,000–20,000 years ago). Note house built right on the fault scarp.

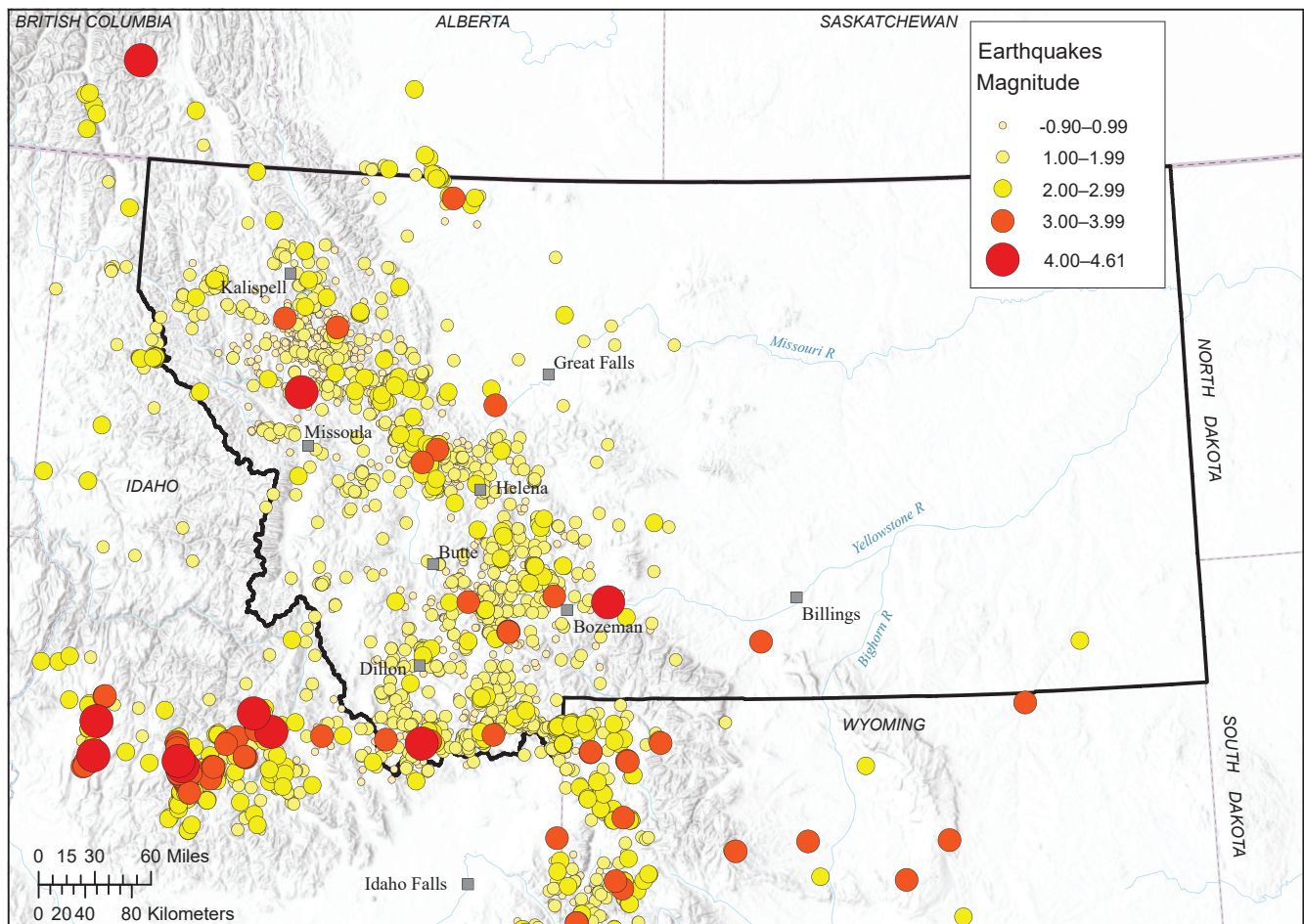
EARTHQUAKE STUDIES

Western Montana has a history of large, damaging earthquakes and remains seismically active. Most earthquakes (including the 1925 M 6.6 Clarkston earthquake centered north of Three Forks, and the M 6.3 and 6.0 Helena earthquakes in 1935) occur 3 to 10 miles deep along faults that do not extend to the Earth's surface. The seismic hazards associated with these “blind” faults cannot be evaluated with traditional surficial fault mapping and are best studied with data from a permanent network of seismograph stations. As the population and infrastructure of earthquake-prone western Montana continue to grow, the exposure to seismic hazards—the risk—increases.

The MBMG operates a network of 47 seismic monitoring stations throughout western Montana, the most seismically active region of the State. The MBMG records data from 103 local and regional seismograph stations in real time from 16 different networks, including data from 8 USGS stations in Montana, 4 of which operate in eastern Montana. Other regional seismic monitoring centers in Utah, Idaho, Washington, and Canada exchange seismic data with the MBMG, which provides additional monitoring coverage near Montana's borders.

These seismic data are used to determine earthquake locations and magnitudes to create a seismicity catalog, which is also provided to the USGS National Earthquake Information Center. State, Tribal, and Federal agencies (Montana Disaster and Emergency Services, Montana Dam Safety Program, Confederated Salish and Kootenai Tribes Safety of Dams Program, and the U.S. Geological Survey), the media, and the public use this information. As part of its routine earthquake cataloging procedure, the MBMG determined origin times, locations, and magnitudes for 5,635 earthquakes with magnitudes ranging from -0.9 to 5.4 from July 1, 2022 to June 30, 2024. This catalog, which extends back to 1982 and includes over 91,000 earthquakes, provides crucial data for characterizing seismic hazards in Montana.

The largest of 3,554 earthquakes in Montana during this period occurred on July 14, 2023 with a magnitude (M) of 4.6 and was centered 2 miles south of Lima. Two other earthquakes with magnitudes greater than 4 included a M 4.5 centered 6 miles south of St. Ignatius on November 16, 2022 and a M 4.4 centered 2

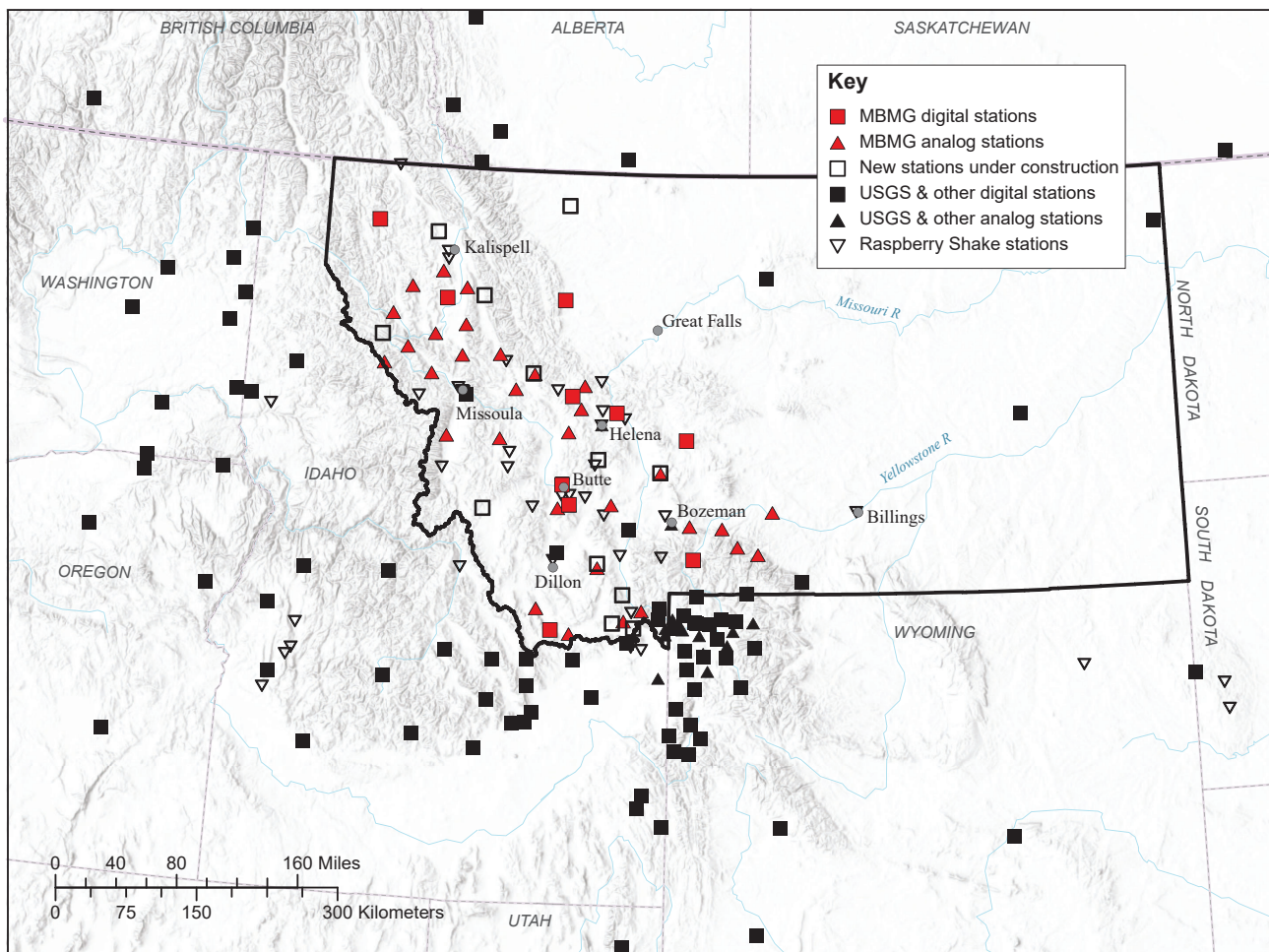


Epicenter locations for 5,635 earthquakes located by the MBMG from July 1, 2022 to June 30, 2024. Of these, 3,554 occurred within Montana.

miles north of Livingston on January 30, 2023. Citizens reported feeling these earthquakes plus 18 others around western Montana, but no damage was reported. A M 3.5 earthquake occurred 24 miles northeast of Red Lodge on July 21, 2023. This unusual south-central Montana earthquake demonstrates that no region of Montana is completely immune from earthquake activity. In seismically active western Montana, citizens reported feeling earthquakes southeast of Libby, near Flathead Lake, southwest of Great Falls, southeast of Lincoln, south of Whitehall, near Belgrade, Pony, Ennis, and Dillon. The concentration of epicenters northwest of Helena are late aftershocks of the M 5.8 Lincoln earthquake that occurred on July 6, 2017. Hundreds of open-pit mine blasts are also recorded annually and cataloged separately from natural tectonic earthquakes. The Montana seismic network records many Yellowstone earthquakes each year, but the University of Utah is responsible for analyzing and reporting Yellowstone seismicity.

Most of the MBMG seismograph stations utilize outdated analog instrumentation (red triangles on seismic network map) that has been in service for decades and badly needs updating. The MBMG received a DNRC Reclamation and Development Grant in September 2022 to purchase and install 12 new digital seismograph stations to upgrade the existing seismic network and enhance seismic monitoring coverage of the most active parts of Montana. This project is well underway, with 11 new sites installed and prepared to receive new seismic instrumentation. To improve the density of seismic monitoring stations and enhance public outreach and education, the MBMG purchased 20 low-cost Raspberry Shake home seismographs. Most of these tiny seismographs have been provided to home owners, schools, and fire stations to join a network of over 2,400 Raspberry Shakes operating globally (<https://stationview.raspberryshake.org/>).

Current seismograms from the MBMG network are available on the MBMG Earthquake Studies Office website (<http://www.mbmgt.mtech.edu/MontanaGeology/geohazards/main.asp>), along with a listing of recent earthquakes and other information about seismic hazards in Montana.



Seismograph stations recorded in real time at the Earthquake Studies Office and used to locate 2022–2024 earthquakes. Red symbols are seismograph stations operated by the MBMG; squares show modern digital stations while triangles show older analog stations. Open squares show digital stations being installed with DNRC RDGP grant and expected to be operational by November 2024. Black squares and triangles are stations operated by the U.S. Geological Survey and other regional seismic networks including the University of Utah, Idaho National Labs, University of Washington, Idaho Geological Survey, Canadian Geological Survey, and Alberta Geological Survey. Open inverted triangles are Raspberry Shake stations hosted by homeowners and schools. Most of these within Montana were provided by the MBMG.

ENVIRONMENTAL HYDROGEOLOGY

The Environmental Hydrogeology Program works with a variety of local, state, and federal organizations providing technical assistance on groundwater and surface-water problems stretching from Sanders County to Richland County. The geographic breadth of projects is related to the diversity of Montana's economy, ranging from mineral extraction by underground and surface mining, and ore processing to farming and ranching operations.

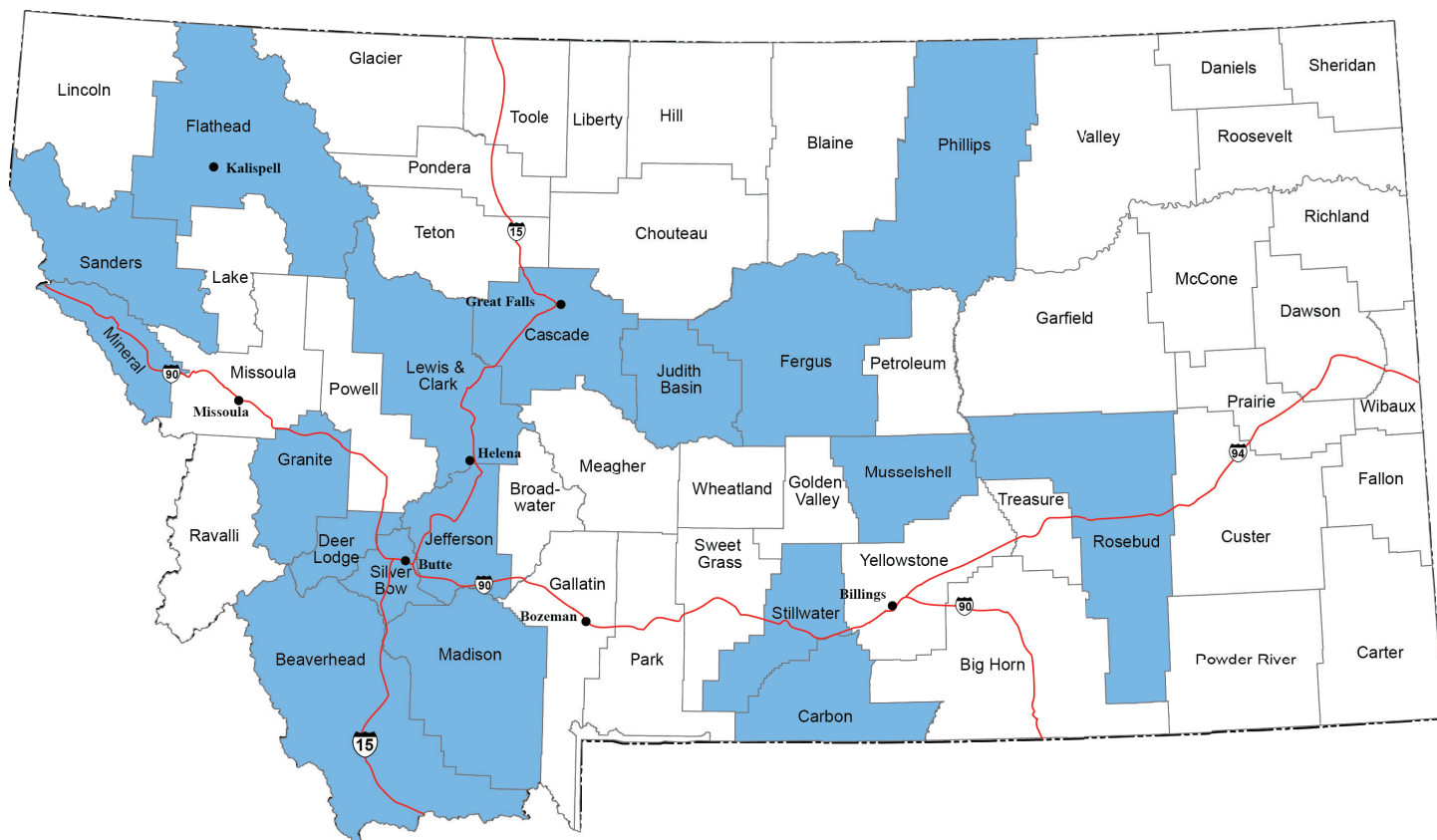


Figure 1. Locations by county where abandoned/inactive mine and mine processing facilities have been identified for REE sampling and analysis.



Figure 2. Jackson Quarles collecting a water sample from the Landusky Water treatment plant.

The MBMG, in cooperation with the Montana Technological University–Center for Advanced Materials Processing (CAMP), has received funding from the U.S. Army Research Laboratory to investigate the occurrence of rare earth elements (REEs) and the best methods to process them. The Environmental Program is investigating the occurrence of REEs at former and current large-scale mines and mine processing facilities throughout Montana. More than 20 sites/areas were initially identified for both solid and aqueous sampling; figure 1 shows the counties where metal mines and processing facilities in western and central Montana and coal mines in central and eastern Montana were sampled (figs. 2, 3). The program is designed to collect opportunistic samples from mine water discharges and mine waste piles, i.e., waste rock, slag, and tailings, for initial characterization. During the initial characterization process, 316 solid and 218 aqueous samples have been collected and analyzed. The initial results will be used to target more detailed future sampling.

The MBMG is also working with researchers from West Virginia University (WVU), Montana Resources (MR), and others to investigate the potential to recover REEs and other metals from the sludge generated during the treatment of Berkeley Pit (Butte, MT). WVU developed a process for the collection and processing of acid mine drainage waters and sludge from coal mine discharges for eastern coal areas, and selected the Berkeley Pit site to demonstrate the process suitability for implementation at a western U.S. hard rock mine site. MBMG and MR employees performed temporary modifications to the existing water treatment plant for pH adjustment and collection of treated sludge in specially designed sample bags (fig. 4). More than 120 tons of sludge or hydraulic



Figure 3. MBMG and DEQ employees collecting water and tailings samples from the MT Tunnels tailings pond and tailings dam.



Figure 4. MBMG, MR, and WVU personnel monitoring the filling of sample bags with HPC containing REEs.

preconcentrate (HPC) was collected from the water treatment plant operations over 3 days (total collection time was about 18 hours). Samples of the HPC were shipped to WVU facilities for REE recovery. High concentrations of total REEs and several critical minerals (cobalt, nickel, and zinc) were determined to be present in the HPC. Researchers are working with representatives from the Department of Defense on development of future testing and treatment plant modifications that may allow construction of a REE concentrator for further mineral separation and refinement.

Current Projects

- Identification and Characterization of Rare Earth Elements at Large-Scale Abandoned/Inactive Mine Sites Throughout Montana
- Rare Earth Element Recovery Demonstration-Berkeley Pit
- Butte Mine Flooding Long-Term Monitoring
- Basin Watershed-Acid Mine Drainage (Bullion and Crystal Mines)
- Rocker Controlled Groundwater Area
- Butte Area Controlled Groundwater Program
- Mouat Superfund Site, Columbus, MT: Long-Term Groundwater Monitoring
- Elkhorn Mine: Underground Mine Drone Development for Safety Evaluation and Acid Mine Drainage Technical Assistance
- Richland County Conservation District: Fox Hills-Hell Creek Flowing Well Evaluation and Rehabilitation
- Beal Mountain Mine Conceptual Site Model
- Determining Surface-Water Influences on Groundwater Upper Silver Bow Drainage
- Abandoned Mine Site Reports Preservation

ENERGY RESOURCES

The **Billings Office** of the Montana Bureau of Mines and Geology was established in 1967 to inventory coal resources and investigate development-associated impacts to water resources. The Billings Office staff specialize in geologic and hydrogeologic research of Montana's energy resources and hydrogeology studies unique to the semi-arid, agricultural settings of eastern Montana.

Hydrocarbon Investigation Program

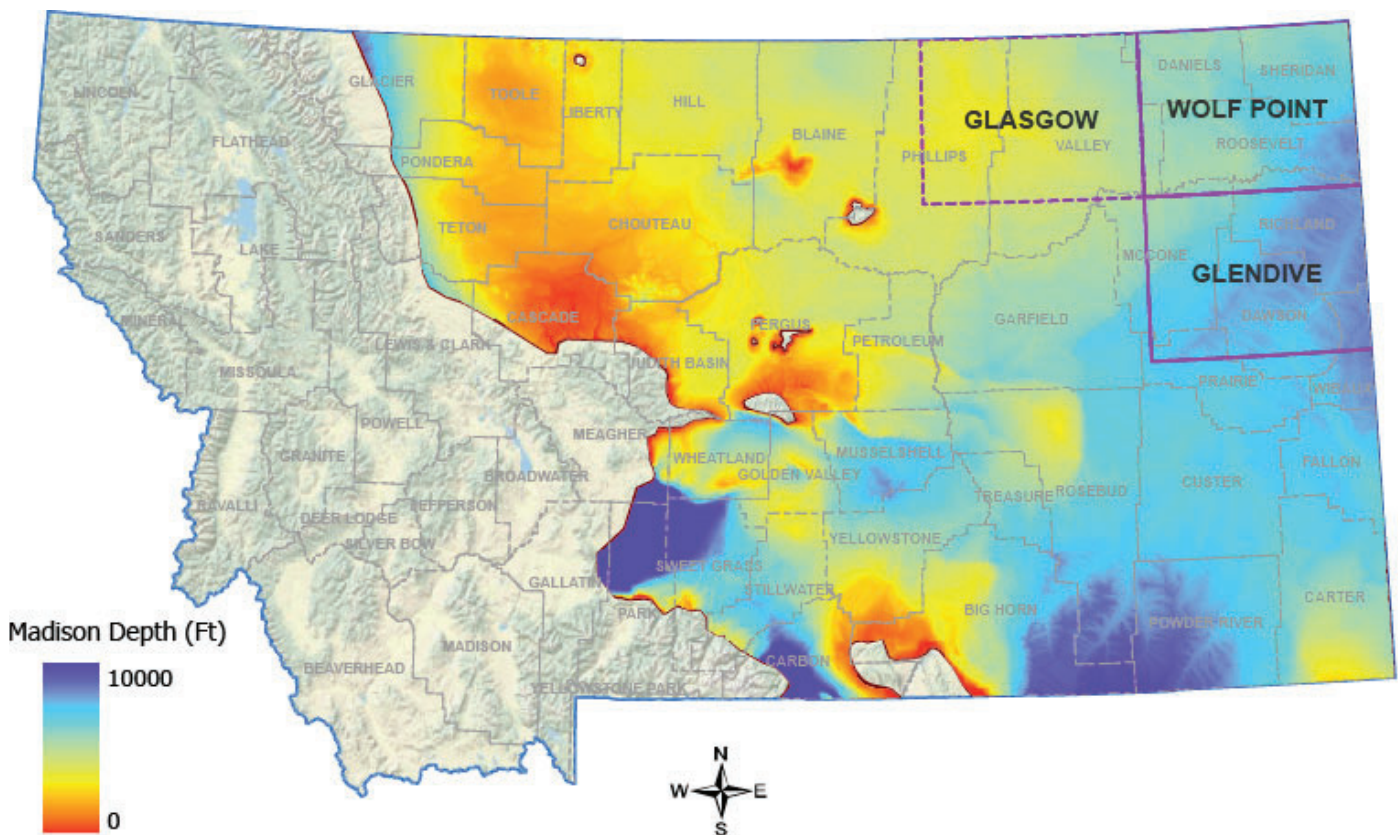
The MBMG's Hydrocarbon Investigation Program was established by the 2020 Montana State Legislature to conduct research that encourages and facilitates petroleum exploration and production in the State.

Current projects include:

- Providing petroleum information and data to the public via the MBMG website.
- Mapping subsurface geology—critical for petroleum exploration.
- Estimating volumes of oil that could be recovered from known oil fields using enhanced recovery techniques.

Geologic maps depicting the extent, thickness, and reservoir characteristics of subsurface geologic formations are critical for identifying new drilling targets for petroleum exploration. These maps are also fundamental to understanding geologic hazards such as faults, identifying targets for wastewater or CO₂ injection, and managing and protecting groundwater aquifers.

During the 2022–2024 biennium, we completed six regional-scale structure maps. We also began a project to generate detailed structure and thickness maps of subsurface geologic formations on a 250K quadrangle basis. The Wolf Point and Glendive quadrangles have been completed; the Glasgow quadrangle is in progress.



This map is an example regional structure map, displaying the depth to the Madison Formation, an important petroleum reservoir and groundwater aquifer, depending on location within the State. The status of our detailed mapping is shown by quadrangle outlines in purple (solid boundary is completed; dashed boundary is in progress).

Coal Program

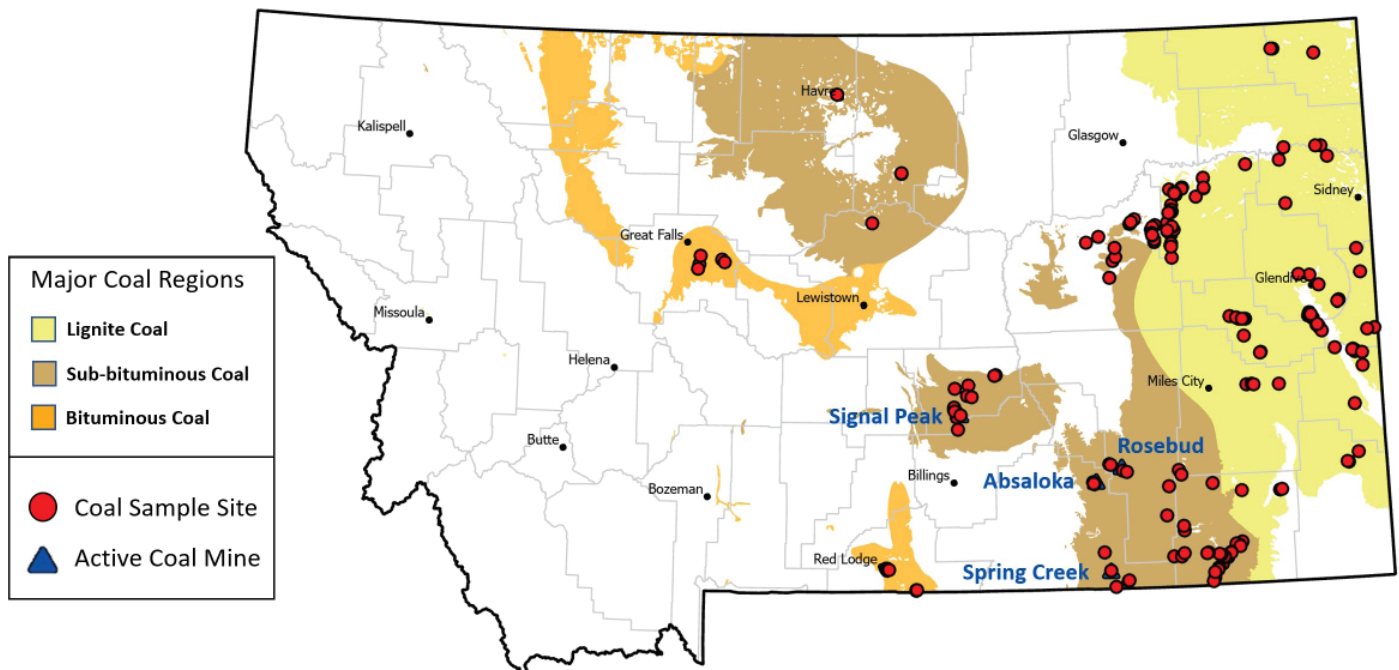
Since the 1960s, the MBMG Coal Program has conducted statewide coal resource assessments and coal availability studies to determine the distribution, quantity, and quality of the State's mineable reserves. Despite the shift away from coal-fired power in the U.S., coal has the potential to remain a valuable commodity for the state of Montana. Nationally, there is interest in coal as a host rock for rare earth elements (REEs) and other critical minerals. REEs possess unique properties essential to future technologies, and the demand for REEs is expected to increase significantly over the next few decades.

In 2022, the MBMG, in collaboration with neighboring states, launched several multi-year projects to evaluate Montana's coal deposits for high concentrations of REE and other critical elements. Roughly 900 coal samples from over 100 sites have been collected and assayed for rare earth elements during the past 2 years. Several coalbeds show promise, with total REE concentrations up to three times the Department of Energy's minimum economic standard of 300 parts per million.



Sampling a coalbed in eastern Montana.

Montana Coal Sample Sites



Map showing locations where coalbeds were sampled and tested for REEs and other critical elements.

Geothermal Energy

Geothermal energy, in the form of heat, radiates from the Earth's interior as a result of the radioactive decay of isotopes in the Earth's crust. Groundwater is heated as it circulates through faults and fractures in subsurface geologic layers, and occasionally makes its way to the surface as geysers and hot springs. In 2024, the MBMG began a multi-year project investigating Montana's geothermal potential for power generation. The occurrence of geothermal systems depends on local and regional geology. The MBMG's goal is to characterize specific sites that could be developed for geothermal energy, and thereby add to Montana's energy portfolio and future economy.

DATA PRESERVATION AND MINING ARCHIVES

Summary

The Data Preservation Program continued to rescue and preserve historical mining and geology information and convert it to digital media, increasing its access and use by public and private users from Montana and throughout the country. The MBMG's Data Preservation webpage continues to spread public awareness of our preservation efforts and has led to the acquisition of 12 new collections. Between July 2022 and June 2024, our webpage averaged 2,655 unique users each month. Over 1 million searches delivered 2.4 million downloaded records. Staff researched and responded to more than 120 information inquiries made in person, by telephone, or by email.

Program Development

We updated program operations and policies to improve preservation of historical records and our services to the public:

- Consolidated MBMG archival collections from various campus locations into appropriate storage.
- Aligned our policies and procedures to national archival best practices.
- Formalized procedures for and publicized potential subsampling of geologic material collections for research.
- Purchased a forklift to better access and manage our core collections.

Grants

The USGS National Geological and Geophysical Data Preservation Program (NGGDPP) awarded grant funding (100% matching funds are required) to support the following efforts for data rescue and preservation of data.

- **Mineral Storage Building**

The newly constructed building serves three primary functions: to provide archival storage space for documents and legacy geologic materials, to house the sample repository of materials collected by MBMG field geologists, and to create workspace for staging, viewing, and processing geologic samples.

- **Chadwick and Feeley Collections**

We accessioned, inventoried, photographed, and provided digital access to the research collections of two Montana State University geology professors, Dr. Robert Chadwick and Todd Feeley. The almost 6,000 samples from ore deposits in Montana and the Absaroka Volcanic Supergroup will facilitate additional research in areas that are no longer easily accessible.

Agency Collaboration

Staff routinely provide digital and paper copies of claims, prospects, mines, underground mine workings, oil and gas, and historic geologic data to local, State, and Federal agencies.

- Montana Department of Environmental Quality: The MBMG has arranged to take possession of the DEQ's remaining archived geologic, hydrogeologic, and mine engineering data related to abandoned mine lands. We continued to inventory, scan, and digitally restore documents, reports, and maps related to mine reclamation and remediation.
- Butte–Silver Bow (BSB) Government: We expanded the coverage of transparent overlays of mine workings within 200 feet of the surface throughout the greater Butte Area to assist the BSB Reclamation Specialist in identifying possible property subsidence problems; staff provides updated files as they scan additional historic claim maps.



Drill core staged for sampling in the Mineral Storage Building.

New Donations

The MBMG accepted donations of 12 Montana-related historical mining and geophysical collections. The donations vary in size and include reports, maps, specimens, and drill core received from mining companies, other state surveys, universities, and geologists from throughout the U.S.

Notable acquisitions include:

- **Don Winston Collection:** This collection of Winston's hand-drawn stratigraphic sections and background research document his contribution to our foundational understanding of the Belt Supergroup.
- **Tom Chadwick Collection:** Chadwick's years of work as an economic geologist generated a wealth of geologic maps, reports, and other supporting materials. Requests for access to this collection were immediate and comprehensive.

Economic Geology Support

Critical Minerals

The MBMG was again awarded funding through the National Geological and Geophysical Data Preservation Program (NGGDPP) grant to continue identifying and evaluating mineral resources in Montana. Data Preservation staff provide ongoing support for this critical mineral research.

Oil and Gas

Data Preservation staff uploaded a digital collection to the MBMG website of the Montana Geological Society (MGS) Maps and Cross Sections. The collection objects, illustrating and interpreting the geology of various oil and gas prospects, can be viewed on the website, and metadata can be directly downloaded.

The Bill Boberg collection of cuttings from oil and gas drill core from the Belt Basin in western Montana, including well logs, geochemical data, and reports bolsters our information for that area.

Uranium

We digitized reports and additional supporting information for uranium logs digitized last biennium. Additionally, the MBMG rescued two boxes of uranium exploration records from disposal.



A portion of the large volume of abandoned mine reclamation records from the DEQ.

Montana Geological Society Maps
Maps and Cross Sections in Montana and Wyoming

3. Willow Creek Tear Fault
4. Butcher Creek Seeps Vista
5. East Rosebud Mountain Front
6. East Rosebud Lake
7. Lazy EL Ranch

Home Browse Subjects Locations Timeline Data About

Search

Back to Collections

Description
This collection of maps and cross sections were recovered from the Montana Geological Society's storage facility in Billings, MT. The interpretive maps and cross sections were generated by petroleum geologists and members of the Montana Geological Society (formerly Billings Geological Society) during the last half of the 20th century. Most depict various aspects of geology related to oil and gas prospects. Some may be published in Montana or Wyoming Field Conference Guidebooks; others are unpublished.

[Learn More >](#)

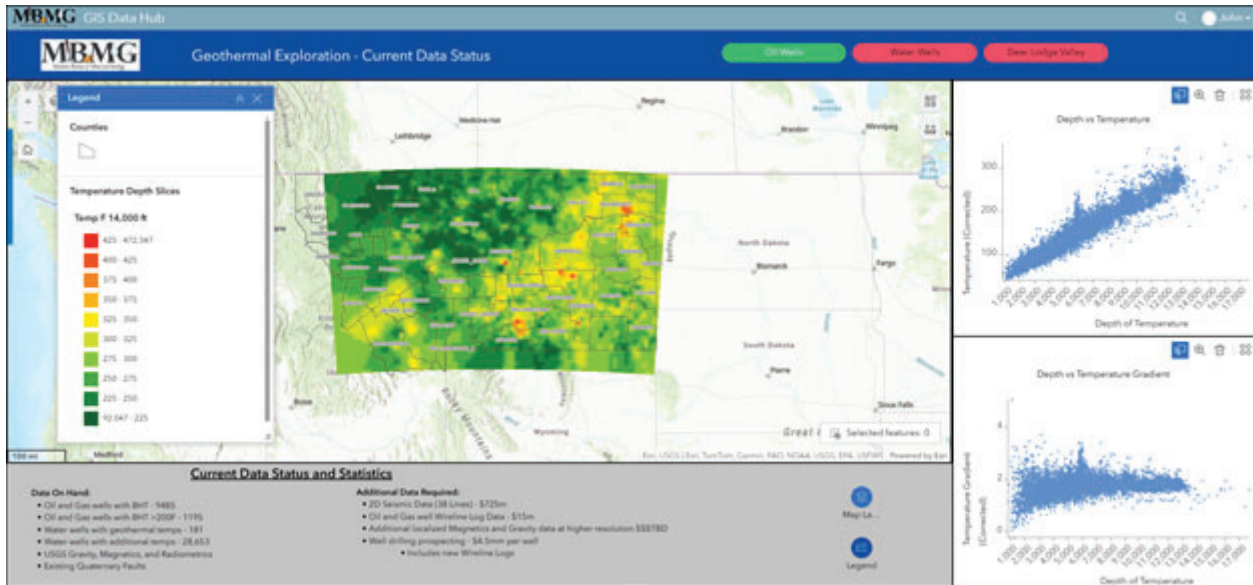
Time Span
1932 to 1985
[View Timeline](#)

Top Subjects
Geologic Map Contour Map Cross Section
Location Map Well Location Map

The CollectionBuilder interface simplifies accessing digital collection objects and metadata.

GIS LABORATORY

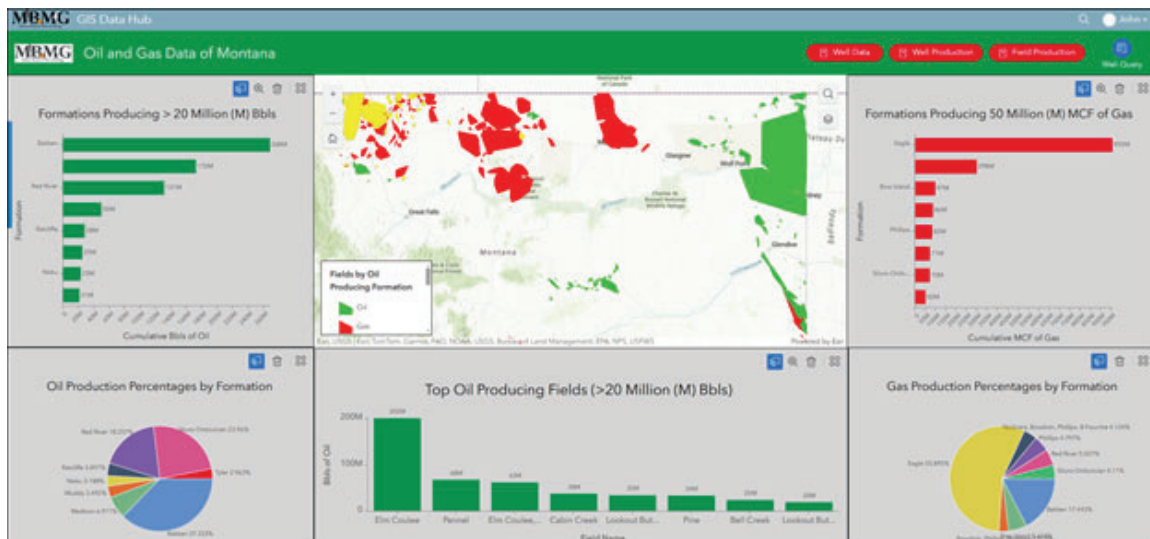
The MBMG has long had large and complex databases of geologic and hydrogeologic data. The focus for 2024 and beyond is to make sure all those data are not just available in tabular fashion, but also spatially in GIS format. Translation of our data into ArcGIS Enterprise level databases began in February 2022, and we have made significant strides in spatializing data that were otherwise only available in tables.



Geothermal analytical web application.

The goals of data spatialization, the enterprise data management process, and modernization are to facilitate the creation of 2D maps, 3D maps, and statistical and analytical dashboards that will better visualize the MBMG data. Datasets are easier to understand when presented visually, whether as maps, charts, or graphs. As of 2024 the GIS staff have built 34 public web applications, have 13 web applications in development. These web applications are in both 2D and 3D space.

Part of the modernization process is to provide easier access to our maps, apps, and data. Released in 2022 and in continued development is the MBMG's GIS Open Data Hub Site. It is built on the ArcGIS Hub Site platform. This is a new section that is accessed from our current MBMG website. It is a hub of all things GIS for the MBMG, the one-stop shop for all web maps, analytical dashboards, and story maps, along with direct download access to the MBMG GIS data.



Oil and gas dashboard application.

ANALYTICAL LABORATORY

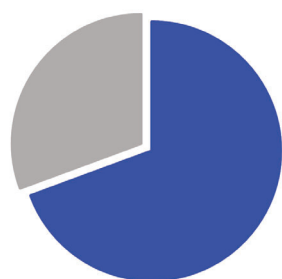
The MBMG Analytical Laboratory conducts analytical method development and sample analyses in support of research conducted by MBMG programs. Although the lab is licensed by the State of Montana–Department of Health and Human Service to analyze drinking water supplies, we typically do not perform analyses for the general public. Our QA/QC program meets criteria established by the U.S. Environmental Protection Agency, as well as the U.S. Geological Survey.

The lab has inorganic and organic analytical capabilities. The inorganic lab routinely determines major anions, cations, trace metals, selected rare earth metals, selected isotopes, alkalinity, pH, and radon. The primary focus of the organic lab is the determination of acidic compounds, polynuclear aromatic compounds, and extractable petroleum hydrocarbons in waters and soils. All groundwater data obtained by the lab are reported in the GWIC database. In addition to supporting the numerous research projects and ongoing monitoring by MBMG programs, the Analytical Lab works closely with Montana Tech and other universities within the Montana University System (MUS) to provide analyses to both graduate and undergraduate research. Available instrumentation includes:

- Thermo Scientific iCAP Q inductively coupled plasma/mass spectrometer (ICP/MS) for trace metal analyses
- Thermo Scientific iCAP 6000 Series inductively coupled plasma optical emission spectrometer (ICPOES) for determining major cations
- Thermo Scientific ISQ 7000 VPI gas chromatograph with mass spectrometer detector (GC/MS) for organic compounds and extractable hydrocarbons
- Two Metrohm Compact IC Plus instruments for anion analyses
- Metrohm Robotic Titrator for measuring pH, conductivity, and alkalinity
- Picarro Isotopic Water Analyzer, L2130-I for water isotope analysis
- Picarro $\delta^{13}\text{C}$ High-Precision Isotopic carbon dioxide (CO_2) analyzer, G2131-I for ^{13}C isotopic analysis of CO_2 in water; a Costech Combustion Module was added to the Picarro G1231-I to allow for ^{13}C isotopic analyses of solid samples
- Aurora 1030 West Oxidation TOC Analyzer for analyzing organic and inorganic carbon in water samples

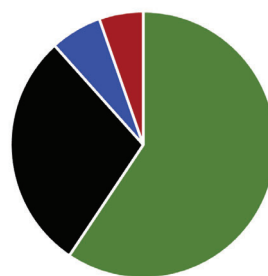
Over the past 2 years the MBMG Laboratory has analyzed thousands of samples, both from MBMG projects and research efforts at Montana Tech and other MUS schools. The graphs below show comparisons of total samples received per year, the number of samples that are for MBMG projects vs. non-MBMG research, and research samples coming from Montana Tech vs. other MUS schools.

FY2023 TOTAL SAMPLES (1094)



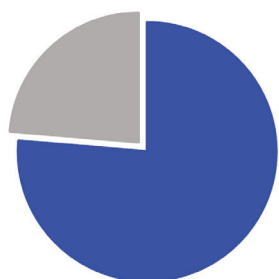
■ MBMG ■ NON-MBMG

FY2023 NON-MBMG SAMPLES



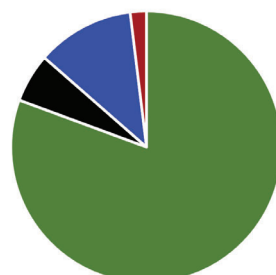
■ MT TECH ■ WESTERN ■ MSU ■ UM

FY2024 TOTAL SAMPLES (1174)



■ MBMG ■ NON-MBMG

FY2024 NON-MBMG SAMPLES



■ MT TECH ■ WESTERN ■ MSU ■ UM

MINERAL MUSEUM

The Mineral Museum on the Montana Tech campus began with the purchase of 177 specimens within 6 months of the founding of the Montana School of Mines, in 1901. Today, the MBMG curates over 12,000 specimens from all over the world, with new acquisitions every year.

The Mineral Museum @ Montana Tech is undergoing a major renovation. A major goal of this renovation is to preserve the geoheritage of the Museum space itself and enhance the lighting and security of the displays and enliven the visitor experience. The renovation started with abatement of the asbestos tile floors revealing the original flooring. Much to everyone's delight, the maple hardwood floors stood intact. After refinishing, the floors significantly brighten the space. The display of the collection has also transformed. Several heritage cases were hoisted down from the balconies to the main floor and refurbished with new lighting and security. The popular ultraviolet display is being redone and the stage once used for campus-wide events is functional once again to support gatherings in the Museum space.



Heritage mineral case being moved from the balcony to the main floor of the museum space. Photo by S. Quane.



The Mineral Museum @ Montana Tech before (left) and during (right) the current renovation. Photos by S. Quane.



Museum space prior to 1979 when it was used as both Mineral Museum and auditorium. Photos from Mineral Museum archives (colorized by S. Quane).

full-time Museum Director in late 2022. The Museum holds several public events and open houses throughout the year.

The beautiful collection not only holds amazing scientific information, but also the interesting and inspiring stories of the colorful people involved in the collection over the past 125 years. We invite you to come hear these stories and create new ones for yourselves. Museum admission is always free and open to the public.

Despite closure for renovation (January–May 2024) and major construction on campus limiting Museum access (May–September 2024), our visitation stayed consistent. This biennium the Museum hosted approximately 9,100 visitors, including 88 tour groups. In addition, Mineral Museum staff attended the Denver and Butte Mineral shows. Over this biennium, the Mineral Museum accessioned 50 new specimens, including a collection of over 7,000 microminerals from Montana, further building out the mineral collection.

The Mineral Museum @ Montana Tech and its collection are wholly owned by Montana Technological University. Since its inception in 1969, the Montana Bureau of Mines and Geology has been responsible for the operation of the Mineral Museum and curation of the mineral collection under the direction of the Montana State Geologist. The museum and mineral collection remain a resource for courses offered at Montana Tech. The MBMG hired its first



"Boris" the Siberian Cave Bear in his new home. Photo by S. Quane.



Minerals displayed in new cases obtained during the renovation. Photo by S. Quane.

INFORMATION SERVICES

The Information Services Division is responsible for creating, editing, and distributing MBMG publications and reports to the public, both through our Publication Sales office and the MBMG's website. Visit the MBMG site, <http://www.mbmgt.mtech.edu>, or come see us in the Natural Resources Building.

New publications in this biennium:

Analytical Datasets

- AD 1, Major oxide and trace element analyses of rock samples collected in the Dillon and Wisdom 30' x 60' quadrangles, southwest Montana, Mosolf, J.G., Hanson, A.E.H., McDonald, C., Parker, S., and Scarberry, K., 2023
- AD 2, Major oxide and trace element analyses of rock samples collected in the Dillon and Hamilton 30' x 60' quadrangles, southwest Montana, Mosolf, J.G., Brennan, D.T., Gavillot, Y., Parker, S., and Sears, J. 2023
- AD 3, U-Pb geochronology data from rock samples collected in the Dillon, Hamilton, Philipsburg, Townsend, and Wisdom 30' x 60' quadrangles, western Montana, 2020-2021, Mosolf, J.G., and Kylander-Clark, A., 2023
- AD 4, U-Pb geochronology data from rock samples collected in the Dillon and Wisdom 30' x 60' quadrangles, western Montana, 2021-2022, Mosolf, J.G., and Kylander-Clark, A., 2023
- AD 5, U-Pb geochronology data from rock samples collected in the Dillon, Ennis, Gardiner, Hamilton, Hebgen Lake, Lima, and Wisdom 30' x 60' quadrangles, western Montana, 2022-2023, Mosolf, J.G., Brennan, D.T., and Kylander-Clark, A., 2023
- AD 6, Preliminary data release of whole-rock assays from Phosphoria-related entities in southwest Montana, Van Rythoven, Adrian, 2023
- AD 7, Preliminary data release of whole-rock assays from active and inactive mines in southwest Montana, Van Rythoven, A., Scarberry, K., and Eastman, K., 2023
- AD 8, Preliminary data release of whole-rock assays of coal-related deposits in central and eastern Montana, Davison, Ryan, 2024
- AD 9, Major oxide and trace element analyses of rock samples collected in the Dillon 30' x 60' quadrangle, southwest Montana, 2019-2020, Mosolf, J.G., and McDonald, C., 2024
- AD 10, Preliminary data release of whole-rock assays from active and inactive minerals and metal mines in southwest Montana, Van Rythoven, A., Scarberry, K., and Eastman, K., 2024
- AD 11, Preliminary data release of whole-rock assays from rare earth and niobium deposits in Ravalli County, Montana, Van Rythoven, A., Scarberry, K., and Risedorf, S., 2024

Bulletins

- B 142, Quaternary slip rates and most recent surface rupture of the Bitterroot fault, western Montana, Gavillot, Y., Lonn, J., Stickney, M., and Hidy, A., 2023

EDMAP

- EDMAP 15, Geologic map of the Carpp Ridge 7.5' quadrangle, southwestern Montana, Neal, B.A., Burrell, W.B., Laskowski, A.K., and Lonn, J.D., 2023
- EDMAP 16, Geologic map of the eastern half of the Melrose 7.5' quadrangle and the western half of the Wickiup Creek 7.5' quadrangle, southwestern Montana, Rone-mus, C.B., and Orme, D.A., 2023

Fact Sheets

- FS 2, Critical mineral commodity potential in the Butte Mining District, Duaine, Ted, 2023
- FS 3, Critical mineral: Tantalum, Van Rythoven, Adrian, 2023
- FS 4, Geohazards research at the Montana Bureau of Mines and Geology, Stickney, M., and Rossi, A., 2023
- FS 5, Critical mineral: Germanium, Davison, R., and Van Rythoven, A. 2023
- FS 6, Critical mineral: Lutetium, Davison, R., and Van Rythoven, A., 2023
- FS 7, Critical commodity research in western Montana, Scarberry, K., and Eastman, K., 2023
- FS 8, Critical mineral: Zinc, Van Rythoven, Adrian, 2023
- FS 9, Mineral deposits of Beaverhead County, Montana, Eastman, Kyle, 2023
- FS 10, Critical mineral: Ytterbium, Davison, R., and Van Rythoven, A., 2023
- FS 11, Critical mineral: Yttrium, Davison, R., and Van Rythoven, A., 2023
- FS 12, Critical mineral: Gallium, Van Rythoven, Adrian, 2023
- FS 13, Critical mineral: Graphite, Davison, R., and Van Rythoven, A., 2023
- FS 14, Critical mineral: Thulium, Davison, R., and Van Rythoven, A., 2023
- FS 15, Critical mineral: Indium, Van Rythoven, Adrian, 2023

Information Services Statistics

Publication Sales:

- 716 titles sold
- 7,474 items sold
- 88 items published/released

Data downloaded:

- 2,250 titles
- 362,190 files

- FS 16, Ground Water Assessment Program: Characterizing Montana's Aquifers, July 2023, MBMG, 2023
- FS 17, Critical mineral: Erbium, Davison, R., and Van Rythoven, A., 2023
- FS 18, MBMG STATEMAP Program 2023, MBMG, 2024
- FS 19, MBMG Legislative Update 2023 MBMG, 2024
- FS 20, Critical mineral: Holmium, Davison, R., and Van Rythoven, A., 2024
- FS 21, Critical mineral: Cobalt, Van Rythoven, Adrian, 2024
- FS 22, Critical mineral: Dysprosium, Davison, R., and Van Rythoven, A., 2024
- FS 23, Critical mineral: Niobium, Van Rythoven, Adrian, 2024
- FS 24, Data Preservation Program, Herman, Denise, 2024
- FS 25, Critical mineral: Nickel, Van Rythoven, Adrian, 2024
- FS 26, Critical mineral: Terbium, Davison, R., and Van Rythoven, A., 2024
- FS 27, Critical mineral: Gadolinium, Davison, R., and Van Rythoven, A., 2024
- FS 28, Critical mineral: Platinum, Van Rythoven, Adrian, 2024
- FS 29, Critical mineral: Palladium, Van Rythoven, Adrian, 2024

Geologic Maps

- GM 84, Quaternary fault map of Jefferson County, southwest Montana, Gavillot, Yann G., 2022
- GM 85, Landslide inventory and slope map of Jefferson County, southwest Montana, Gavillot, Yann G., 2022
- GM 86, Geologic map of the Odell Lake 7.5' quadrangle, southwestern Montana, Lonn, J.D., and Scarberry, K.C., 2022
- GM 87, Geologic map of the Pine Hill 7.5' quadrangle, southwest Montana, Elliott, Colleen G., 2022
- GM 88, Geologic map of the Beaverhead Rock area, east 1/3 Block Mountain through west 2/3 Beaverhead Rock 7.5' quadrangles, southwest Montana, Yakovlev, Petr V., 2022
- GM 89, Geologic map of the Dillon East 7.5' quadrangle, Beaverhead County, Montana, McDonald, Catherine, 2022
- GM 90, Geologic map of the Bond 7.5' quadrangle, Beaverhead County, Montana, McDonald, Catherine, 2022
- GM 91, Geologic map of the Dillon West 7.5' quadrangle, Beaverhead County, Montana, McDon-

ald, C., and Mosolf, J.G., 2023

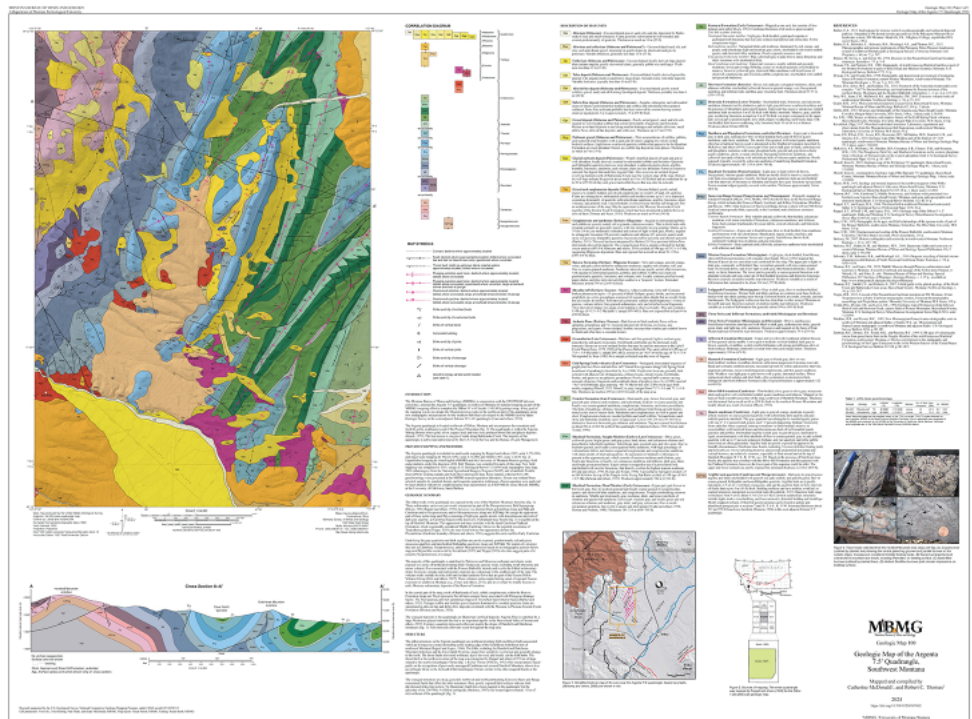
- GM 92, Geologic map of the Hubbard Reservoir 7.5' quadrangle, Flathead and Sanders Counties, Montana, Scarberry, Kaleb C., 2023
- GM 93, Geologic map of the Kofford Ridge 7.5' quadrangle, Flathead and Sanders Counties, Montana, Scarberry, K.C., McDonald, C., and Coppage, E.L. 2023
- GM 94, Geologic map of the Big Hole Pass 7.5' quadrangle, southwestern Montana and eastern Idaho, Lonn, J.D., Elliott, C.G., Burmester, R.F., and Lewis, R.S., 2024
- GM 95, Geologic map of the Red Canyon 7.5' quadrangle, Beaverhead and Madison counties, Montana, Mosolf, J.G., and Sears, J., 2024
- GM 96, Geologic map of the Burns Mountain 7.5' quadrangle, Beaverhead County, Montana, Mosolf, Jesse G., 2024
- GM 97, Geologic map of the Big Hole Battlefield 7.5' quadrangle, southwestern Montana, Elliott, Colleen G., 2024

Ground-Water Atlas Series

- GWAA 8-05, Potentiometric surface in the Madison, Upper Jefferson, Beaverhead, Big Hole, and Ruby River Valleys within Madison County, southwest Montana, Madison, James P., 2023
- GWAA 9-01, Hydrogeologic framework of the upper Yellowstone River Valley, Park County, Montana, Edinberg, Sara C., 2024

Information Pamphlets

- IP 14, Groundwater/surface-water study in the Upper Jefferson Valley, Montana: Modeling the effects of changing irrigation practices and increased residential development on low streamflows, Bobst, A., Gebriel, A., and Dohman, J., 2023



Geologic Map 100 from the MBMG.

Montana Bureau of Mines and Geology

- IP 15, Sources of salinity to the Musselshell River: Executive summary, Meredith, E., Smith, M., and Kuzara, S., 2023
- IP 16, Groundwater recharge in flood to pivot irrigation conversions, Kuzara, Shawn, 2023
- IP 17, Groundwater inputs to rivers and streams: Using temperature and visual cues on the Big Hole River, southwestern Montana, Dohman, J.M., and Hanson, A.E.H., 2024

Memoirs

- M 69, Estuarine deposits in the Kootenai Formation as evidence of an early Cretaceous (pre-Albian) marine advance into western Montana and relationship to Cordilleran foreland basin evolution, Schwartz, R.K., and Vuke, S.M., 2019

Open-File Reports

- MBMG 750, Aquifer tests completed in the Upper Gallatin River Valley, Big Sky, Montana, Rose, James, 2022
- MBMG 751, Butte Mine Flooding Operable Unit water-level monitoring and water-quality sampling, 2021 consent decree update, Butte, Montana, 1982-2021, Duaime, T.E., McGrath, S.F., and Icopini, G.A., 2022
- MBMG 752, An evaluation of the unconsolidated hydrogeologic units in the south-central Flathead Valley, Montana, Bobst, A., Rose, J., and Berglund, J., 2022
- MBMG 753, MBMG earthquake catalog, January 1982-August 2015, Stickney, M.C., 2022
- MBMG 754, Aquifer test completed in the northern Bitterroot Valley, Lolo, Montana, Myse, Todd, 2022
- MBMG 755, Investigation of the inorganic groundwater quality in the West Yellowstone Basin, Gallatin County, Montana, Hanson, A.E.H., and English, A.R., 2023
- MBMG 756, Hydrogeologic investigation of the Belgrade-Manhattan area, Gallatin County, Montana: Superposition groundwater modeling report, Sutherland, Mary, 2023
- MBMG 757, Analyses of three constant-rate aquifer tests, East Flathead Valley, northwest Montana, Myse, T., Bobst, A., and Rose, J., 2023
- MBMG 758, Standard procedures and guidelines for field activities, Montana Bureau of Mines and Geology, Version 2, Gotkowitz, M.B., ed., 2023
- MBMG 759, Groundwater quantity and quality near Hamilton, Montana, Myse, T., and Hanson, A.E.H., 2023
- MBMG 760, Hydrogeology and irrigation potential of the West Crane aquifer, Richland County, Montana, Reiten, J., and Chandler, K., 2023
- MBMG 761, Butte Mine Flooding Operable Unit: Forty years of water-level monitoring and water-quality sampling, 2022 consent decree update, Butte, Montana 1982-2022, Duaime, T.E., McGrath, S.F., and Icopini, G.A., 2023
- MBMG 762, Groundwater and surface-water interaction in Rock Creek Valley between Red Lodge and Rockvale, Carbon County, Montana, Kuzara, Shawn, 2024

- MBMG 763, Analyses of constant-rate aquifer tests in the Quaternary–Tertiary basin-fill sediments and the Tertiary–Archean fractured bedrock near Ennis, Montana, Hanson, A.E.H., and Sutherland, M., 2024
- MBMG 764, Three aquifer tests in the Tobacco Valley, near Eureka, Montana, Bobst, Andrew, 2024

Miscellaneous Contributions

- MC 25, Final Technical Report for NGWMN Award G20AC00187, LaFave, John I., 2024

Miscellaneous Publications

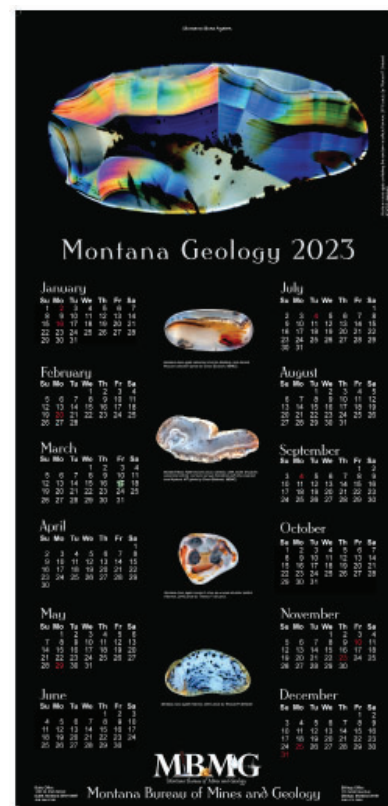
- MISC 71, 2023 MBMG Calendar: Montana Moss Agate, Icopini, Gary, 2022
- MISC 72, 73, 74, Montana Geologic Map Puzzle, MBMG, 2023
- MISC 75, 2024 Calendar: The Hebgen Lake Earthquake and Madison Slide, Sitckney, Michael, 2023

Reports of Investigation

- RI 31, Manganese concentrations in Montana's groundwater, Hanson, A.E.H., and LaFave, J.I., 2022
- RI 32, Hydrogeologic investigation of the deep alluvial aquifer, Flathead Valley, Montana, Rose, J., Bobst, A., and Gebril, A., 2022
- RI 33, Developing a sulfate-isotope fingerprint of acid mine drainage to identify underground controls on groundwater flow paths, Gammons, C., and Kuzara, S., 2022
- RI 34, Morphology of sapphires from secondary deposits, southwestern Montana, Berg, Richard B. 2022
- RI 35, Sources of salinity to the Musselshell River, Musselshell County, Montana, Meredith, E., and Kuzara, S., 2023

Special Publications

- SP 124, Proceedings of the Montana Mining and Mineral Symposium 2023, Van Rythoven, A., and Barth, S., eds., 2024



COMMITTEES

The Montana Bureau of Mines and Geology endeavors to provide sound scientific maps and reports for use by many segments of society. An important component of our activities is the decision process to determine topics and geographic areas of our research; advisory groups and steering committees are critical to that process. The MBMG gratefully acknowledges the many individuals and agencies who participate on these committees.

Advisory Committees

Ground Water Assessment Program and Ground Water Investigation Program Steering Committee

VOTING MEMBERS

Mr. Attila Felnagy, Department of Natural Resources
 Mr. Chris Boe, Department of Environmental Quality
 Mr. Brett Heitshusen, Department of Agriculture
 Mr. Troy Blandford, Montana State Library, Natural Resources Information System

EX OFFICIO MEMBERS

Governor Appointees

Mr. Walt Sales, Association of Gallatin Agricultural Irrigators, Bozeman—Agricultural water users
 Mr. Mark Thompson, Montana Resources Inc., Butte—Industrial water users
 Mr. Scott Brown, MT Salinity Control Assn., Conrad—Conservation or ecological protection organization
 Mr. Eugene (Igan) Graf IV, Developer, Bozeman—Development community

OTHER

Dr. Payton Gardner, Montana University System, appointed by the Board of Regents
 Mr. John LaFave Montana Bureau of Mines and Geology
 Mr. Jason Mohr, Legislative Services Division
 Mr. Ben Jones, Board of Oil and Gas Conservation
 Mr. Alden Shallcross, Bureau of Land Management
 Mr. Rodney Caldwell, U.S. Geological Survey
 Mr. Jeff Baumberger, U.S. Bureau of Reclamation
 Mr. Thor Burbach, USDA Forest Service
 Mr. Peter Brumm, U.S. Environmental Protection Agency
 Ms. Karin Hilding, City of Whitefish, appointee for Montana cities and towns

State Map Advisory Committee

Mr. Tim Bartos, U.S. Geological Survey
 Dr. John Childs, Childs Geoscience
 Mr. Steven J. Czehura, Applied Geological Services
 Dr. Chris Gammons, Montana Technological University
 Mr. James W. Halvorson, MT Board of Oil and Gas Conservation
 Mr. Scott Helm, Montana Dept. of Transportation
 Dr. Marc Hendrix, The University of Montana
 Mr. Mike Huffine, U.S. Forest Service
 Ms. Teresa Kinley, MT Dept. of Natural Resources and Conservation
 Dr. David Lageson, Montana State University
 Mr. Seth Makepeace, Confederated Salish and Kootenai Tribes
 Ms. Kari Scannella, USDA MT Natural Resources Conservation Service
 Mr. Dan Seifert, U.S. Forest Service
 Mr. Garrett Smith, Montana Dept. of Environmental Quality
 Mr. Robert Wintergerst, U.S. Forest Service

Yellowstone Controlled Ground Water Area Technical Oversight Committee

Mr. Attila Felnagy (chair), Department of Natural Resources and Conservation
 Mr. John Kilpatrick, U.S. Geological Survey
 Mr. Marvin Miller, Montana Bureau of Mines and Geology
 Mr. Jefferson Hungerford, National Park Service—Yellowstone National Park
 Mr. Kirk Waren, Montana Bureau of Mines and Geology (retired)

Data Preservation Committee

Ms. Mitzi Rossillion, Butte—Silver Bow Archives
 Mr. Dave Frank, U.S. Geological Survey
 Mr. Ted Antonioli, Consultant Geologist

The MBMG thrives on its interaction with citizens and agencies throughout Montana. Serving on various advisory committees and boards gives us an opportunity to learn about many issues facing the State and provide information on quite a range of topics. Committees on which MBMG members have served:

Anaconda RWWS Operable Unit: Groundwater Technical Review Committee

Association of American State Geologists Executive Committee

State Water Plan Basin Advisory Committees

Board of Environmental Review

Butte Citizens Technical Environment Committee

Butte Mine Flooding Public Education (Pit Watch)

Butte—Silver Bow Pre-Disaster Mitigation Plan Committee

Butte-Silver Bow Superfund Advisory and Redevelopment Trust Authority

Clark Fork Watershed Education Program

Coalbed Methane Protection Program

DNRC Technical Advisory Council on Coalbed Methane

Future Fisheries

Gallatin Local Water Quality District Board

Governor's Drought and Water Supply Advisory Committee's Monitoring Sub-committee

Montana Board of Water Well Contractors

Montana Geologic Society

Montana Mining Association

Montana Resources - Groundwater Modeling Working Group

Montana Section of the American Water Resources Association

Montana Water Center

Montana Watershed Coordination Council National Geologic and Geophysical Data Preservation Committee

National Ground Water Monitoring Network

Science Mine

Sheridan County Water Reservation Technical Advisory Committee

Subcommittee on Groundwater to the Advisory Committee on

Water Information (DOI)

Tobacco Root Geological Society

Western Montana Conservation Commission

Western States Seismic Policy Council

Williston Area Aquifer Models Consortium

Yellowstone Controlled Groundwater Area Technical Oversight Committee

Yellowstone Volcano Observatory Seismic Monitoring Team

MBMG GRANTS AND CONTRACTS

in effect during this biennium

Davidson, R., REEs in Coal in Central and Eastern Montana, U.S. Army Research Lab
Duaime, T., Butte Area Long Term Monitoring, Butte Silver Bow
Duaime, T., Stream Flow Monitoring, Montana Resources
Duaime, T., MR/ Drone Boat Modifications, Montana Resources
Duaime, T., Deep Bedrock Monitoring Well, Montana Resources
Duaime, T., Rare Earth Recovery Demonstration, West Virginia University
Duaime, T., REEs in Montana's Large-Scale Mine Wastes, U.S. Army Research Lab
Eastman, K., Radersburg/Earth MRI, U.S. Geological Survey
Eastman, K., Basin/Earth MRI, U.S. Geological Survey
English, A., YCGA Ground Water Area, U.S. Department of Interior–National Parks Service
English, A., NRCS Technical Assistance, U.S. Department of Agriculture–Natural Resource Conservation Service
Gavillot, Y., Quaternary Slip Rates, WY State Geological Survey
Gavillot, Y., Bitterroot Fault, U.S. Geological Survey
Gavillot, Y., Fault Displacement Hazard Mapping of MT, U.S. Geological Survey
Gavillot, Y., Earthquake Hazards Reduction, MT Disaster & Emergency Services
LaFave, J., Clear Lake Aquifer , Sheridan County CD
LaFave, J., MT National Groundwater Monitoring Network, U.S. Geological Survey
Metesh, J., Managed Aquifer Recharge in MT, MT Board of Investments
Metesh, J., Geothermal Resources for Power Generation in MT, MT Board of Investments
Mosolf, J., State Map, U.S. Geological Survey
Quane, S., Montana Geological Story, The Foundation for Montana History
Scarberry, K., Data Preservation, U.S. Geological Survey
Scarberry, K., Data Preservation - building, U.S. Geological Survey
Scarberry, K., Chadwick & Feeley Collection, U.S. Geological Survey
Stickney, M., Modernization of Seismic Network, MT Department of Natural Resources and Conservation
Stickney, M., Flathead Seismic Monitoring, Confederated Salish & Kootenai Tribes
Timmer, J., Montana Pole Analytical Services, MT Department of Environmental Quality
Van Rythoven, A., Sheep Creek/ Earth MRI, U.S. Geological Survey
Van Rythoven, A., Western Phosphate/ Earth MRI, Regents of the University of Idaho
Van Rythoven, A., AIM/ Earth MRI, U.S. Geological Survey
Van Rythoven, A., REE Investigation of the Phosphoria Formation, U.S. Army Research Lab
Van Rythoven, A., Critical Minerals in Montana's Abandoned Mine Lands, U.S. Army Research Lab

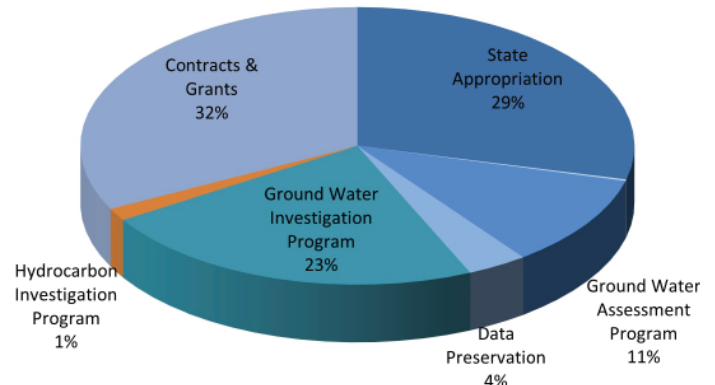
FINANCES

The Montana Bureau of Mines and Geology was established in 1919 to collect, interpret, and publish information on the geology of Montana. The main office is on the campus of Montana Tech in Butte and a second office is in Billings at 101 Grand Avenue. The MBMG comprises about 55 research professionals, 24 technical/clerical positions, and 5 to 10 students.

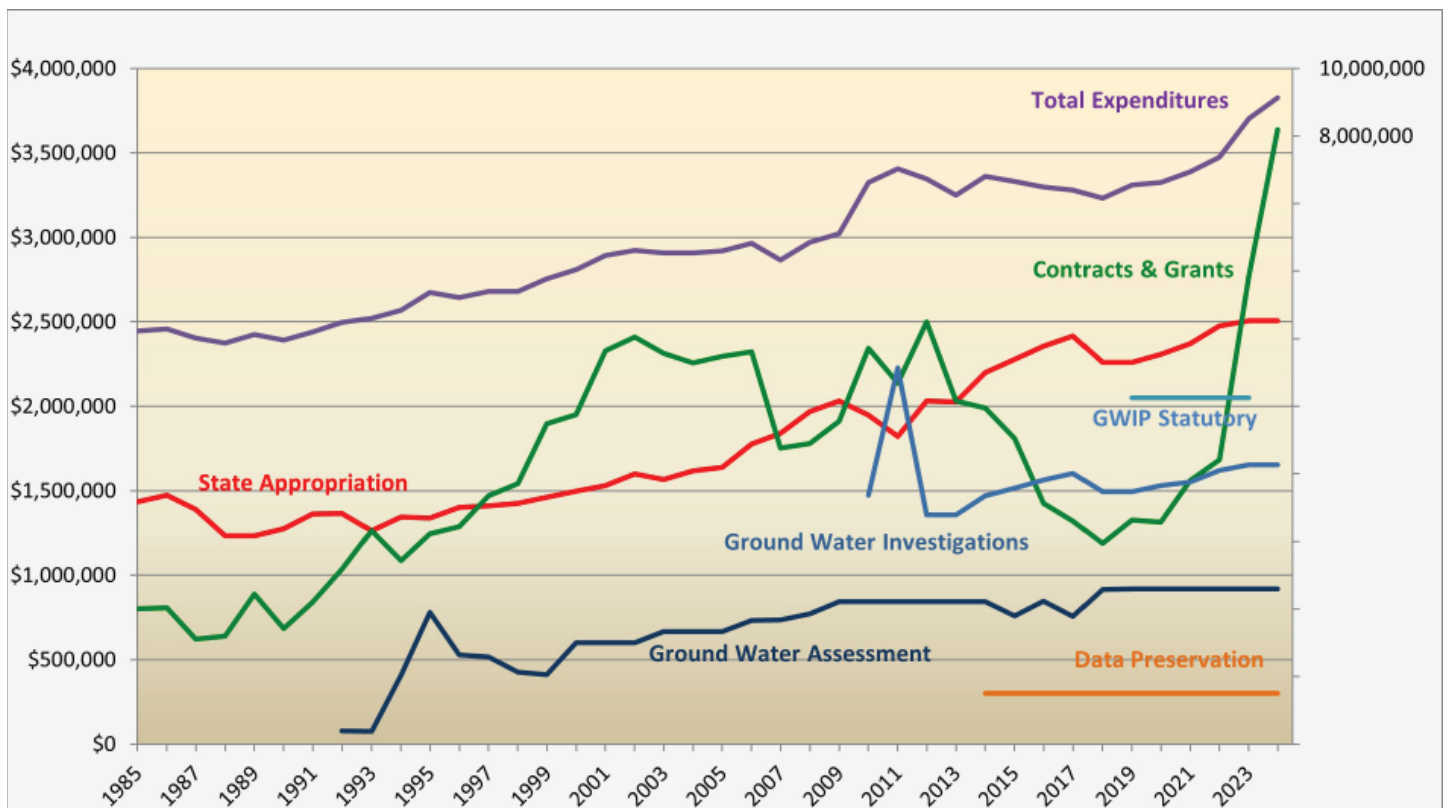
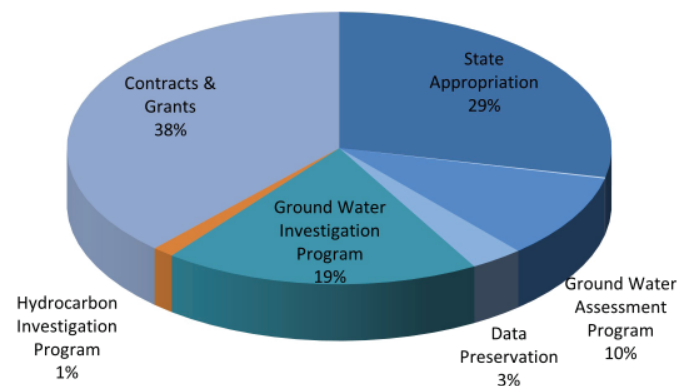
Funding for the past biennium came from seven categories: (1) a biennial appropriation from the State's general fund to maintain core programs; (2) a biennial appropriation from the State's general fund for the Ground Water Investigation Program; (3) a statutory appropriation for the Ground Water Investigation Program provided by the 2019 Legislature; (4) biennial appropriations from the State's special accounts for the Ground Water Assessment Program; (5) contracts and grants derived through agreements with a variety of Federal, State, and local organizations to address specific issues of mutual interest to the sponsoring organization and the MBMG; (6) income from sales of MBMG publications; and (7) Data Preservation.

The long-term trend for three of the four major sources of funding continues upward at a modest rate; the generosity of the Montana Legislature and Governor is reflected in the steady growth of the core geologic programs as well as the recent addition of the new groundwater program. Many of the projects under contracts and grants rely on partial state support (matching funds). Contracts and Grants, mainly from Federal funding, has shown significant growth in geologic mapping and critical mineral exploration.

FY 2023



FY 2024



MBMG STAFF

Director's Office

John J. Metesh, Professor, Director and State Geologist

John LaFave, Professor, Chief Research Division

Stacey Holms, Administrative Associate III

Accounting

Cassandra Welsh, Budget Analyst II

Data Center, GIS, and Computer Support

Simon Bierbach, Network/Computer Systems Admin I

Daniel Buckley, Professional Scientist, Data Scientist

Luke Buckley, Associate Professor, Data Scientist

Patricia Gallagher, GIS Specialist

Jeff Johnson, Computer Support Specialist III

Stacey Konda, Computer Software Engineer I

Bulbul Majumder, Computer Software Engineer I

Yiwen Li, Professional Scientist, GIS Specialist

John Sanford, Associate Professor, GIS Manager

Geology, Economic Geology, and Geologic Hazards

Jesse Mosolf, Professor, Senior Research Geologist/Program Manager

Richard Berg, Professor Emeritus, Geologist

Daniel Brennan, Assistant Professor, Mapping Geologist

Kyle Eastman, Assistant Professor, Economic Geologist

Colleen Elliot, Professor, Geologist, Professional Practice Faculty

Yann Gavillot, Associate Professor, Geologist

Jeffrey D. Lonn, Professor, Geologist

Catherine McDonald, Professor, Geologist

Stuart Parker, Assistant Professor, Geologist

Raymond Salazar, Professional Scientist, Geologist

Henry Stahl, Professional Scientist, Geologist

Michael C. Stickney, Professor, Director Earthquake Studies Office, Geologist

Adrian Van Rythoven, Associate Professor, Economic Geologist

Susan M. Vuke, Professor Emeritus, Geologist

Jarred Zimmerman, Assistant Professor, Economic Geologist



Information Services

Susan Barth, Assistant Professor, Chief Information Services Division, Publications Editor

Susan Smith, Geologic Cartographer

Analytical

Jacqueline Timmer, Assistant Professor, Chief Chemist

Ashley Huft, Chemist

Connie Thomson, Assistant Professor, Mineral Separation Laboratory Manager

Energy Resources and Eastern Montana Geology and Hydrogeology

Ryan Davison, Associate Professor, Geologist

Jay Gunderson, Professor, Geologist

Gary Hughes, Geologist

Shawn Kuzara, Associate Professor, Hydrogeologist

Elizabeth Meredith, Professor, Hydrogeologist

Jon C. Reiten, Professor Emeritus, Hydrogeologist

Matthew Smith, Professional Scientist, Hydrogeologist

Data Preservation and Mining Archives

Denise Herman, Data Research Analyst

Chelsea Pincock, Computer Software Engineer/Applications I

Anthony Roth, Map Technician

Mineral Museum

Steve Quane, Assistant Professor, Director Mineral Museum/MBMG Outreach Program

John Foley, Museum Assistant Curator

Groundwater

Ginette Abdo, Professor, Ground Water Investigation
Program Manager

Andrew Bobst, Professor, Hydrogeologist

Camela A. Carstarphen, Associate Professor,
Hydrogeologist

Cole Denver, Professional Scientist, Hydrogeologist

Jenna Dohman, Assistant Professor, Hydrogeologist

Sara Edinberg, Assistant Professor, Hydrogeologist

Alan English, Associate Professor, Hydrogeologist

Ali Gebril, Associate Professor, Hydrogeologist

Ann Hanson, Assistant Professor, Hydrogeologist

Alex Johanson, Hydrogeologic Field Assistant

Skye Keeshin, Professional Scientist, Hydrogeologist

James Madison, Associate Professor, Hydrogeologist

Donald C. Mason, Research Specialist

Marvin Miller, Professor Emeritus, Hydrogeologist

Todd Myse, Associate Professor, Hydrogeologist

Brett Oliver, Assistant Professor, Hydrogeologist

Mike Richter, Research Specialist

Tyler Storey, Hydrogeologist

Mary Sutherland, Assistant Professor, Hydrogeologist

Mark Wolfram, Professional Scientist, Hydrogeologist

Kurt Zeiler, Associate Professor, Hydrogeologist

Environmental Hydrogeology

Terence E. Duaime, Professor, Hydrogeologist,
Environmental Hydrogeology Manager

Michael Calhoun, Water Resource Specialist

Dalayna Christinson, Data Specialist

Katherine Herder, Data Specialist

Gary Icopini, Professor, Hydrogeologist

Steve McGrath, Analytical Chemist

Jackson Quarles, Professional Scientist, Hydrogeologist

John Roitz, Water Resource Technician

Matthew Vitale, Professional Scientist, Hydrogeologist

Retirees

Don Sasse, Assistant Professor, Hydrogeologist





Photo by Stacey Konda, MBMG.

Contact us:

Butte

1300 W. Park Street
Butte, MT 59701
Phone: 406-496-4180
Fax: 406-496-4451

Billings

1300 N. 27th Street
Billings, MT 59101
Phone: 406-657-2938
Fax: 406-657-2633

This report was created and printed by Publications staff of the Montana Bureau of Mines and Geology.

