UTAH GEOLOGICAL SURVEY

SURVEY NOTES

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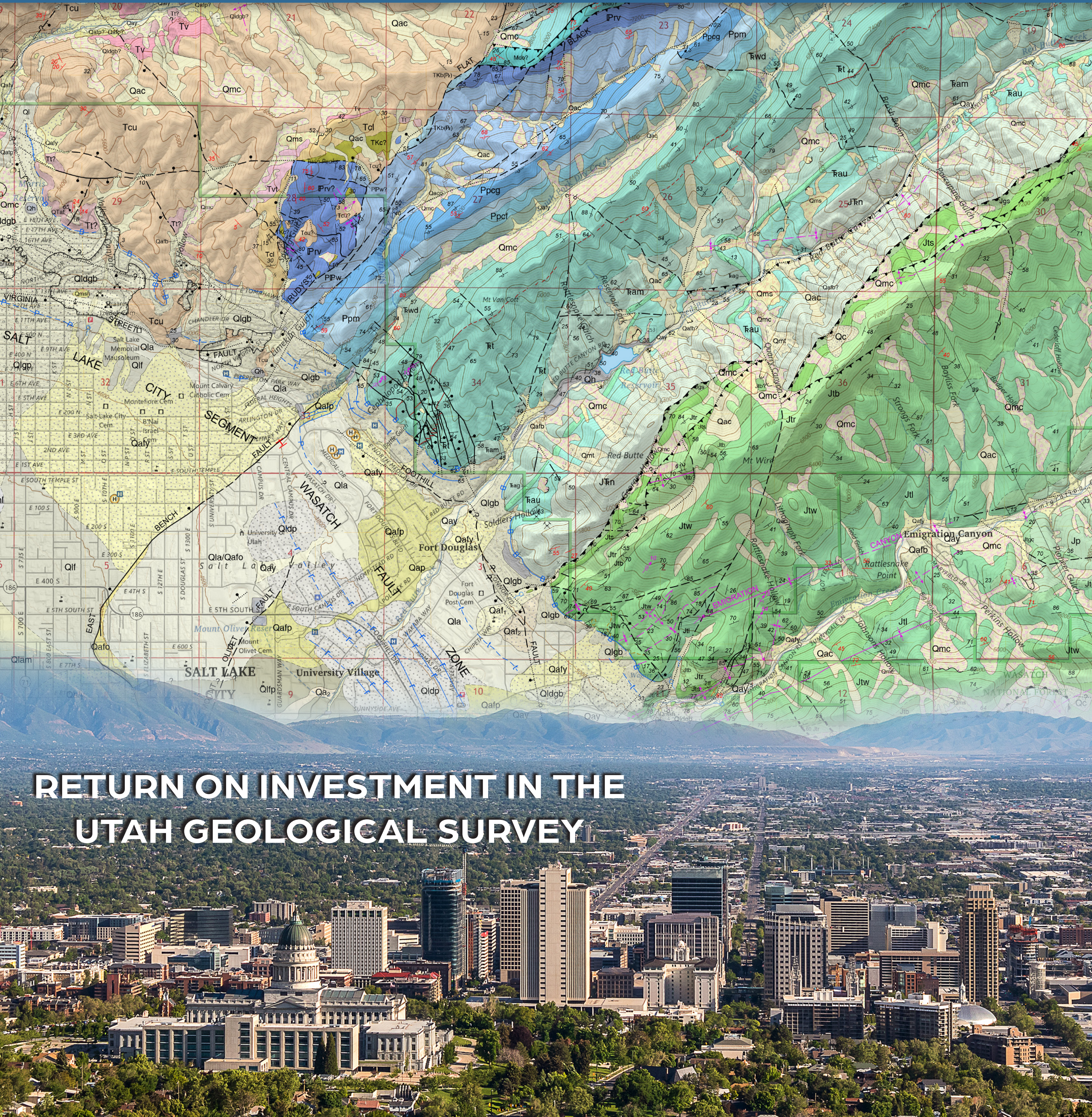

RETURN ON INVESTMENT IN THE UTAH GEOLOGICAL SURVEY

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Design | *John Good*

Cover | Part of the Fort Douglas 7.5-minute quadrangle geologic map, by Zachary W. Anderson, Adam P. McKean, and W. Adolph Yonkee and view to the south of downtown Salt Lake City from Ensign Peak (https://doi.org/10.34191/OFR-767).

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DIRECTOR'S PERSPECTIVE

by L. Darlene Batatian

The Utah Geological Survey (UGS) is part of a rich tradition of state geological surveys that dates back to the early frontier years of the United States—the first state geological survey, in North Carolina, was founded in 1823. Since their inception, state geological surveys have remained remarkably consistent in their primary responsibility of characterizing and cataloging geological and mineral resources. The need for these resources was so important to the early success of states that several state geological surveys were founded by the original 13 states more than 50 years prior to establishment of the federal geological survey (U.S. Geological Survey). This foundational task of identifying and inventorying earth resources directly relates to the UGS's statutory imperative to assist in the development of geological resources for the economic benefit of the state. Leveraging investments by state and federal funding, the UGS provides high-quality baseline and "precompetitive" geologic information, delivering a tremendous return on investment and added value, as demonstrated by several recent studies and summarized in Stefan Kirby's article in this issue of *Survey Notes*.

This issue also presents diverse topics from several of our programs including an article that highlights the role of historic mining districts as gateways to future critical mineral potential, focusing on the porphyry copper potential in the Gold Hill mining district in western Tooele County. The "Glad You Asked" article delves into native versus invasive phragmites and management challenges within wetlands and waterways. Our "News" section showcases updated mapping released for central Utah's active faults, covering parts of six counties—Garfield, Juab, Millard, Piute, Sanpete, and Sevier—that incorporates new mapping based on lidar data. These new fault maps provide a critical update to our understanding of active faults and earthquake hazards in the central Utah region, and can be used to build more resilient communities and protect the infrastructure that connects our state, ensuring a safer future for all Utahns.

The UGS continues to be wise stewards of our state and federal funds, delivering a high return on investment of our state and federal funding dollars as we deliver valuable and unbiased scientific data on Utah's geologic resources and hazards. Investment of state and federal dollars in the UGS allows us to research, delineate, publish and share geological resource information that guides informed decisions about Utah's resource development, spurs industry exploration, and makes Utah a safer and more prosperous state.

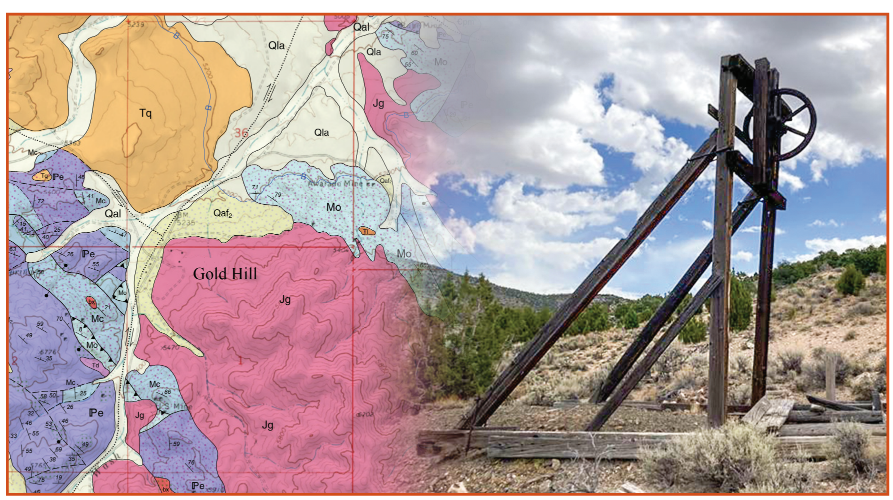


Image of the geologic map of the Gold Hill quadrangle, Tooele County, Utah, by James P. Robinson and abandoned entrance to a mine shaft in the Gold Hill mining district (https://doi.org/10.34191/M-301DR).

Return on Investment in the Utah Geological Survey

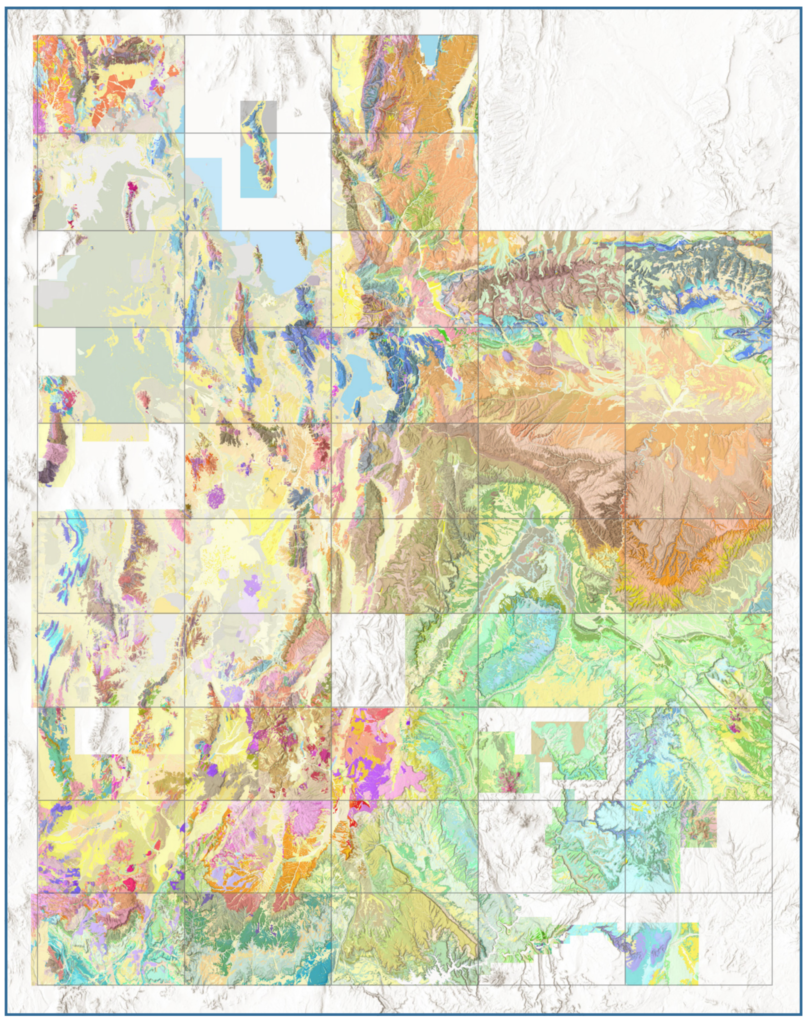
by Stefan Kirby, L. Darlene Batatian, Michael Vanden Berg, and Ben Dlin

The Utah Geological Survey (UGS) is Utah's "go-to" source for all geologic resources information. The data we collect has a wide variety of uses across entities ranging from all types of private industry to local, state, and federal government. Our research often forms the basis for important activity that drives the current and future economy of the state. As such, the information and data that we make readily accessible add significant value to the prosperity of the state of Utah, our industry, and our citizens. In this article, we provide insights from recent efforts to assess the value of geological data provided by state geological surveys.

Much of the data that the UGS provides to the public is considered "precompetitive," a term that refers to data (e.g., geological, geophysical, and geochemical data) that has been collected and consolidated by government or other agencies and made publicly available. This data is critical to reducing the risk for private industry investments into development and production of energy and mineral resources. Despite the importance of this data, only recently have attempts been made to quantify the relative value of precompetitive information provided by state geological surveys.

A recent publication prepared by the Nevada Bureau of Mines and Geology (NMBG) (https://pubs.nbmg.unr.edu/Nevada-Precompetitive-Data-Survey-2025-p/pds-2025.htm) quantified the importance of various types of precompetitive geological data to private sector users. Mineral and energy data users were surveyed about the relative importance and value of different types of geological resource data. The survey results indicate that geologic mapping in particular, along with geochemical and geophysical data, ranked highest for data published by state geologic surveys. The study shows the importance of state geological surveys continuing to deliver baseline, precompetitive data that are fundamental to exploration investment, current and future resource development and economic growth. The State of Utah's investment in the UGS helps our state accelerate our competitive edge.

Nearly all development, from real estate to energy, minerals, and water resources, begins with a geologic map. Maps of the location, character, and extent of energy and mineral resources and hazards were part of the earliest work produced at the UGS, and have been vital to the Survey's mission throughout its history. A team of specially trained scientists and GIS cartographers invest a significant amount of time to create and publish a modern geologic map, with the total staff time and cost dependent on the scale of the map and complexity of the geology. For example, a 1:24,000-scale, 7.5-minute quadrangle map covers over 45 square miles and takes approximately 1 year of staff time to complete and publish. Utah has over 1,400 maps of this scale, and around 75 of these have been published that meet modern standards for scientific and data quality. These maps are particularly valuable for real estate and commercial development, providing information on bedrock and soils, geologic hazards, and groundwater supply. Maps that cover larger areas, such as 1:100,000-scale (intermediate scale) maps, often involve mapping highly complex geology and thus can take 4 to 6 years of staff time. Intermediate scale maps are particularly valuable for energy and mineral resource development and assessment of regional-scale development opportunities. Because this foundational mapping is so important to industry and government, the State and various Federal agencies have invested in these products over the history of the UGS.

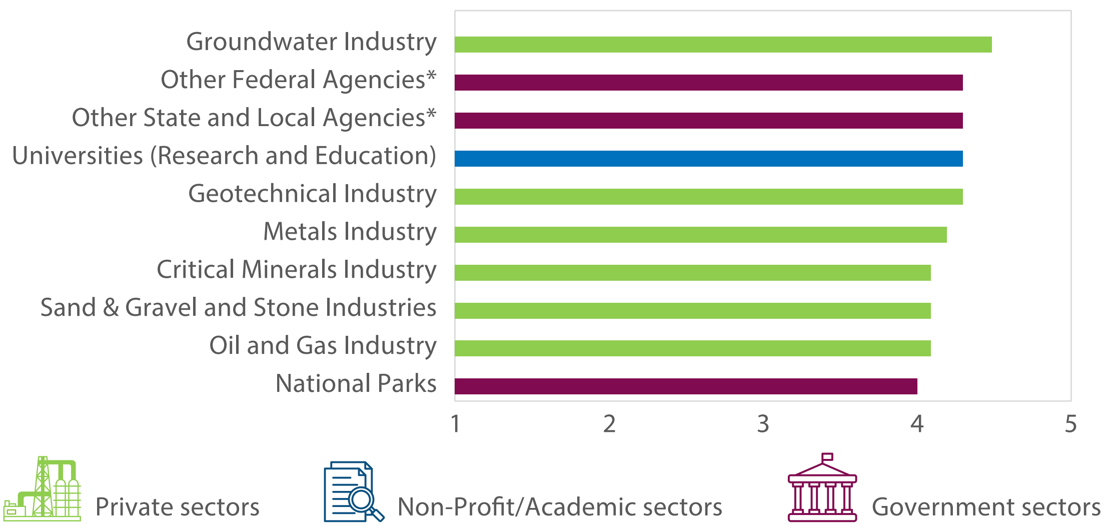


Map of Utah showing completed intermediate-scale geologic mapping.

Although the value and importance of geologic mapping has been recognized in resource development and other economic uses, few efforts have directly analyzed the return on investment (ROI) of geologic maps relative to various economic output. A recent economic analysis published by the American Geoscience Institute (AGI) (https://profession.americangeosciences.org/reports/geological-mapping-economics/) is the first to quantify estimates of the ROI for geologic mapping across the United States. The analysis is based on 4,779 survey responses from data users in all 50 states, by individuals in both public and private sectors across a swath of industries including transportation, real estate development and construction, water supply and storage, oil, gas, and minerals exploration, land planning, environmental consulting, waste disposal, planning, and various other uses. The results demonstrate high ROI for geologic maps, with ratios ranging from 7:1 to potentially as high as nearly 100:1 in urbanizing areas that have significant infrastructure value. This means that for every dollar invested in an average geologic map, at least seven dollars are added to the economy. In areas of significant infrastructure and resources such as urban areas or specific mineral deposits, the ROI ratio can be up to $100 of economic output for every dollar spent on geologic mapping.

> "The results demonstrated high ROI for geologic maps, with ratios ranging from 7:1 to potentially as high as nearly 100:1, in urbanizing areas that have significant infrastructure value."

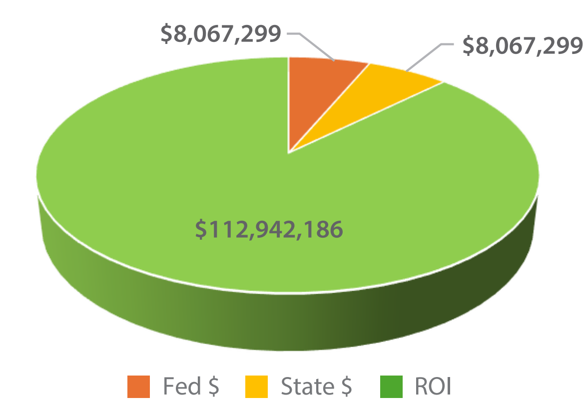
Value of Geologic Maps For Various Public and Private Entities
(Ranked 1–5)



*Other Federal, State, and Local Agencies are those that are not geological surveys (e.g., planning commissions).

The value of geologic maps to national survey respondents as reported in the 2025 AGI publication* Economic Analysis of the Costs and Benefits of Geological Mapping in the United States of America from 1994 to 2019, *edited by Richard C. Berg and James E. Faulds.

Cumulative ROI of Geologic Mapping



Federal and State dollars invested in geologic mapping by the Utah Geological Survey (orange, red) and resulting ROI dollars (green) contributed to the Utah economy assuming the lowest estimated ROI of 7 to 1.

Intangible benefits were also collected in the AGI report. When asked to comment on the benefits of geological maps and analyses provided by state geological surveys, stakeholders repeatedly mentioned "time and cost savings, assistance in resource exploration and development, general education, geological research, filling information gaps, enhancing decision making including planning, providing credibility, furnishing accurate and unbiased information, and affording context to site specific work." Importantly, mean cost-benefit for each U.S. region was calculated, and the Intermountain West region yielded the highest scores.

Case studies from the UGS's Energy and Minerals Program illustrate very high ROI on energy resources research. Utah has significant untapped geothermal resources across the state, most notably in the west desert, and the UGS has been actively exploring and characterizing these resources for over 60 years. Recently, the UGS was part of a team of scientists, led by the Energy & Geoscience Institute (EGI) at the University of Utah, whose research ($16 million total, $1.7 million to UGS) led to the selection of Utah as the host for the national Frontier

Observatory for Research in Geothermal Energy (FORGE) site. The success of the FORGE project yielded total research funding, administered by EGI, of over $300 million, resulting in an ROI of nearly 20:1 of the original investment in basic geothermal research. Building on the success of FORGE, Fervo Energy is investing up to $1 billion in the planned 500 megawatt Cape Station enhanced geothermal power station, multiplying the ROI even more. Given that Utah has abundant untapped geothermal resources, future research investment could be both a boon for rural development and for meeting Utah's energy abundance strategy.

Over the past 30 years, the UGS has helped secure over $40 million in federal oil/gas research grants. In 2018, the UGS and partners at EGI at the University of Utah secured a $10 million Department of Energy (DOE) grant to research the emerging Cane Creek shale play in the northern Paradox Basin. The project teamed up with Zephyr Energy to drill a vertical research well that included the recovery of 100+ feet of core from the Cane Creek interval. As highlighted in a recent DOE press release, "The [Zephyr] team used the results of the [UGS/EGI] studies to design two horizontal wells…the more recently developed State 36-2R well is projected to have an estimated ultimate recovery of up to 6 billion cubic feet of gas and 160,000 to 240,000 barrels of condensate. The success of the project and the State 36-2R well marks an important step forward in unlocking the potential of the Paradox Basin and offers a model for approaching the development of other complex, unconventional resource plays."

In 2012, the UGS's Energy and Minerals team received a $1 million+ DOE grant to investigate tight oil potential in the lower Green River Formation (GRF). Fast forward 10+ years and drilling in the lower GRF has led to a doubling of Utah's oil production (to 70+ million barrels per year). Building on this success, the UGS continues to research new plays in the Uinta Basin (e.g., Flagstaff, Mancos), as well as enhanced oil recovery opportunities and CO_2 storage possibilities. Much of this research success was the result of studying the extensive core collection at the Utah Core Research Center (UCRC) which holds over 75 miles of core representing about $10 billion worth of investment in Utah's natural resources. This collection not only benefits UGS research, but is extensively used by Uinta Basin operators (9 different companies visited the UCRC in 2025 to view core) to further understand the basin's remarkable hydrocarbon resource and spur continued development.

As the case studies show, the UGS's geologic mapping, energy and mineral research and precompetitive data have a high return on investment for the state of Utah. The work we perform with state and federal funding will continue to focus on our statutory mission to research, delineate, publish, and share geological resource information that guides informed decisions about Utah's resource development, spurs industry exploration, and makes Utah a safer and more prosperous state.

ABOUT THE AUTHORS

Stefan Kirby is the Deputy Director at the UGS. He has a diverse background in field geology and interpretive science and has authored and co-authored numerous geologic maps, reports and papers on the geology, hydrogeology, and geothermal resources across Utah.

L. Darlene Batatian is the Director of the UGS. Her areas of expertise include geologic mapping and managing geologic hazards and land use planning. She has a background in environmental geology, land development, and geological engineering.

Michael Vanden Berg is the UGS Energy and Minerals Program Manager, leading a diverse team of geoscientists that research Utah's energy and mineral resources. His main area of research focuses on the petroleum-bearing lacustrine Green River Formation in the Uinta Basin. He is also involved in research on the modern Great Salt Lake, including its extensive microbialites, as an analogue for ancient lacustrine deposits.

Ben Dlin is the Contract and Grants Analyst and Public Information Officer for the UGS. His background is centered in finance, public relations, and operations. He has previously held multiple titles in energy project development and cybersecurity.

Historic Mining Districts:

A Gateway to Future Critical Mineral Potential

by James McVey and Stephanie E. Mills

The Utah Geological Survey (UGS) has been a leader in critical minerals research, long before the U.S. Geological Survey (USGS) formalized the definition and list of critical minerals in 2018. One of the UGS's recent critical mineral projects, funded by the USGS Earth Mapping Resources Initiative (EMRI), began in 2020 and focused on geological mapping and tungsten evaluation in the Gold Hill mining district in western Tooele County. During this study, UGS geologists recognized a unique mineralization feature in the district, known as the Clifton vein swarm, that had not previously been researched. The veins are an array of sheet-like minerals consisting of quartz, calcite, and oxide ores containing gold, copper, molybdenum, and lead. The vein swarm is like those associated with giant copper porphyry deposits in Utah and worldwide, suggesting the district may have unrecognized mineralization potential.

Importance of Copper Porphyry Deposits

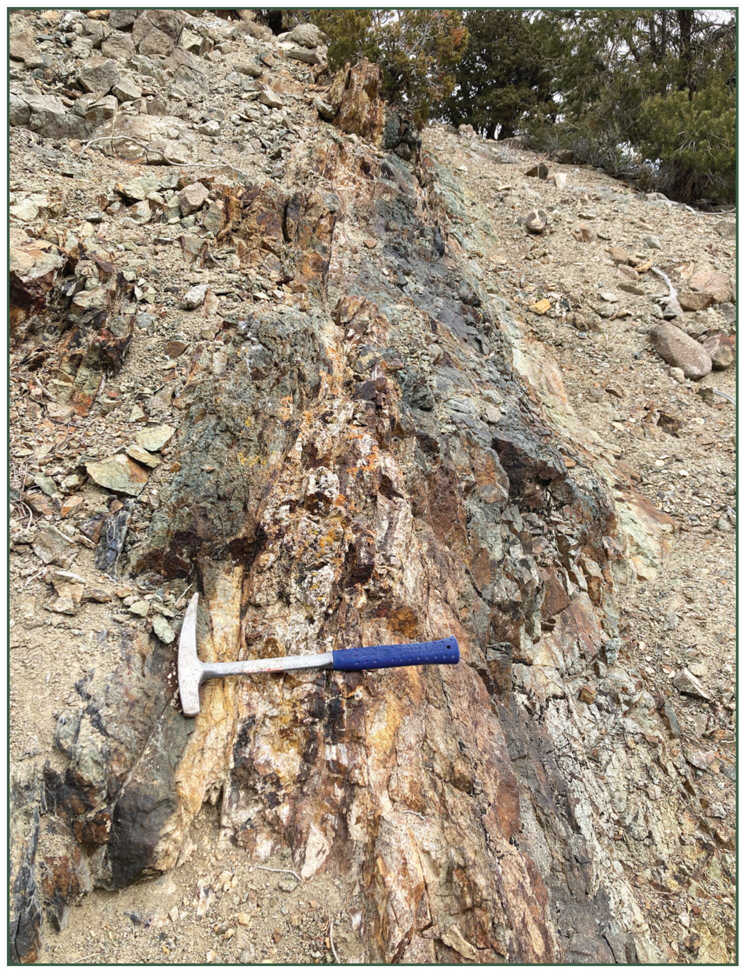
Copper is one of the most foundational metals in modern economies and is essential to many aspects of modern life. It is critical to electric/hybrid vehicles, power transmission lines, plumbing components, solar panels, electronics, and wind turbines, among many other applications. As more emphasis is placed on domestic mineral resources, attention has returned to many historical mining districts and the opportunity for unrecognized mineralization. In Utah, this attention is largely directed at the potential for copper (+/- molybdenum, gold, and silver) porphyry deposits—the same kind of deposit that is currently being mined at Kennecott's Bingham Canyon.

The focus on copper porphyries is due to their economy of scale, characterized by large tonnage and consistent grade, and their common association with other deposit types and potential byproducts. Porphyry copper systems are the world's primary source of mined copper, accounting for ~60% of production globally and over 90% of production in the United States. Additionally, because such a large tonnage of rock is processed to extract copper from porphyry deposits, many otherwise sub-economic minerals and commodities become viable to produce. These minerals include several critical minerals, such as tellurium, which is a byproduct of production at Bingham Canyon.

Despite their importance, copper porphyry deposits are becoming more difficult to discover, and there is increasing focus on methods to discover "blind" deposits, i.e., those that do not outcrop at the surface. The modern prospecting and exploration approach for porphyries focuses on identifying geologic features, such as vein swarms that are commonly associated with, but distant from, the porphyry itself, and using those features to point towards porphyry mineralization. Porphyry copper deposits are created in areas of volcanism and from magmatic processes that generate water and metal-enriched magmas. The ore zones (copper sulfide minerals such as chalcopyrite, chalcocite, bornite, and covellite) are often found in a "cupola," a distinctive upside-down bowl shape that sits as a cap over shallow subsurface magmatic bodies, which often have a porphyritic texture (large crystals in a fine-grained matrix—hence the term copper porphyry deposit). Utah contains several ancient volcanic/magmatic terrains which are prospective for porphyry mineralization, such as Gold Hill.

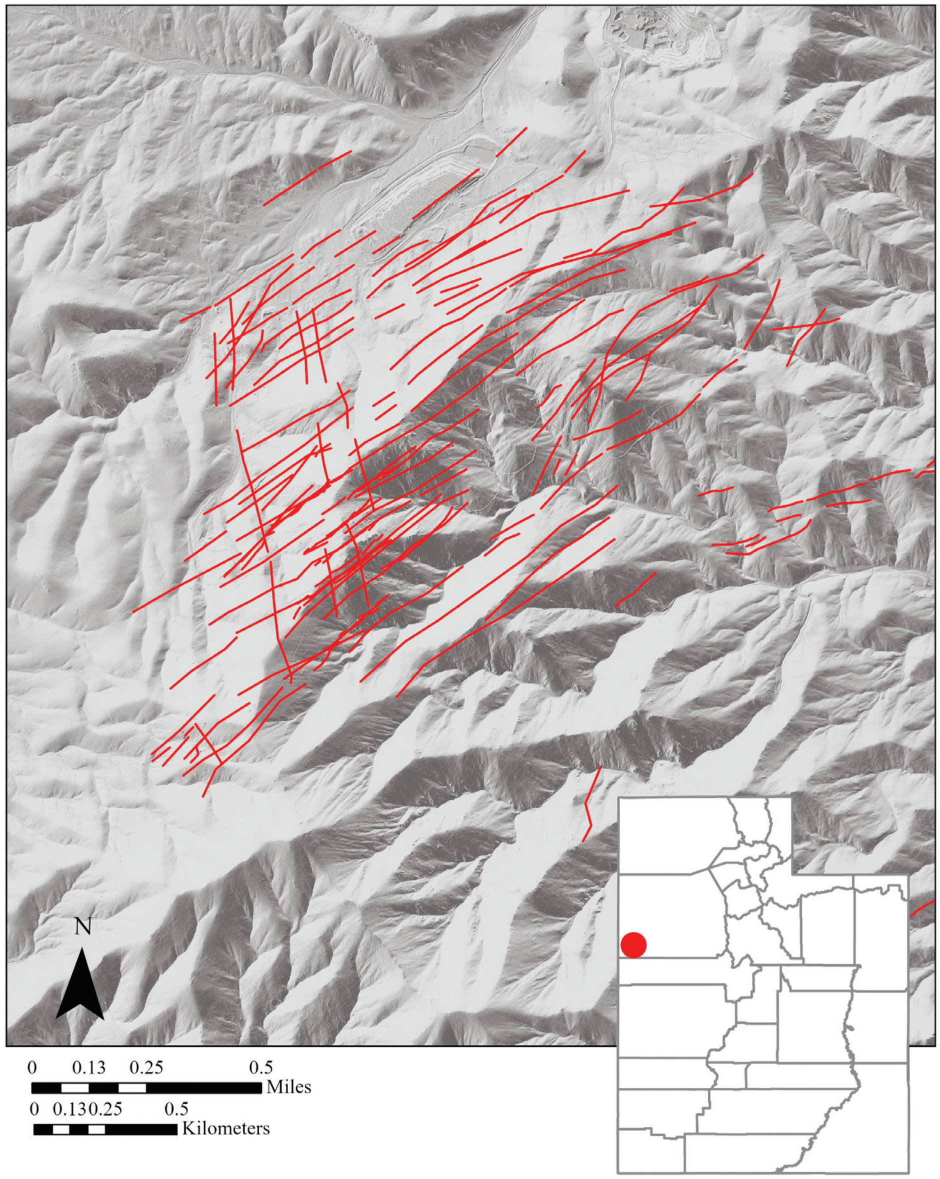
Clifton Vein Swarm: An Indicator of Potential Copper Porphyry Deposits?

The Gold Hill mining district is one of the oldest mining districts in Utah and is the leading historical producer of tungsten and arsenic in the state. Much focus has been paid to skarn, replacement, epithermal, and sediment-hosted gold potential



A vein in the Clifton vein swarm. Minerals include quartz, calcite, and oxide ores containing copper, lead, gold and molybdenum.

in the district, with relatively little interest in the dense vein swarm that forms a ~1.5 by 2 km footprint along a distinct northeast-southwest trend. Veins such as these can sometimes form in connection to porphyry deposits, particularly when occurring in such density. As an example, a similar size vein swarm occurs at the Bingham Canyon porphyry deposit. Since identifying the porphyry prospectivity associated with the veins at Gold Hill, UGS geologists have been mapping, characterizing, sampling, and dating the veins to understand their formation and potential indications of associated mineralization. This research and similar studies will provide new interpretations for the formation of mineralized geological features and offer the potential to better predict the location of unrecognized buried porphyry deposits, with the objective of expanding Utah's critical mineral portfolio to stimulate exploration and development of these resources in Utah.

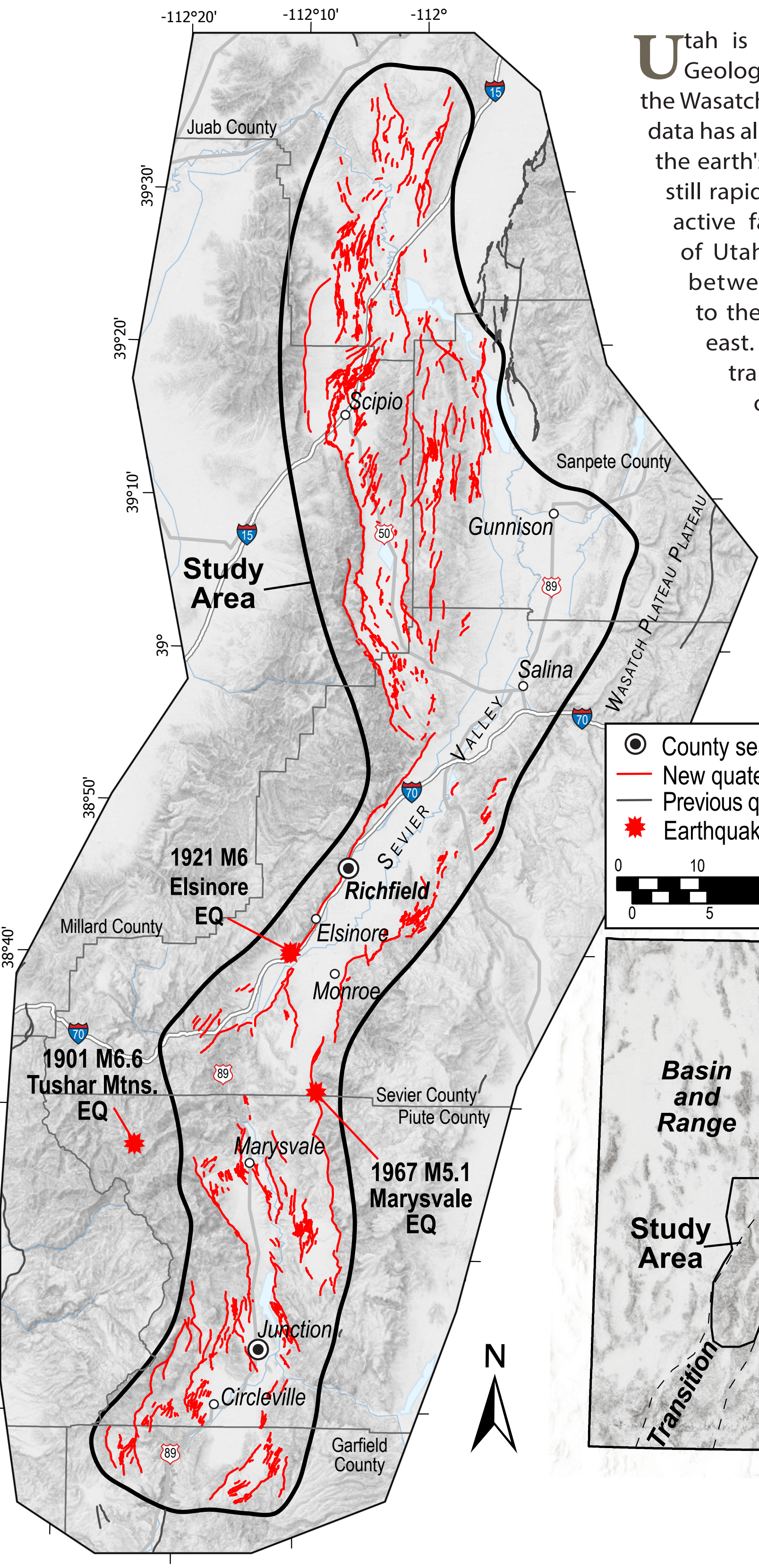


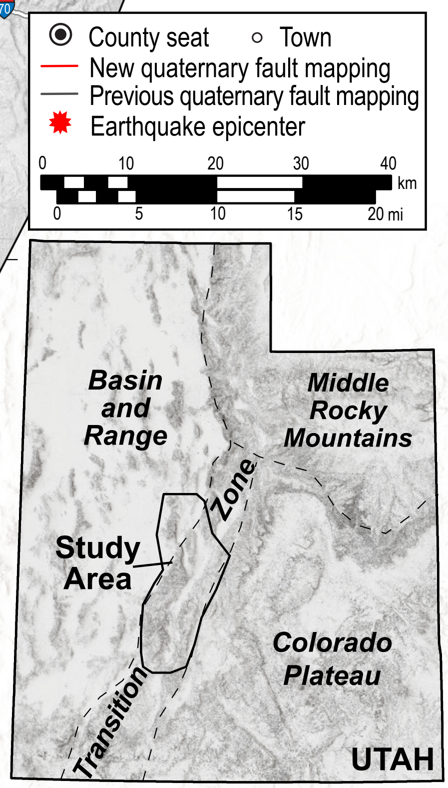
The extent and scale of veins at Gold Hill, based on historical mapping by Dumont Exploration.

View from the Southern Mine with the remains of the mine's winch and "hot bulb" semi-diesel engine which was used to hoist ore from one of the veins in the Clifton Shears vein swarm.

A Clearer View of Earthquake Risk: New Maps Reveal Central Utah's Active Faults

by Adam I. Hiscock, Tyler R. Knudsen, and Rachel N. Adam





Utah is earthquake country! Although the bulk of the Utah Geological Survey's (UGS) active fault mapping has focused on the Wasatch Front and northern Utah, new high-resolution elevation data has allowed us to map active faults (faults which have ruptured the earth's surface in the past 2.6 million years) in more rural, but still rapidly growing, regions of the state. Several significant and active fault zones run right through the geographical heart of Utah. The central Utah region spans the transition zone between the actively extending Basin and Range Province to the west and the stable Colorado Plateau Province to the east. The region is home to growing communities, major transportation routes, vital infrastructure, and has a history of powerful earthquakes. In fact, two of Utah's largest historical earthquakes, the 1901 magnitude 6.6 Tushar Mountains (https://quake.utah.edu/isbhep/1901-southern-utah/) and 1921 magnitude 6.0 Elsinore (https://quake.utah.edu/isbhep/1921-elsinore-ut/) earthquakes, were felt widely in the area, with damage reported throughout the Sevier Valley.

Map showing the central Utah region with new faults mapped as part of this study, alongside significant earthquakes in the area, counties and towns, and major roadways. Inset map at right shows the study area boundary and geological provinces encompassing Utah. Shaded relief base maps generated from ESRI, USGS, and NOAA elevation data.

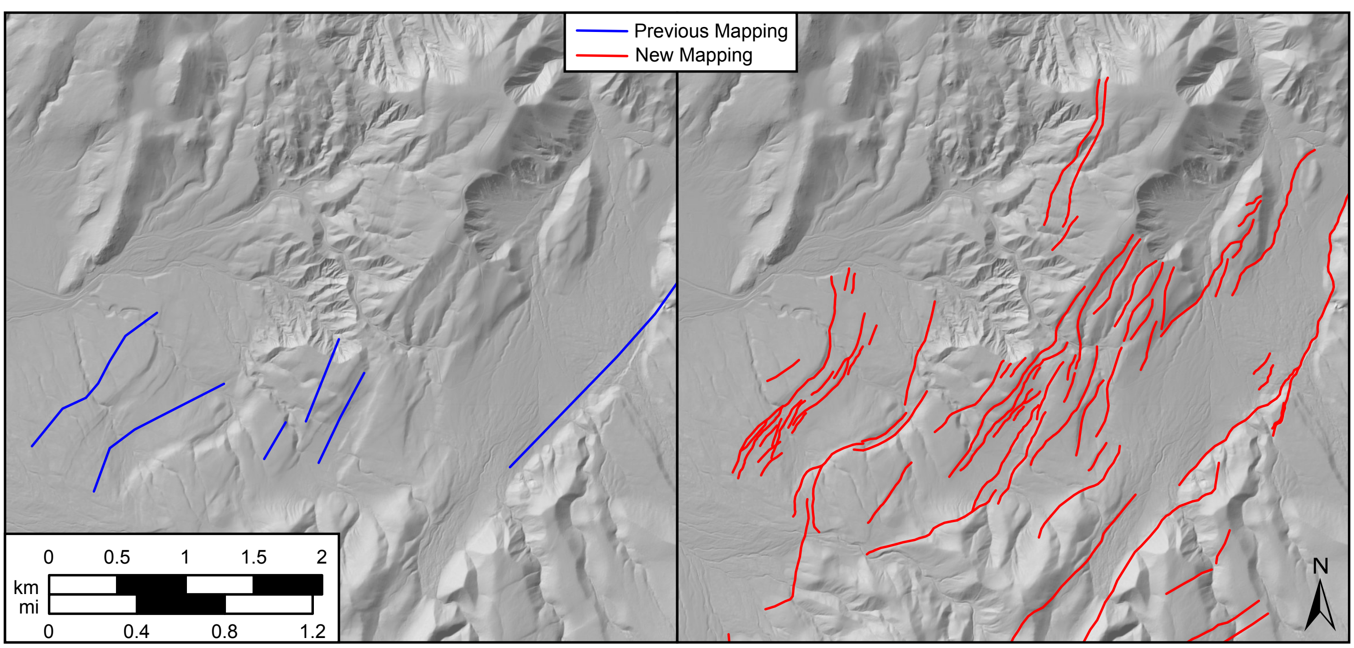
Recognizing earthquake risk in one of Utah's fastest-growing rural regions, the UGS embarked on a project to remap the area's active faults capable of producing strong earthquakes. This project covers parts of six counties—Garfield, Juab, Millard, Piute, Sanpete, and Sevier—and provides a critical update to our understanding of the faults and earthquake hazards in the central Utah region. Our work provides the foundational knowledge needed to build more resilient communities and protect the infrastructure that connects our state, ensuring a safer future for all Utahns. Supplemental funding from the U.S. Geological Survey's Earthquake Hazards Program made this work possible.

Many of the faults in this region were previously identified and mapped by geologists. However, accurately mapping their locations and true extent was challenging. Previous researchers relied on aerial photographs and fieldwork, making it less likely to spot subtle fault escarpments ("scarps")—the step-like features formed on the landscape created by large earthquakes—especially if the scarps were small or covered by dense vegetation like juniper and sagebrush.

Enter light detection and ranging (lidar) data. This powerful tool allows UGS geologists to digitally "see through" vegetation and expose the bare earth beneath, revealing small or eroded fault scarps that were once difficult to map. Using this data, the region's active faults were meticulously re-mapped. Compared to previous fault mapping, our new mapping shows more detail and complexity of the faults in the central Utah region.

As part of this new mapping, UGS geologists created recommended surface-fault-rupture special-study zones around each mapped fault trace. These zones are advisory areas where a detailed, site-specific investigation by a geologist is recommended by the UGS prior to new development. These recommendations help ensure safer and smarter community growth, and provide essential guidance for city and county planners to create and enforce geologic-hazard ordinances.

All the data from this project, including the final report, detailed fault maps, and surface-fault-rupture special-study zones, are publicly available through the Utah Geologic Hazards Portal (https://maps.geology.utah.gov/hazards) as well as in a GIS geodatabase along with a detailed report (https://doi.org/10.34191/RI-293). These resources allow homeowners, developers, and local officials to access the most up-to-date information to make informed decisions.



Map showing a comparison of old (left) vs. new (right) mapped fault traces in the Annabella Graben near Richfield, Utah. Shaded relief base maps generated from ESRI, USGS, and NOAA elevation data.

GEOSIGHTS

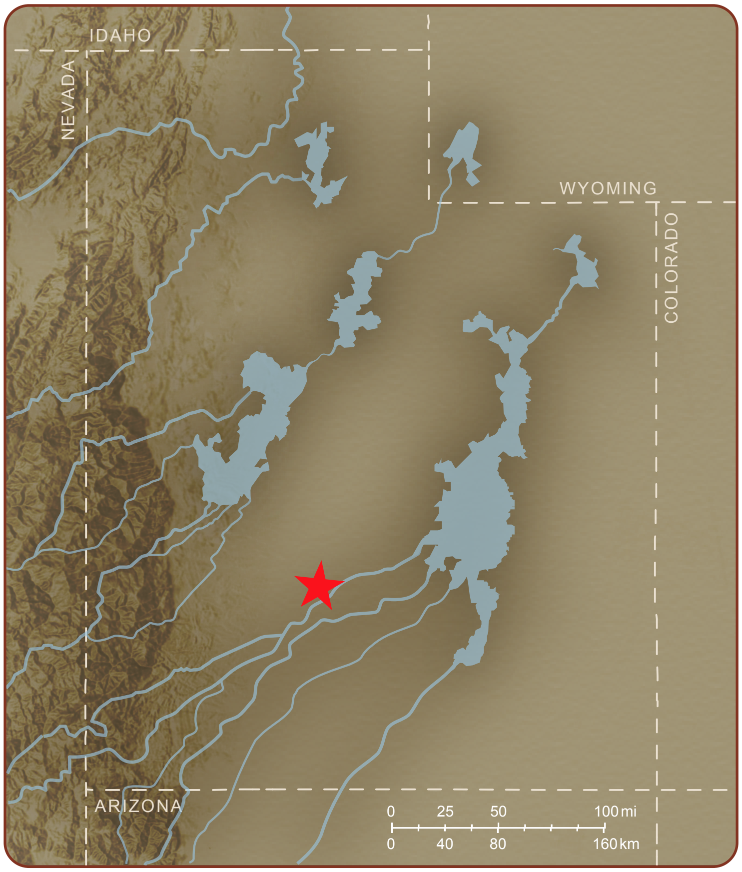
View to the north of variegated slopes of the Brushy Basin Member of the Jurassic-age Morrison Formation in the Bentonite Hills.

Bentonite Hills

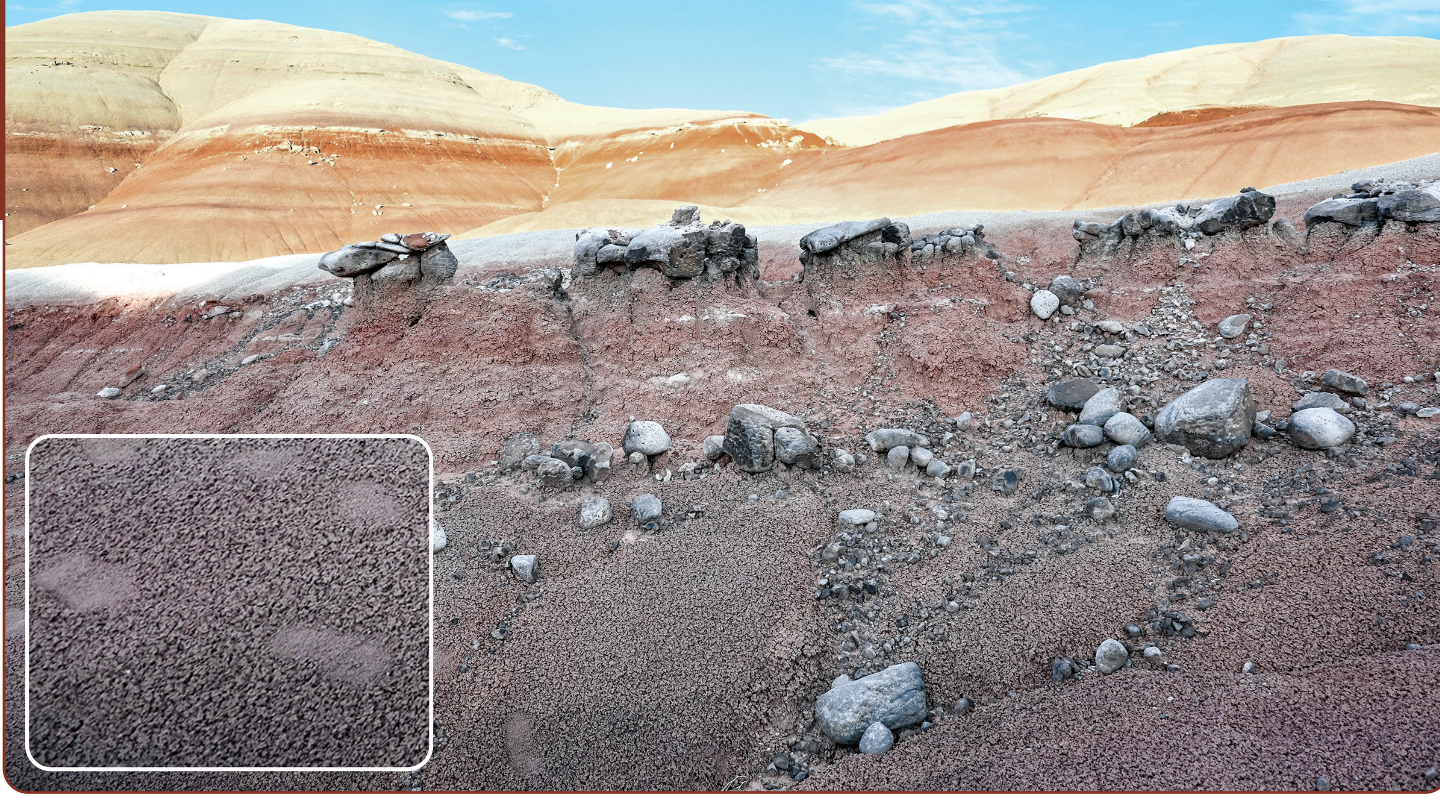
by Stephanie Carney and Jackson Smith

With so many interesting and scenic places in Utah, it is hard to choose where to plan your next adventure. But if you are looking for spectacular geology somewhere off the beaten path, consider a visit to Bentonite Hills. Located just outside the northeastern boundary of Capital Reef National Monument on public land, this quiet, remote area in central Utah is a fantastically barren landscape of rounded, rolling hills with variegated reddish-brown-, green-, gray-, and yellow-colored layers. These slopes and hills are composed of sedimentary strata of the Brushy Basin Member of the Late Jurassic-age Morrison Formation and sporadically capped by the Early Cretaceous-age Cedar Mountain Formation.

The Morrison Formation was deposited during the Late Jurassic between about 157 and 150 million years ago and is famous for containing over 30 genera of dinosaur fossils. At the time of deposition, the Farrallon tectonic plate was subducting beneath the western edge of North America, creating a broad area of volcanoes and highlands west and southwest of Utah. Most of the sediment that would become the Morrison Formation was transported and deposited by large rivers and streams draining east and northeastward from these highlands. These rivers deposited sediments over a vast alluvial plain that extended from northern Arizona and New Mexico northward to southern Canada and eastward to central Nebraska, South Dakota, and North Dakota. These sediments also include a complex mosaic of deposits from lakes, wetlands, floodplains, and swamps that dotted the region, and copious amounts of ash from volcanic eruptions accumulated over the region. During the Late Jurassic, the climate in this area is thought to have been semi-arid.



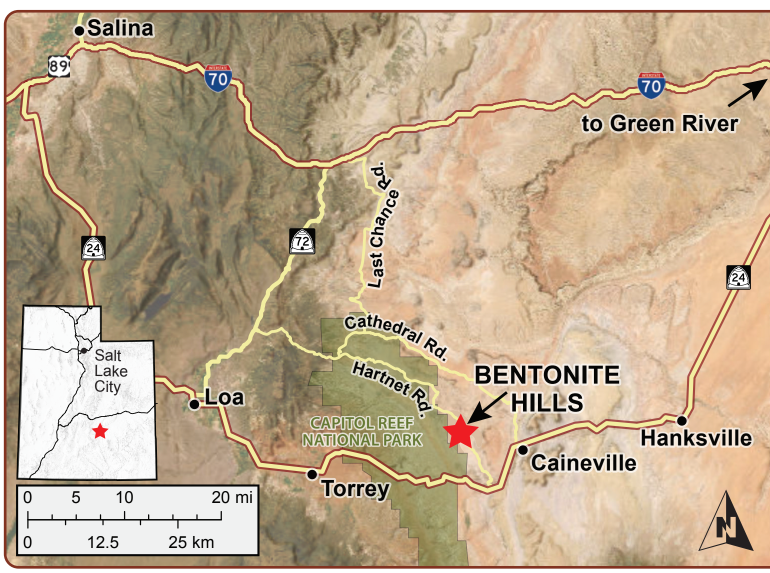
Paleogeographic map of Utah during the Late Jurassic.



The Brushy Basin Member and close-up view of "popcorn" weathering. Shoe prints for scale.

The Morrison Formation is divided into three members in the Capitol Reef and Bentonite Hills area (from oldest to youngest): the Tidwell, Salt Wash, and Brushy Basin Members. The Tidwell and Salt Wash Members are generally light gray and brown sandstone and conglomerate, whereas the Brushy Basin Member is mostly siltstone and mudstone, with some lenses of sandstone and limestone. During deposition of the Brushy Basin, volcanic eruptions would periodically inundate the river systems with ash leaving broad areas of floodplain deposits composed of fine-grained silt, mud, and ash. After deposition and burial, the feldspar and silica minerals in the ash were chemically altered to smectite clay minerals, also known as "swelling clays." Bentonite, which consists mostly of the smectite clay montmorillonite, swells when wet and then dries to a bumpy, crusty texture. Cyclical wetting and drying creates this "popcorn" weathering across exposures of the Brushy Basin Member.

The colorful layers in the Brush Basin indicate whether the sediments were exposed to either an oxidizing or reducing environment during their deposition. Red-, reddish-orange-, reddish-brown-, and purple-colored sediment contains iron oxide, usually hematite, which shows the sediments were deposited in oxygenated terrestrial environments like rivers, flood plains, and very shallow lakes. Green-, gray, and grayish-white-colored sediments were subjected to reducing (low oxygen) conditions indicating they were deposited in deeper lakes or had contact with or were submerged below the water table (groundwater) soon after deposition. The spectrum of colors in Brushy Basin strata reveal its dynamic depositional environment.



How to Get There

Bentonite Hills is located along the Hartnet Road which can be accessed from Interstate 70 or State Route (SR) 24 west of Hanksville, Utah. A high-clearance and/or four-wheel-drive vehicle is required to navigate the dirt road, which is impassable when wet, due to the swelling clay in the Brushy Basin Member. Also, if approaching from SR 24, the road crosses the Fremont River, which can be impassable if the river level is too high. Contact Capitol Reef National Park (435-425-3791) or visit their web page (https://www.nps.gov/care) to inquire about conditions. Once in the area, stay on designated roads, limit foot traffic to previously disturbed areas, and please practice "leave no trace."

Coordinates: 38.3603° N -111.1282° W

How is the UGS helping manage invasive phragmites?

by Becka Downard and UGS Staff

Glad You Asked!

Phragmites, pronounced "frag-my-tees," is a tall, conspicuous perennial wetland grass with a single hollow and stiff vertical stem and distinctive bushy, feathery plumes of flowers and seed heads. There are four subspecies of phragmites and it is among the most widely distributed flowering plants in world. Historically, it has been used in Europe, Africa, and the Middle East for roof thatching, fencing (*phragma* is Greek for fence), and paper production, among many other purposes. Utah has a native variety of phragmites (*Phragmites australis* subspecies ***americanus***) that local tribes utilized for building structures and making woven mats and baskets, ropes and twine, sandals, arrow shafts, musical instruments like flutes and whistles, and bird snares. They also used stems for tobacco and herb pipes, and parts of the plant for medicine. The entire plant is edible—young shoots and roots, seeds, and sugar from the stems provide a year-round resource.

Phragmites have been a beneficial plant for humans, however, the introduction of the Eurasian subspecies of phragmites (*Phragmites australis* subspecies ***australis***) is becoming increasingly problematic in Utah. This exotic plant likely reached the coast of North America over two hundred years ago and has since extended its range across the continent along roads, water ways, and lakeshores. In the last few decades, this invasive phragmites has aggressively expanded throughout Utah, reducing habitat for native plants (including native phragmites) and animals and consuming limited groundwater resources.

The Eurasian subspecies of phragmites (hereafter called invasive phragmites) is legally known as a Class III Noxious Weed in Utah that must be contained to prevent its spread. The plant thrives in disturbed, marginal, and barren grounds and it can quickly move into areas after flooding, fire, native vegetation removal, or nutrient loading. It is remarkably versatile, growing in seasonally dry, submerged, or saturated soil. Invasive phragmites flourish in acidic or alkaline soil, slightly salty or freshwater, and oxygenated or oxygen-free (anoxic) water.

Invasive phragmites have an immense impact on our wetlands. The tightly packed stems of the plant, with upwards of 60 stems per square yard, crowd and shade out other plants. The plant also releases toxins into the soil that can prevent seedlings of other species from taking hold. Invasive phragmites affect the hydrology of wetlands, stagnating water and providing an ideal breeding ground for mosquitoes. Studies suggest it uses twice as much or more water than native wetland vegetation. Currently the Utah Geological Survey (UGS) is partnering with the Utah Division of Water Resources to measure evapotranspiration in phragmites-invaded marshes to quantify how much the invasive grass is using and how much water can be conserved through eradication.

UGS Wetlands Program Manager and wetlands ecologist Becka Downard holds native phragmites (left side of photo) and invasive phragmites (right side of photo).

Invasive phragmites grow from seeds (up to 2,000 seeds from one seed head) or spread via runners, a process called cloning, to create a robust, dense network of rhizomes (horizontal underground stems) and stolons (above ground stems). The majority of phragmites biomass is an underground network of rhizomes and roots. These amass over time, trapping sediment—up to several pounds of sediment per square yard per year—which gradually raises the ground elevation of wetlands, moving the ground surface farther from the water table. Invasive phragmites reduces habitat for most fish, migratory and resident shorebirds, waterfowl, and marsh birds. It clogs canals and culverts, and limits access for recreational opportunities

A UGS wetland ecologist moves through a thick, well-established stand of invasive phragmites. Invasive phragmites obscures views, limits shoreline access, and reduces biodiversity in wetlands and waterways. Photo courtesy of Becka Downard.

Erosion has exposed the dense, underground structure of a stand of invasive phragmites. Photo courtesy of by Delaware Division of Fish and Wildlife.

such as fishing, hunting, and swimming. Stands of invasive phragmites can also present an extreme fire hazard—at the end of the growing season the stalks and leaves die off, dry out, and will swiftly burn if ignited.

The first invasive phragmites specimen in Utah was collected at the Jordan River near Camp Williams and officially identified as the invasive subspecies in 1993. Researchers believe that the invasive phragmites population around Great Salt Lake surged during and after the 1980s wet years, when prolonged flooding inundated vast areas of wetlands along the east side of the lake. The lake then receded, leaving behind barren lands that were ripe for a phragmites invasion. Its colonization of the eastern side of Great Salt Lake also coincided with urbanization and population growth, which resulted in a several-fold increase of two key plant nutrients: phosphorus and nitrogen. By 2011, invasive phragmites occupied at least 23,000 acres around Great Salt Lake. Today it represents more than 90% of the phragmites in the Great Salt Lake watershed, greatly outcompeting the native species.

Because invasive phragmites is so robust, both above- and below-ground, successful treatment requires a multi-year, multi-pronged approach (i.e., integrated invasive species management). The first step is to treat phragmites during late summer with herbicide approved for aquatic ecosystems. The plant must be healthy so that herbicides can translocate to the roots, ensuring that the grass and its root system is killed. Once dead, treatments such as mowing, trampling, cattle grazing,

A UGS hydrologist helps install an evapotranspiration monitoring station in a stand of phragmites. Photo courtesy of Paul Inkenbrandt.

or controlled burns are used to remove the above-ground material so that native wetland plants can thrive. The herbicide and physical treatment combo is repeated until the phragmites is entirely removed, after which native vegetation (including native phragmites) is planted to prevent further invasion and improve habitat.

In the last 20 years, three-quarters of invasive phragmites coverage has been eliminated on Utah Lake and tens of thousands of acres eliminated from around Great Salt Lake. The Department of Natural Resources has invested significant time and money in removing phragmites around Great Salt Lake, treating more than 6,000 acres in 2022 alone. In 2024 the state allocated $1.4 million for invasive species management on sovereign lands.

Although Utah has turned a corner in phragmites treatment, stopping expansion and restoring significant acreage of invaded marshes, the work has only just begun. Effective follow up treatment requires up-to-date mapping showing where phragmites is growing during the current year, a challenge given the size of waterfowl management areas. To help identify these areas of new growth, the UGS, in partnership with the Utah Division of Forestry, Fire & State Lands and the U.S. Fish and Wildlife Service, is developing computer models that can use drone and satellite imagery to map phragmites in a 30,000-acre wildlife management area to direct large-scale phragmites treatments each season (see *Survey Notes*, v. 57, no. 2).

The Utah Division of Forestry, Fire & State Lands and Division of Wildlife Resources partner with Ducks Unlimited to burn phragmites on Great Salt Lake.

Forestry Fire and State Lands (FFSL, a division of the Utah Dept. of Natural Resources) is the executive management authority of approximately 1.5 million acres of lakebed that includes critical wetlands of hemispheric importance. Invasive vegetation is actively managed by FFSL to enhance and maintain the crucial functions of these wetlands.

Scan this QR code to visit FFSL's StoryMap of the Phragmites removal success at Utah Lake.

SURVEY NEWS

New UGS Board Members

We are pleased to welcome two new members to the UGS Board. Michael Hansen, representing Engineering Geology, and Richard Borden, representing the Minerals Industry. Terms have expired for Rick Chestnut and David Garbrecht who have served the UGS well, and we thank them for their efforts.

Employee News

Crystal Garza joined the UGS as our new Financial Analyst and replaces **Winnie Pan** who accepted a position with the Division of Outdoor Recreation. Crystal has worked for the State for five years and has expertise in payables, federal grants management, and budgeting. **Kitri Spencer** accepted the position of Geological Technician with the Natural Resources Map & Bookstore. Kitri is originally from California and moved to Utah to earn a M.S. degree in applied environmental geosciences from Utah State University. **Jay Hill** resigned from the Data Management Program to accept a position in the private sector. **Rebecca Molinari** resigned from the Groundwater & Wetlands Program and is now doing contracted work with the UGS. We wish a warm welcome to Crystal and Kitri and farewell to Winnie and Jay.

Recent Outside Publications by UGS Authors

Mineral Microbiomes Entombed in Great Salt Lake Gypsum—Considerations for Martian Evaporites, by P. Martinez-Koury, J. Baxter, D.M. Keller, **E.A. Jagniecki**, S.B. Farrer, B.J. Adams, and B.K. Baxter: Astrobiology, v. 25, no. 8, https://www.liebertpub.com/doi/10.1177/15311074251365204

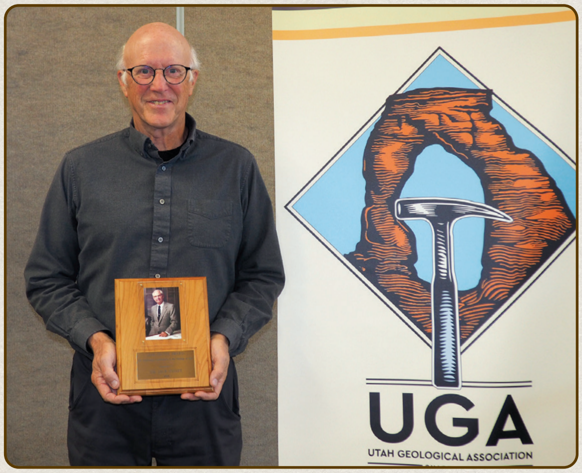
Global Evidence that Cold Rocky Landforms Support Icy Springs in Warming Mountains, by Brighenti, C.I. Millar, S. Hotaling, A. Reato, T. Wiegand, M. Hayashi, L. Carturan, **M. Morriss**, F. Bearzot, V. Lencioni, A. Scotti, A. Janicke, A. Fischer, S. Larsen, A. Benech, A. Gschwentner, M. Tolotti, M.C. Bruno, D.S. Finn, M. Freppaz, D. Herbst, L. Tronstad, F. Comiti and N. Colombo: Environmental Research Letters, v. 20, https://doi.org/10.1088/1748-9326/adf07f

Detecting and Preserving Biosignatures in Sulfate Minerals Prone to Instability, by K.K. Gill, K.C. Benison, **E.A. Jagniecki**: American Mineralogist, https://doi.org/10.2138/am-2024-9689

Awards

Lehi Hintze Award

The Utah Geological Association (UGA) and the Utah Geological Survey (UGS) presented the 2025 Lehi Hintze Award to **Charles G. (Jack) Oviatt** for his outstanding contributions to Utah geology and the study of Lake Bonneville and the other Quaternary lakes in the Bonneville Basin.



Jack's career began with studying glacial geology at the University of Wyoming. Following this his collaboration with Professor Donald Currey at the University of Utah pulled him into Lake Bonneville research. For over 40 years Jack has authored over 90 scientific publications and at least 25 geologic maps that have shaped our understanding of Lake Bonneville and the Late Pleistocene and Holocene geologic history of Utah. His 2016 co-authored book *Lake Bonneville: A Scientific Update* marked the first comprehensive study of the lake since G.K. Gilbert's 1890 *Lake Bonneville* (U.S. Geological Survey Monograph 1). As one of the first mappers in the UGS Mapping Program (founded in 1983), he co-developed the style guide that is used for the geologic mapping of surficial deposits in Utah. After a productive career, Jack retired in 2014 but remains active in geologic research. He is celebrated as a generous mentor, colleague, and friend—known for his humility, optimism, and collaborative spirit. His passion for nature, teaching, and family enriches his professional legacy.

Named for the first recipient, the late Dr. Lehi F. Hintze of Brigham Young University, the Lehi Hintze Award was established in 2003 by the UGA and UGS to recognize outstanding contributions to the understanding of Utah geology.

Employee of the Year

Congratulations to **Don Clark** who was selected by his peers as the 2025 UGS Employee of the Year. Don has demonstrated consistent excellence throughout his 21-year tenure with the UGS. He is immensely dedicated to the success of the Geologic Mapping Program, frequently prioritizing program needs over his own projects. His substantial contributions to the creation, review, and completion of STATEMAP deliverables have ensured that tasks progress efficiently and often ahead of schedule. Don's excellent technical skills have enabled him to lead significant mapping projects across the state, and his contributions to the 30- x 60-mapping initiative are invaluable. As the program's most senior member, his fieldwork methodology has served as a valuable learning model for a new generation of mappers. Don is a quiet, humble person and always willing to help anyone who asks. He is an outstanding employee and has been an anchor for the mapping team for years, making him a highly deserving recipient of this special recognition.

Crawford Award

The Utah Geological Survey's prestigious 2025 Crawford Award was presented to **James I. Kirkland** in recognition of his study of the Mancos Formation, culminating in the outstanding paper "Revisiting the Cretaceous Mancos Group in Utah—problems, previous methods, and new perspectives on a world-class Cretaceous marine section" published in *Geology of the Intermountain West*. This comprehensive, full-color field trip guidebook is the result of several years of intensive study in which the current state of geologic research was meticulously compiled and expanded with new field work on the Mancos Group. Jim Kirkland's dedication to the study of these rocks spans over four decades, establishing him as one of the world's foremost authorities on this significant geologic unit.

UTAH DNR GEOLOGICAL SURVEY

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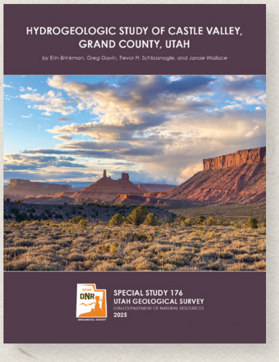
Salt Lake City, UT 84114-6100

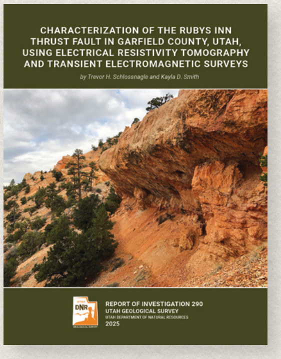
Address service requested
Survey Notes

New Publications

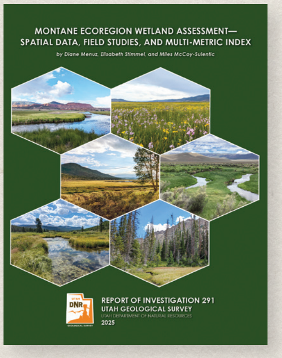
Available at the Natural Resources Map & Bookstore—**utahmapstore.com** and for download at **geology.utah.gov**.



Hydrogeologic Study of Castle Valley, Grand County, Utah, by Erin Brinkman, Greg Gavin, Trevor H. Schlossnagle, and Janae Wallace 56 p., 2 appendices, **SS-176**, https://doi.org/10.34191/SS-176

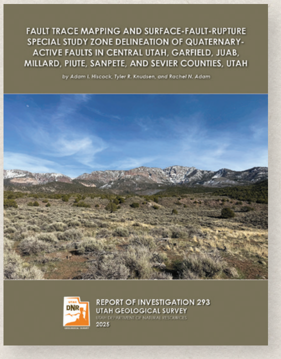


Characterization of the Rubys Inn Thrust Fault in Garfield County, Utah, Using Electrical Resistivity Tomography and Transient Electromagnetic Surveys, by Trevor H. Schlossnagle and Kayla D. Smith, 19 p., 4 appendices, **RI-290**, https://doi.org/10.34191/RI-290



Montane Ecoregion Wetland Assessment—Spatial Data, Field Studies, and Multi-Metric Index, by Diane Menuz, Elisabeth Stimmel, and Miles McCoy-Sulentic, 71 p., 6 appendices, **RI-291**, https://doi.org/10.34191/RI-291

Natural Pozzolan in Utah and Reconnaissance for Potential Resources on SITLA Lands, by Andrew Rupke, Taylor Boden, and Marie D. Jackson, 47 p., 2 appendices, 1 plate, **RI-292**, https://doi.org/10.34191/RI-292



Fault Trace Mapping and Surface-Fault-Rupture Special Study Zone Delineation of Quaternary-Active Faults in Central Utah, Garfield, Juab, Millard, Piute, Sanpete, and Sevier Counties, by Adam I. Hiscock, Tyler R. Knudsen, and Rachel N. Adam, 26 p., **RI-293**, https://doi.org/10.34191/RI-293

- **Delineation of Geoheritage Sites in Utah**, by Jim Davis, Mackenzie Cope, and Mark Milligan, 21 p., 1 appendix, **DS-3**, https://doi.org/10.34191/DS-3
- **Bouguer Gravity Anomaly Map and Data of Timpanogos Rock Glacier, Utah**, by Bronson Cvijanovich, Michael Thorne, Leif S. Anderson, Ivan Tochimani-Hernandez, Tonie Van Dam, and Christian Hardwick, 6 p., 1 appendix, **DS-4**, https://doi.org/10.34191/DS-4