Mackay School of Earth Sciences and Engineering
College of Science
University of Nevada, Reno

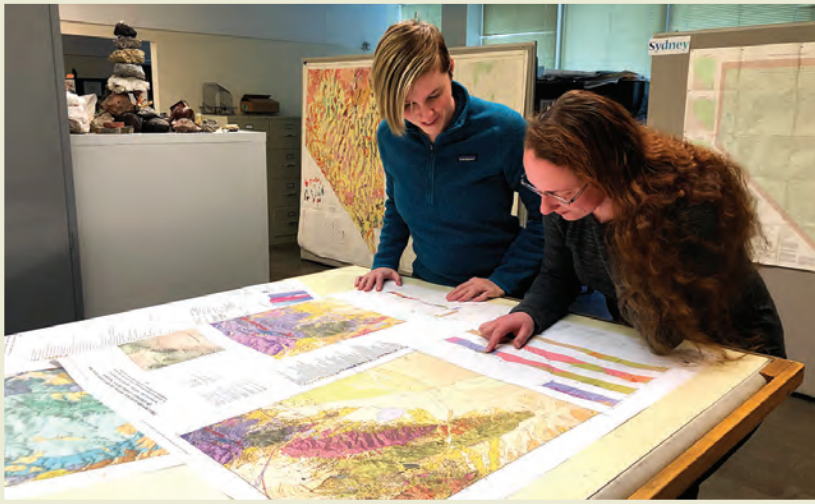
Nevada Bureau of Mines and Geology

NEVADA BUREAU OF MINES AND GEOLOGY

OPEN-FILE REPORT 18-8

Biennial Report of the Nevada Bureau of Mines and Geology

2016–2017



James E. Faulds
Director and State Geologist

PREPARED FOR
The Board of Regents of the Nevada System of Higher Education
2018

NBMG Contact Information

The Nevada Bureau of Mines and Geology (NBMG) is a research and public service unit of the University of Nevada, Reno (UNR) and is the state geological survey, applying its expertise across the entire state. NBMG is part of the Mackay School of Earth Sciences and Engineering within the College of Science at UNR.

NBMG scientists conduct research and publish reports on mineral resources, engineering geology, environmental geology, hydrogeology, geologic hazards, and geologic mapping. Individuals interested in Nevada geology are encouraged to visit, call, write NBMG, or visit our website.

http://www.nbmg.unr.edu

Most NBMG scientists (Director and research faculty) and cartographic and administrative staff are located on the **University of Nevada, Reno campus**, 775-794-6691.

U.S. Mail:
Nevada Bureau of Mines and Geology
Mail Stop 178
University of Nevada
Reno, NV 89557-0178

UPS or Federal Express:
Nevada Bureau of Mines and Geology
University of Nevada / Mail Stop 178
1664 N. Virginia Street
Reno, NV 89503

The **Publication Sales and Information Office** is located at the **Great Basin Science Sample and Records Library**.

Nevada Bureau of Mines and Geology
Great Basin Science Sample and Records Library
2175 Raggio Parkway
Reno, NV 89512

Please contact the Publication Sales Office to purchase NBMG geologic maps and reports and U.S. Geological Survey geologic maps, publications, and topographic maps. For current hours, please call or check online.

Phone: (775) 682-8766 (Tuesday–Friday, 8:00 a.m.–3:00 p.m., PST)
E-mail: nbmg@unr.edu
Web: http://pubs.nbmg.unr.edu

Please contact the Information Office for aerial photographs; cuttings, core, and well records for oil, gas, and geothermal; and general geological information. Please call to make an appointment to view geological samples or air photos.

Phone: (775) 682-8767 (Tuesday–Friday, 8:00 a.m.–3:00 p.m., PST)
E-mail: nbmg@unr.edu

Cover photos

Upper left photo: Aztec Sandstone formations in Red Rock Canyon, Clark County. *Photographer: Matt Richardson*

Upper right photo: NBMG cartographers Sydney Wilson and Irene Seelye. *Photographer: Jennifer Vlcan*

Lower left photo: Graduate student field course near Yerington, Nevada, looking at deep exposures of the Yerington batholith. *Photographer: Greg Dering*

Lower right photo: Multiple faults cut through Mount Rose, Washoe County. *Photographer: Alan Ramelli*

NEVADA BUREAU OF MINES AND GEOLOGY

OPEN-FILE REPORT 18-8

Biennial Report of the Nevada Bureau of Mines and Geology 2016–2017

Contents

Executive Summary **3**
Geologic Mapping **6**
Mineral Resources and Economic Geology **12**
Geothermal **15**
Geologic Hazards **20**
Lidar **27**
Nevada Geodetic Laboratory **29**
Cartography & GIS **33**
Great Basin Science Sample and Records Library **35**
Open Data **37**
Education and Outreach **38**
Appendix **41**

James E. Faulds
Director and State Geologist

PREPARED FOR
The Board of Regents of the Nevada System of Higher Education
2018

Mackay School of Earth Sciences and Engineering
College of Science
University of Nevada, Reno

© Copyright 2018 The University of Nevada, Reno.
All Rights Reserved

Geologic mapping in southern Nevada (above). NBMG's detailed mapping of the different rock and soil types, documenting locations of young flood deposits, and studying active faults (below) is essential to planning for hazards and infrastructure engineering and design.

Executive Summary

Nevada is a unique state whose opportunities and challenges stem from its distinctive geologic, geographic, economic, and demographic heritages. It is richly endowed in natural resources but is also prone to earthquakes, floods, and other natural hazards. The Nevada Bureau of Mines and Geology (NBMG) is the state geological survey of Nevada and is tasked with analyzing and characterizing these resources and hazards for the benefit of Nevada's citizens.

As defined by state statutes (NRS-514), NBMG serves as the state's official locus of data, analysis, and exchange on Nevada's geology, natural resources, and geologic hazards. We disseminate this information to local, state, and federal agencies, major industries, engineers, educators, and to the general public. Our primary mission is to provide geologic information to enhance the safety of Nevada's citizens and to facilitate environmentally sound and sustainable economic development of Nevada's mineral and energy resources, applying geologic research for the public good throughout the state. We are a statewide public service unit that resides in the Mackay School of Earth Sciences and Engineering in the College of Science at the University of Nevada, Reno (UNR). Since its inception in 1929, NBMG has produced geologic maps for much of the state and catalogued more than 320,000 geologic specimens and reports. This report summarizes NBMG activities, programs, and accomplishments for 2016 and 2017.

To fulfill its mandate, NBMG employs about 28 individuals, including geoscientists, GIS (geographic information systems) and cartographic professionals, technicians, and staff. NBMG conducts research and publishes reports on mineral, geothermal, and oil and gas resources, engineering geology, geologic hazards, hydrogeology, geologic mapping, and Nevada's overall geologic framework. NBMG cooperates with numerous state and federal agencies in conducting this research and in providing geologic and resource information. Research results are published as NBMG bulletins, reports, maps, and special publications, as well as in federal publications and scientific journals. In the 2016–2017 period, NBMG produced dozens of publications on Nevada's geology, natural resources, and geologic hazards, including 15 NBMG geologic maps, 11 NBMG reports and other publications, and more than 75 papers in nationally and internationally recognized scientific journals. Geologic research conducted by NBMG has benefited many industries in Nevada (e.g., the gold, lithium, silver, copper, and geothermal industries) and enabled the state to become leading producers of gold and geothermal power (graphs below). Geologic information managed by NBMG also helps government officials make informed decisions on the use of Nevada's lands. To preserve and provide public access to this information, NBMG manages and operates the Great Basin Science Sample and Records Library (GBSSRL,

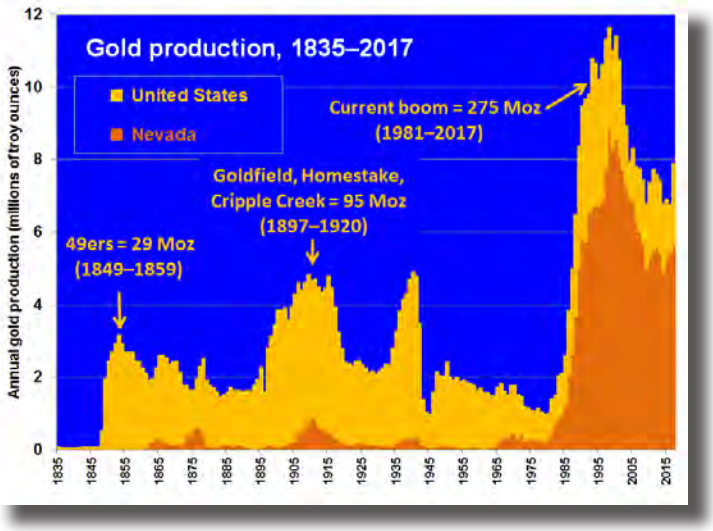
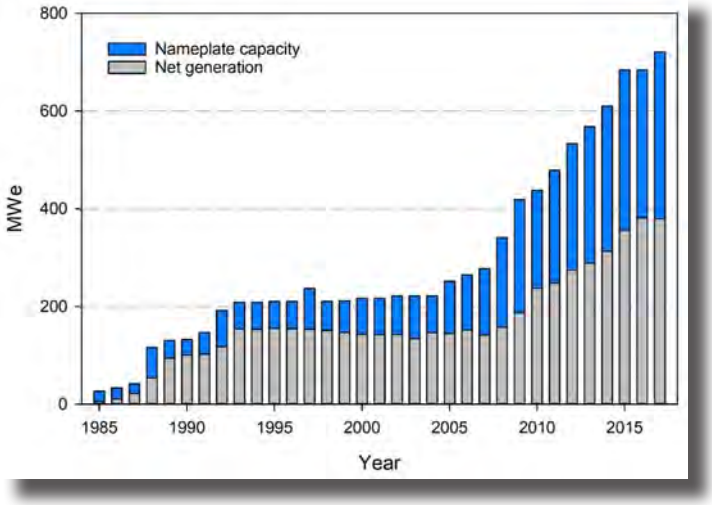


Chart comparing U.S. and Nevada gold production from 1835 to 2017.



Cumulative nameplate generating capacity and net geothermal power production in Nevada from 1985–2017, as reported to the Nevada Division of Minerals. Net generation is calculated by dividing annual net generation in megawatt-hours by the number of hours in a year. MWe, megawatts electricity.

Find additional information on the Nevada Bureau of Mines and Geology on the
Nevada Bureau of Mines and Geology website
http://www.nbmg.unr.edu

Executive Summary

photo below), whose staff catalogues and archives geologic reports, rock and mineral samples (including cuttings and core from geothermal and oil-gas wells), mining district files, aerial photographs, and geologic and topographic maps. About half of the NBMG staff are supported by State funding, with the other half supported by external grants. NBMG has been very successful in acquiring external grants and expended ~$3.36M in external funds on statewide projects in fiscal years 2016 and 2017. State funding during this period totaled ~$2.73M.

Great Basin Science Sample and Records Library (GBSSRL), managed and operated by NBMG. It is the repository for geologic information for Nevada. *Photographer: Charlotte Stock.*

Continued rapid population growth in Nevada (see adjacent photos of Las Vegas and Reno-Sparks areas) has resulted in increasing needs for mineral, energy, and groundwater resources, land-use and infrastructure planning, and assessments of geologic hazards. NBMG's major programs are geared toward applying the forefront of technology (see Lidar, page 26) to satisfy these needs.

NBMG's major activities are briefly described below and reviewed in greater detail in subsequent chapters.

• **Geologic Mapping:** Geologic maps show the distribution of different rock units as well as faults and folds that deform those units (see Geologic Mapping, page 5). These maps provide the foundation for analyzing mineral and energy resources and geologic hazards. For example, geologic maps in urban settings help planners consider geologic hazards, such as earthquakes and floods, as they plan and design infrastructure and development. Studies show that geologic maps save developers and engineers about $50,000 for every construction project. Many different companies utilize the same map, which greatly multiplies the cost savings and value of any particular map. As shown in a recent cost-benefit analysis, every dollar allocated to NBMG for geologic mapping returns >50 times that amount in benefits to the state. Since its inception, NBMG has produced many hundreds of geologic maps, but due to the size of Nevada (7th largest state) and its geologic complexity, more than 75% of Nevada still lacks adequate, modern geologic maps.

• **Mineral Resources:** Nevada produces more gold than any other state. Nevada consistently ranks in the top 5 gold producers worldwide. It also produces large amounts of many other minerals, including copper, silver, and lithium. Lithium is critical for the rapidly growing electrical automotive and energy storage industries. Nevada has the only operating lithium mine in the country. NBMG scientists have been instrumental in understanding the processes that control

View of Las Vegas, which is the largest city in Nevada with over two million in the metropolitan area.

View of the Reno-Sparks metropolitan area, which has a population of more than 500,000.

Find additional information on the Nevada Bureau of Mines and Geology on the
Nevada Bureau of Mines and Geology website
http://www.nbmg.unr.edu

Executive Summary

the formation and location of these mineral resources (see Mineral Resources and Economic Geology, page 11). NBMG also produces annual reports describing mining activities and mineral production in the state.

• **Geothermal Resources:** Nevada has more geothermal resources than any other state and is currently second in the nation in the production of geothermal electricity. Geothermal energy is a clean source of renewable energy with a minimal carbon footprint and ability to operate 24/7. All studies indicate that Nevada has a huge untapped potential for producing much greater amounts of geothermal energy. NBMG scientists are developing new methodologies for geothermal exploration (see Geothermal, page 14), which have reduced the risks of geothermal drilling and thus facilitated development of several new geothermal power plants in recent years.

• **Tectonic Setting:** Nevada owes its unique setting to its location within the Pacific–North American plate boundary, where tectonic stresses drive crustal blocks to slide past one another along major faults (akin and related to the San Andreas Fault in California) and also to extend or stretch in the horizontal dimension. These motions make Nevada literally the fastest-growing state in the country, as the stretching adds new land at the rate of several acres every decade. Through the Nevada Geodetic Laboratory (see Nevada Geodetic Laboratory, page 28), NBMG is documenting and tracking these crustal motions to better understand the implications for earthquake risks, as well as the subtle but measurable effects of groundwater withdrawal and climate change on these crustal motions.

• **Geologic Hazards:** Nevada's tectonic setting has generated its stunning and rugged landscapes of alternating lofty mountains and impressive valleys. Nevada is the most mountainous of the 48 contiguous states (second only to Alaska). Many of the mountain ranges are bounded by active fault zones, making Nevada the third most seismically active state in the country, with a number of large magnitude earthquakes shaking the state in the recent past. The high topographic relief also makes the region vulnerable to landslides and floods. NBMG scientists conduct analyses to better understand the locations of faults and landslide deposits, how often large earthquakes occur along individual faults (including a major ongoing study in Las Vegas Valley), extent and age of flood plains along major streams and rivers, and distribution of debris flow deposits resulting from flash floods (see Geologic Hazards, page 19). NBMG also develops guidelines to mitigate damage and educates the public about possible damage and injury from these natural hazards.

• **Data Dissemination:** NBMG has a responsibility to broadly disseminate its geologic reports and maps to mitigate the effects of geologic hazards and thereby enhance public safety, promote well-planned infrastructure, and facilitate environmentally sound and sustainable development of its natural resources. Geologic and geographic information activities include 1) creating and updating databases on mining districts, active mines and prospects, and geothermal and petroleum exploration and production; 2) implementation and development of statewide geographic information systems and the digital maps needed for these systems; and 3) maintenance of core and cuttings facilities, rock and mineral collections for research, aerial photographic imagery and maps, and extensive files on Nevada geology and resources. Many of these datasets have been digitized and are disseminated through the NBMG website and Open Data portal (see Open Data, page 36; http://www.nbmg.unr.edu/; https://data-nbmg.opendata.arcgis.com/). Physical specimens and archived reports are available at the GBSSRL (see GBSSRL, page 34; http://pubs.nbmg.unr.edu/aboutus.asp).

• **Education and Outreach:** NBMG is dedicated to education and outreach within the state (see Education and Outreach, page 37). NBMG scientists have teaching obligations and advise about 1/3 of the graduate students in the UNR geoscience programs and participate as adjunct faculty at UNLV. NBMG scientists are particularly focused on training the next generation of geoscientists to better understand Nevada's natural resources and geologic hazards. For example, both the Center for Research in Economic Geology and the Great Basin Center for Geothermal Energy reside within NBMG. These centers are focused on analysis, education, and outreach of mineral and geothermal resources, respectively. Earth science education projects include writing guidebooks for the general public, teachers, and students; presenting lectures, short courses, and workshops; and assisting with science fairs, curriculum development, and conferences. Specific examples include publishing geologically oriented guidebooks for the general public and tourism (e.g. Highway 50 guidebook; http://pubs.nbmg.unr.edu/category-s/1973.htm) and conducting K-12 teacher workshops in southern and northern Nevada. NBMG staff members also assist the public, industry, and government agencies by answering specific questions regarding Nevada geology, resources, and hazards.

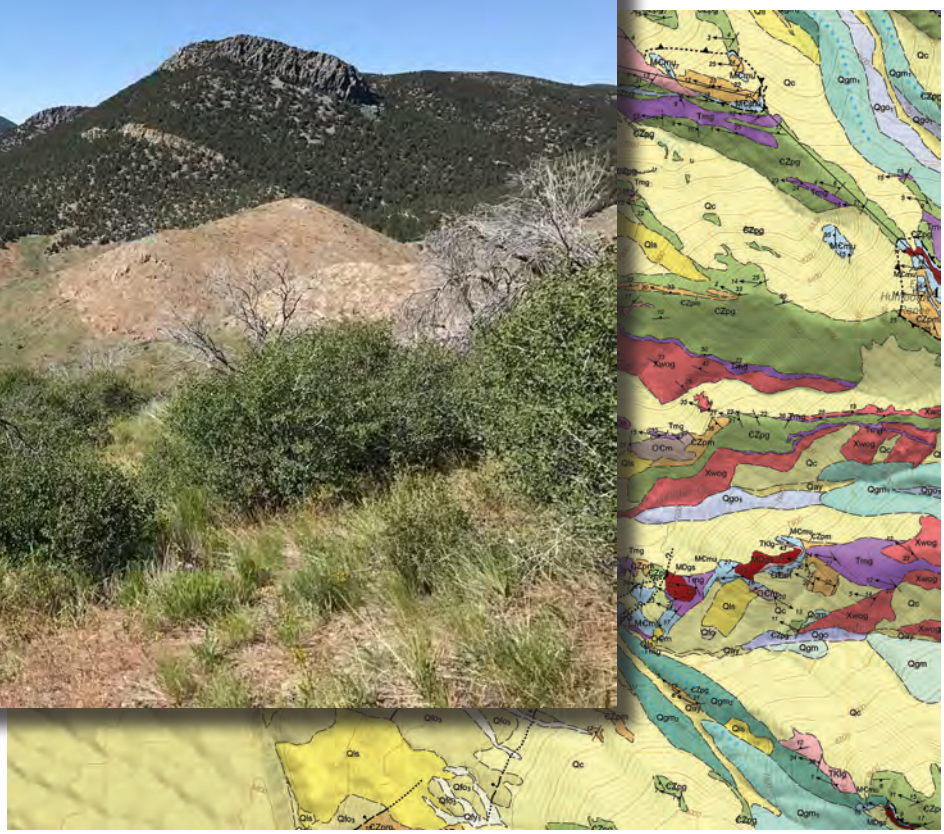
Find additional information on the Nevada Bureau of Mines and Geology on the
Nevada Bureau of Mines and Geology website
http://www.nbmg.unr.edu

Geologic Mapping

Geologic maps are two-dimensional representations of a vast amount of three-dimensional geologic information. They convey the age, composition, and spatial relationships among rocks and sediments at and near the Earth's surface. This information is the foundation for addressing both applied and basic research questions in the Earth Sciences. For example, mapping by NBMG geologists is used to understand the origin and distribution of mineral deposits and energy resources around the state of Nevada and also documents the geologic history of earthquakes, floods, and landslides critical for characterizing and planning for natural hazards. This same mapping can also be used to investigate academic research questions about how the Earth's crust changes through time, including the multiple tectonic events that have shaped our landscapes, magmatic processes operating in ancient volcanoes, and the evolution of North America's western plate boundary. The long-range geologic mapping plan of the NBMG has two major goals that benefit the state directly:

- To facilitate the growth of Nevada's urban centers and statewide infrastructure by providing information on geological hazards, resources, and environmental protection and,
- To assist in the environmentally responsible economic development of mineral and energy resources, which also facilitates economic diversification.

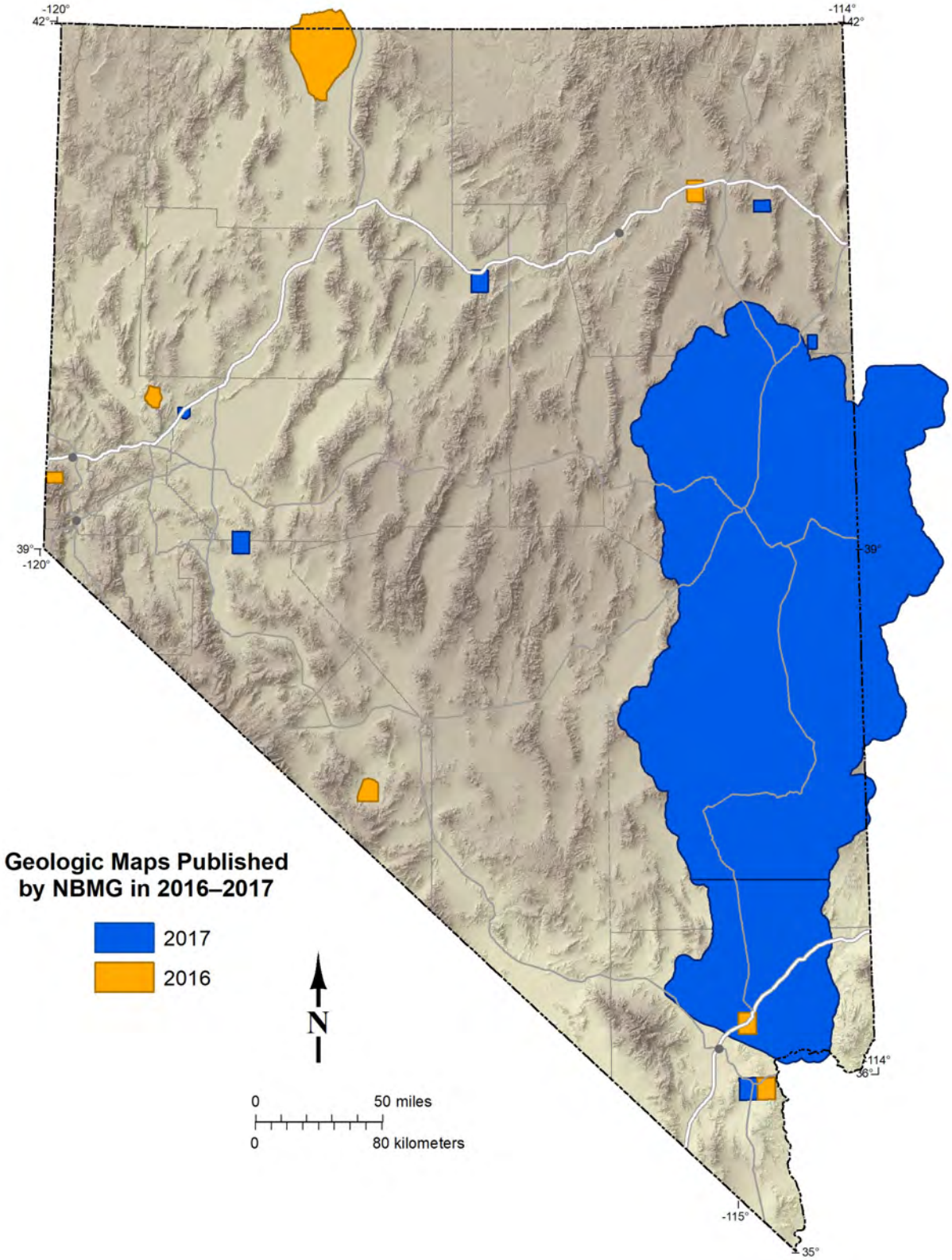
Current geologic mapping priorities focus on rapidly expanding urban areas, including Las Vegas and Reno–Carson City, mineral resources in northeastern Nevada, and geothermal resources throughout the state.



NBMG geologist, Michael Ressel, mapping in the Pequop Mountains of eastern Nevada. *Photographer: Chris Henry*

Find additional information on Nevada geologic maps and data at the
Nevada Bureau of Mines and Geology website
https://data-nbmg.opendata.arcgis.com/pages/geology

Geologic Mapping



Find additional information on Nevada geologic maps and data at the
Nevada Bureau of Mines and Geology website
https://data-nbmg.opendata.arcgis.com/pages/geology

Geologic Mapping

NBMG RESEARCH HIGHLIGHT

Preliminary Geologic Map of the Boulder City NW Quadrangle, Clark County, Nevada

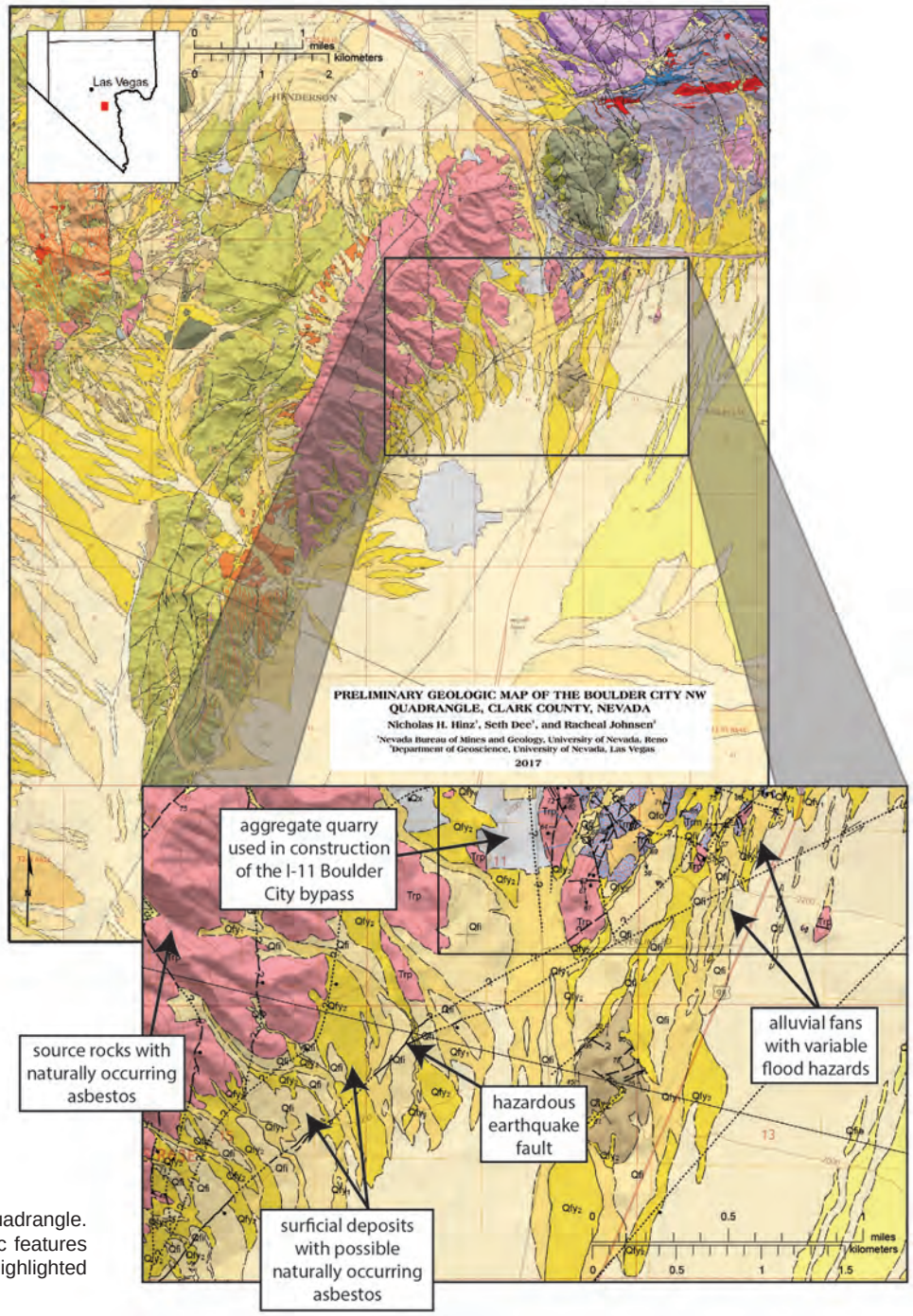
NBMG Open-File Report 17-5

by Nicholas H. Hinz (NBMG), Seth M. Dee (NBMG), and Racheal Johnsen (UNLV)

The geologic map of the Boulder City NW quadrangle depicts the complex geology directly southeast of Las Vegas and west of Boulder City. The area covered by the map has undergone significant recent changes with ongoing urban expansion in the City of Henderson, the recently completed I-11 Boulder City bypass, and expanding solar power generation.

The map documents geologic information relevant to the evolving land use. The location of young alluvial deposits in Eldorado Valley aids in the identification of flood-prone regions, a major concern for solar power plants and urban development.

Detailed mapping of the different rocks and soil types is also critical for understanding the distribution of Naturally Occurring Asbestos (NOA), a recently identified hazard in the area. Accurately locating the recently active faults in the area is essential to planning for seismic hazards and infrastructure engineering and design.



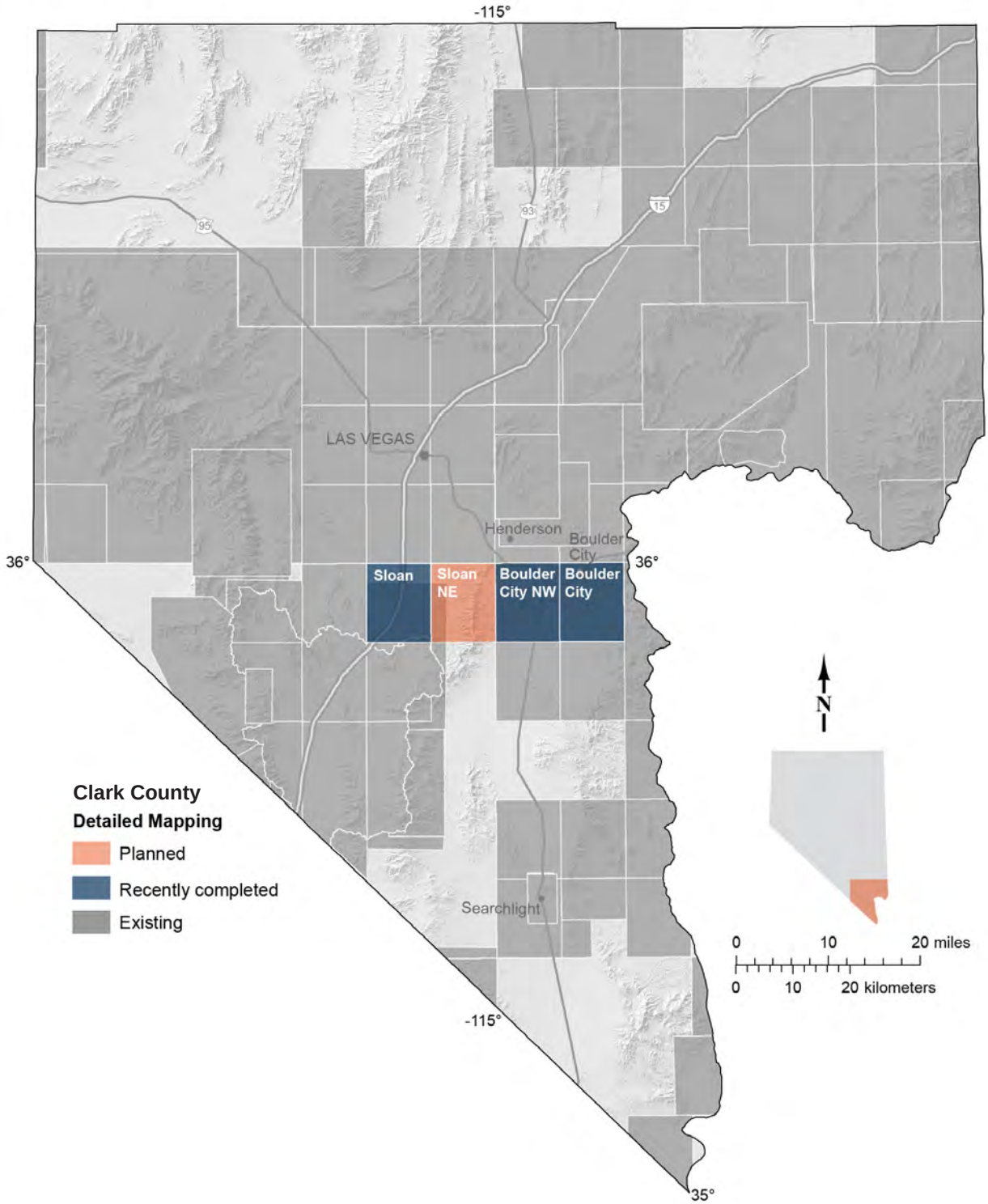
Geologic map of the Boulder City NW quadrangle. The mapping depicts a variety of geologic features with societal impact, several of which are highlighted in the map inset.

Find additional information on Nevada geologic maps and data at the
Nevada Bureau of Mines and Geology website
https://data-nbmg.opendata.arcgis.com/pages/geology

Geologic Mapping

NBMG RESEARCH HIGHLIGHT

Geologic Mapping in Clark County, Nevada



Find additional information on geologic mapping at the
Nevada Bureau of Mines and Geology website
https://data-nbmg.opendata.arcgis.com/pages/geology

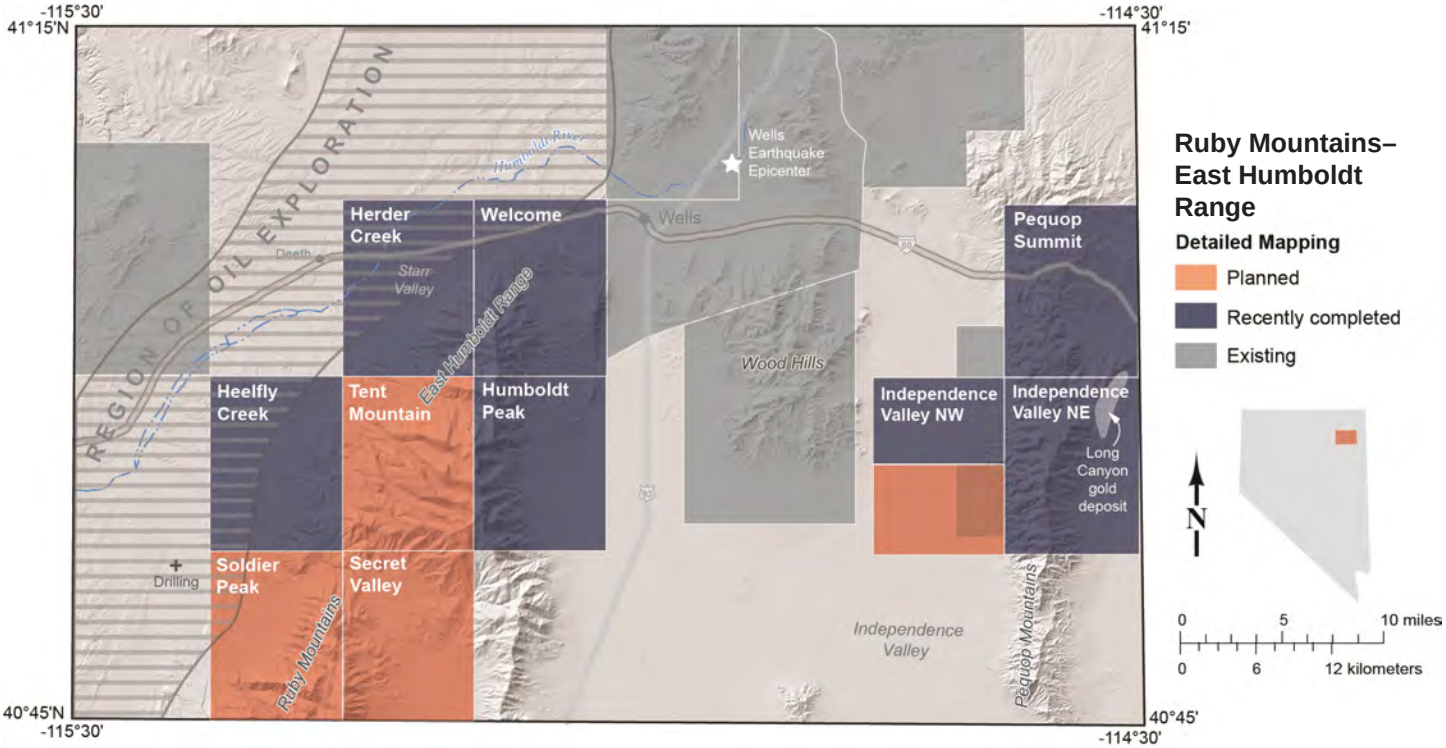
Geologic Mapping

NBMG RESEARCH HIGHLIGHT

Geologic Framework of the Ruby Mountains–East Humboldt Range Area, Northeast Nevada

The region surrounding the Ruby Mountains–East Humboldt Range, east of Elko, is the focus of ongoing geologic mapping and research by NBMG. The goal of the project is to gain a better understanding of the region's geologic history. These findings will help to address several fundamental research questions in the area and will contribute to the understanding of the origin and distribution of mineral deposits, as well as geothermal and hydrocarbon resources. The study area includes several recently identified gold deposits with active exploration and production, and the project has been conducted in close coordination with mining companies. This includes the Long Canyon gold deposit with 174,462 ounces of gold production through 2017.

The most concerted petroleum exploration effort in Nevada in decades was also recently conducted just west of the Ruby Mountains–East Humboldt Range. Although two geothermal power plants already reside in northeast Nevada, the region's full geothermal energy potential has not been tapped, and further development is possible in many areas. In 2016–2017, NBMG scientists collaborated with other national research teams, funded by the U.S. Department of Energy's Small Business Vouchers Pilot Program, to investigate the optimal location and economic viability of direct-use geothermal energy near Wells, NV. This project benefited from previous NBMG geologic mapping and frameworks studies.



Recently completed geologic maps in the Ruby Mountains–East Humboldt Range study area, east of Elko.

Find additional information on geologic mapping at the
Nevada Bureau of Mines and Geology website
http://www.nbmg.unr.edu/Maps&Data/ActiveMapping.html

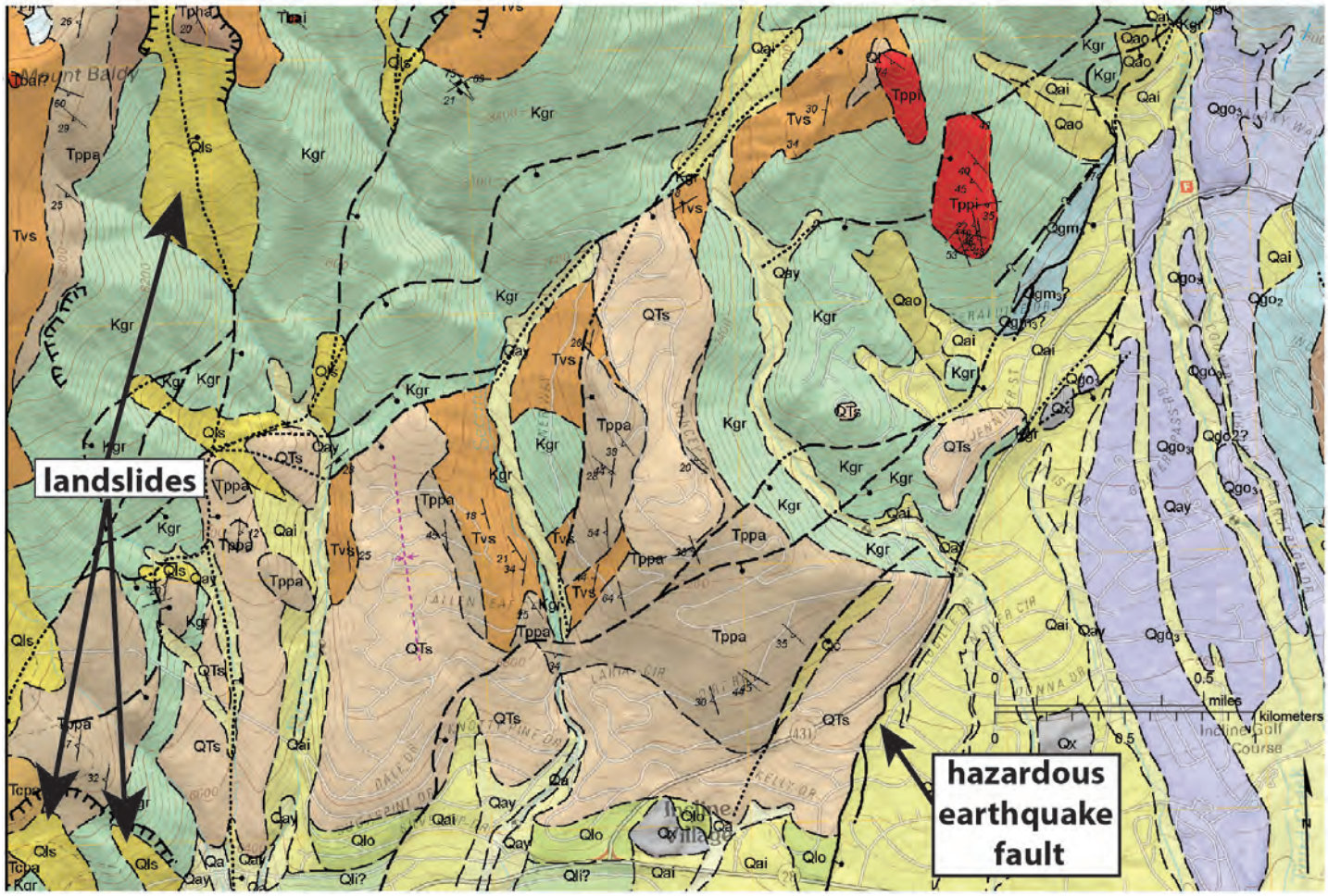
Geologic Mapping

NBMG RESEARCH HIGHLIGHT

Geologic Mapping in the Mt. Rose Area, Reno, Nevada

NBMG has conducted recent geologic mapping in the Mt. Rose area in the Carson Range, west of Reno. Mapping in the area has addressed several research questions regarding the area's history of volcanic eruptions from 2 to 15 million years ago and the timing of uplift of the Sierra Nevada in the last several million years. The maps have also revealed numerous landslide deposits in the recent geologic past and potentially hazardous earthquake faults.

The dynamic landscape surrounding Mt. Rose, Washoe County.
Photographer: Alan Ramelli



A portion of the recently published geologic map of the Mt. Rose quadrangle. The map shows the geology surrounding Incline Village, Nevada, on the north shore of Lake Tahoe. The mapping reveals the recent geologic history of landslides and surface rupturing earthquakes along the Incline Village fault.

Find additional information on geologic mapping at the
Nevada Bureau of Mines and Geology website
http://www.nbmg.unr.edu/Maps&Data/ActiveMapping.html

Mineral Resources and Economic Geology

In both 2016 and 2017, Nevada once again led the nation in the value of its non-fuel mineral production. In 2017, the value was $8.2 billion, with gold accounting for $7.1 billion. In 2017, Nevada produced 5.64 million ounces, making it the fourth-largest producer in the world after China, Russia, and Australia. Nevada has been the focus of the longest, most productive gold boom in the nation's history. Through 2017, Nevada has produced 200 million ounces of gold since 1980. The boom really began in 1965, when the Carlin mine was put into production. The Carlin deposit was different in that the gold was "invisible," located in the crystal structure of the mineral pyrite (otherwise known as fool's gold). Since then, dozens of Carlin-type deposits have been discovered and mined in north-central and northeastern Nevada, accounting for the vast majority of gold production during the boom. Nevada also produced significant amounts of copper, silver, barite, gypsum, and lithium, along with other mineral commodities in 2016 and 2017.

Blast at the Bald Mountain Mine, White Pine County. *Photographer: Steve Castor*

NBMG plays a key role in providing information and carrying out research on Nevada's minerals, which help to spur mineral exploration and development. This information and data are vital to companies that come to Nevada to explore. It saves these companies time and resources in tracking down and compiling data and is especially important for smaller companies. Much of this information comes from mineral industry reports that NBMG publishes annually. These reports contain summaries of production numbers and trends from active mines, as well as summaries of exploration and development projects. NBMG also maintains an online archive of historic mining and exploration records, reports, and maps that go back to the 1800s. In addition, NBMG conducts a semiannual survey of exploration companies, focused on expenditures, employment numbers, and factors that impact exploration in Nevada. Past surveys have shown that small "junior" companies account for nearly half of the mineral exploration expenditures in Nevada.

NBMG also plays an important role in helping state, local, and government officials and agencies make informed decisions regarding land use by assessing mineral potential, mainly on federally managed lands. Mineral assessments are required by law in many cases, before federally managed lands are removed from mineral entry.

In addition to simply producing information, NBMG carries out both applied and basic research on Nevada's mineral deposits. This research discipline in the geosciences is known as "economic geology." Research in economic geology includes detailing the geology of mining and individual ore deposits, identifying the geologic controls on ore from the micron to crustal scale, and identifying the physiochemical processes that were responsible for the deposition of metals and other economic minerals. The products are maps, reports, and publications in scientific journals. The more exploration geologists know about the geology and controls for a specific ore deposit and the processes that form ore, the better equipped they are in predicting where a new ore body may occur. Most of the research has been on gold deposits, but significant effort has also been directed toward other deposits, including lithium.

Find additional reports and data on Nevada's mineral industry at the
Nevada Bureau of Mines and Geology website
http://www.nbmg.unr.edu/Mining/index.html

Mineral Resources and Economic Geology

Much of this research is carried out by the Ralph J. Roberts Center for Research in Economic Geology, known as CREG, which has been housed in NBMG since 2013. CREG is a partnership between the Mackay School of Earth Sciences and Engineering, the Nevada mining and mineral exploration industry, and the U.S. Geological Survey. These partners pool their resources to fund graduate students to carry out research. Typically, ~5–10 students are funded by CREG at any given time. The goals of CREG are to 1) prepare well-educated professionals for careers in the mining industry or in research by exposing them to a wealth of expertise within UNR, the industry, and the U.S. Geological Survey, and 2) produce and publish high-quality research results on topics of critical interest to the Nevada mining industry. In 2016 and 2017, companies donated $211,200 and $187,000, respectively. The U.S. Geological Survey contributed $70,000 as part of its cooperative agreement with UNR. Since inception of the CREG program in 1996, companies have donated just over $3 million, and 50 students have received their graduate degrees. In 2016 and 2017, five students graduated with their MS degrees, and one with a PhD. Many of the graduates moved to Nevada to earn their degrees at UNR and then remained in Nevada with jobs in the mining and mineral exploration industry.

NBMG geoscientists also carry out geologic framework studies of mineral deposits in the region. These studies typically involve geologic mapping, analyses of fault zones, and geochronology involving the dating of different rock types. Completed maps in 2016 and 2017 include the McDermitt caldera in northern Nevada, which includes one of the world's largest lithium-bearing clay deposits, the Kinsley gold mining district in eastern Nevada, and two maps covering a large portion of the Pequop Mountains, where the new Long Canyon gold mine is located.

Future work in economic geology will continue to focus on gold, silver, copper and other metallic ore deposits, particularly how to explore for them where covered by other rocks. Large basins filled with relatively recent alluvial sediments cover half of Nevada. Research focusing on the "footprint" of known deposits, including patterns of hydrothermal alteration and metal zoning, will help companies vector into ore deposits with fewer drill holes. In addition, future research will likely include studies of critical elements, particularly if federal funds become available for Federal Executive Order 13817 of December 20, 2017, "A Federal Strategy to Ensure Secure and Reliable Supplies of Critical Minerals." Of the 35 critical elements listed in the Executive Order, Nevada produces, has produced, or has the potential to produce lithium, barium (barite), magnesium, tungsten, arsenic, antimony, fluorite, vanadium, and cobalt. Very few of the thousands of old mines, including tailings and non-ore waste piles, in Nevada have been analyzed for their potential to contain critical elements, including cobalt, rhenium, tellurium, gallium, scandium, and indium.

Graduate students in the economic geology program learning how to map in detail open-pit mine exposures (inactive MacArthur open-pit copper deposit, located near Yerington). *Photographer: Dylan Baldwin*

Graduate student field course near Yerington Nevada, looking at deep exposures of the Yerington batholith. *Photographer: Greg Dering*

Find additional reports and data on Nevada's mineral industry at the
Nevada Bureau of Mines and Geology website
http://www.nbmg.unr.edu/Mining/index.html

Mineral Resources and Economic Geology

NBMG RESEARCH HIGHLIGHT

The Nevada Mineral Industry 2016

Starting in 1979, NBMG has issued annual reports that describe the mineral (metals and industrial minerals), geothermal, and oil and gas activities and accomplishments. Information on production, reserve and resource statistics, exploration and development, including drilling and new discoveries, is included.

This is a web-only publication available free on the NBMG website:

Special Publication MI-2016, 187 pages
http://pubs.nbmg.unr.edu/The-NV-mineral-industry-2016-p/mi2016.htm

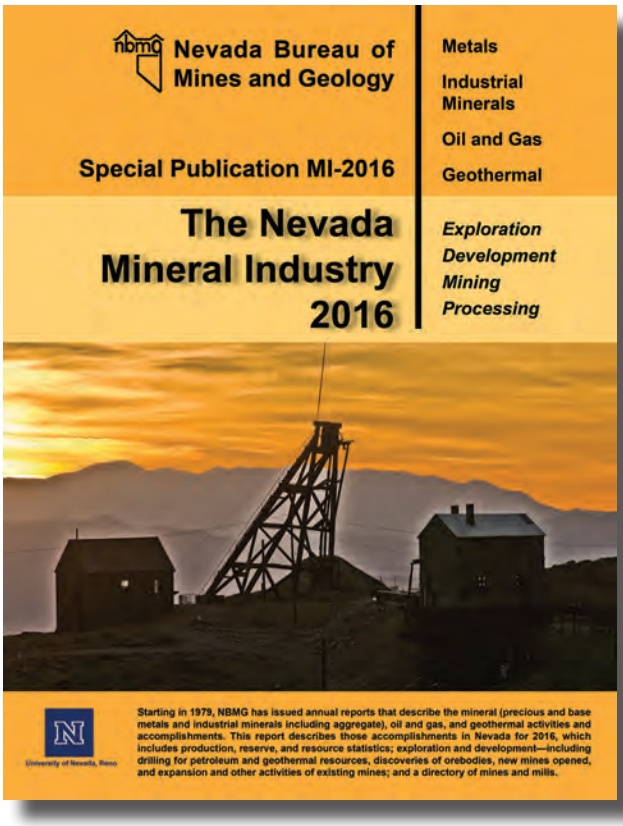
NBMG RESEARCH HIGHLIGHT

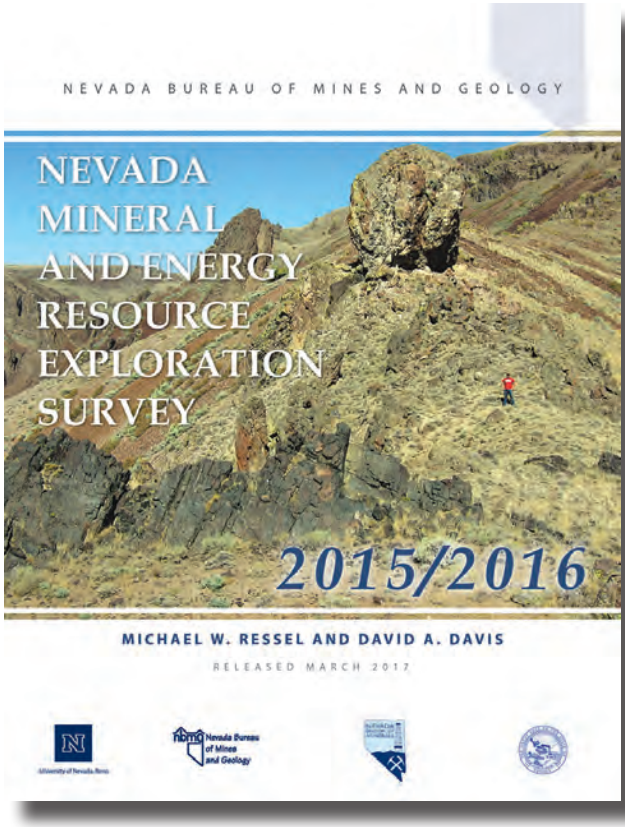
Nevada Mineral and Energy Resource Exploration Survey 2015/2016

NBMG carried out an online survey of companies exploring for new metal, industrial mineral, and geothermal resources in Nevada. Exploration success is imperative for the continued well-being and sustainability of natural resource industries in Nevada.

Copies for sale or available free on the NBMG website:

Exploration Survey ES-2016, 16 pages
http://pubs.nbmg.unr.edu/NV-exploration-survey-2016-p/es2016.htm





Find additional reports and data on Nevada's mineral industry at the
Nevada Bureau of Mines and Geology website
http://www.nbmg.unr.edu/Mining/index.html

Geothermal

Nevada has more geothermal resources than any other state and currently is second (after California) in the production of geothermal energy. At present, Nevada has ~700 MWe of installed electricity generation capacity, but all studies indicate vast untapped geothermal potential in the region. One MWe provides enough electricity for ~700–1,000 homes. In 2016–2017, geothermal electricity generation increased compared to 2014–2015. Two major geothermal plant expansions were completed (McGinness Hills Phase 2 and Don A. Campbell Phase 2), and the new Tungsten Mountain geothermal plant came online. The geothermal team at NBMG was very productive in 2016 and 2017, with completion of several major research projects (most funded by the U.S. Department of Energy), supervision of several graduate students at UNR, multiple new publications, a successful offering of the National Geothermal Academy training program (see photo below of Drilling Engineering and Reservoir Engineering modules offered in 2017), and outreach activities. Additionally, the Great Basin Center for Geothermal Energy (GBCGE) found a new home in NBMG in April 2016 with the hiring of Dr. Bridget Ayling as Center Director and Associate Professor. Dr. James Faulds went on sabbatical to New Zealand for the later part of 2017 through June 2018, extending our collaborative relationships internationally with the University of Canterbury, and Geological and Nuclear Sciences (GNS) (New Zealand's national geological survey organization).

Instructors and attendees at the Reservoir Engineering module of the 2017 National Geothermal Academy, held at the University of Nevada, Reno, Redfield campus in south Reno, June 2017.

RESEARCH PRIORITIES

Our research priorities broadly relate to addressing the key geothermal exploration and development challenges in Nevada that include the following:

1. Identifying and locating hidden (blind) geothermal systems that have no active thermal expression at the surface (e.g. hot springs or fumaroles);
2. Finding the permeability 'sweet spot' or 'play fairway.' High temperatures are relatively easy to find at depth in Nevada, but the primary challenge for geothermal development is locating sufficient fluid flow (or permeability). Permeability is usually controlled by faults, which results in localized zones of permeability that can be difficult to target with drilling.
3. Optimizing the placement of geothermal injection and production wells to ensure resource sustainability (i.e. to minimize thermal drawdown of the resource).

To address these challenges, the NBMG geothermal team conducts innovative, applied research in the following areas:

- Investigation of the geological factors that control where geothermal resources are located in Nevada;
- Development of new approaches for geothermal exploration to facilitate discovery of 'blind'/hidden geothermal systems; and
- Subsurface characterization to optimize the development and sustainable management of geothermal reservoirs (both conventional and Engineered Geothermal Systems or "EGS"). EGS systems are those that have insufficient permeability to allow commercial rates of fluid production, and require reservoir stimulation to create new fractures and thus new fluid pathways.

The NBMG geothermal team obtained funding from the U.S. Department of Energy in 2016 and 2017 for several projects, including the *Nevada Play Fairway Project (Phases 2 and 3), the Fallon Frontier Observatory for Research in Geothermal Energy (FORGE) Phase 2 Project, the Hawthorne Deep-Direct-Use Project, and Applications of Ambient Seismic Noise Interferometry to Characterize the Subsurface in Dixie Valley.* Additionally, a new project was funded by the U.S. Department of State that focuses on building geothermal capacity in foreign countries with geothermal potential via training, country exchanges, and collaborative research.

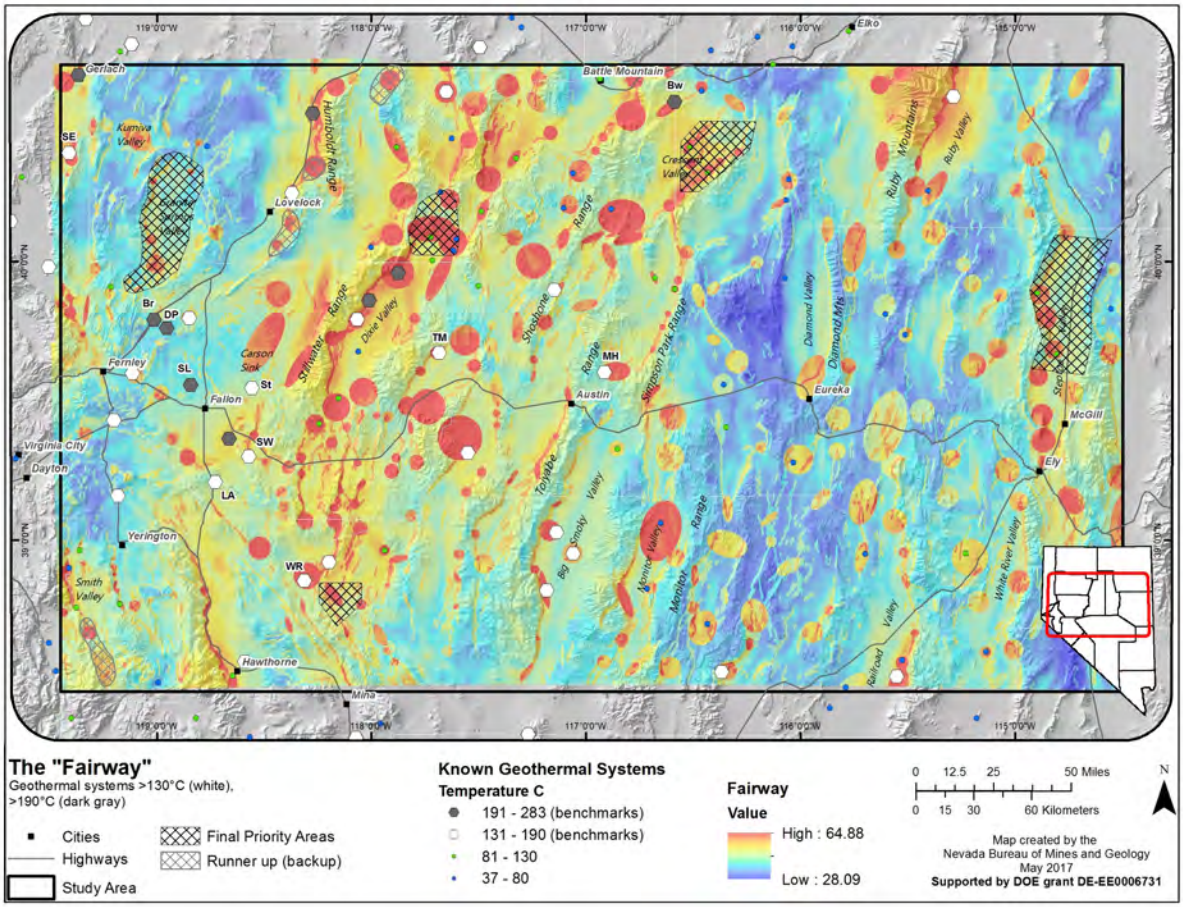
Find additional information on geothermal at the
Nevada Bureau of Mines and Geology website
http://www.nbmg.unr.edu/Geothermal/index.html

Geothermal

NBMG RESEARCH HIGHLIGHT

Nevada Play Fairway Project: Phases 1, 2, and 3 (April 2015 to March 2019)

The primary goal of this project is to develop a methodology that will predict the locations of potential blind hydrothermal geothermal systems (i.e. systems with no surface hot springs or steam vents) and distinguish the most promising systems for development. This project has been funded by the U.S. Department of Energy, with $500,000, $825,000, and $1,500,000 provided for Phases 1, 2, and 3, respectively. In Phase 1 of the Nevada play fairway project, an extensive suite of existing geological, geophysical, and geochemical data were compiled and evaluated, in support of locating new areas with geothermal potential and developing a workflow to reduce geothermal exploration risk. A detailed geothermal potential map was produced for 96,000 km^2 of Nevada in Phase 1 (see graphic below). In Phase 2, five sites were selected for more detailed characterization: southern Gabbs Valley, Sou Hills, Granite Springs Valley, Crescent Valley, and Steptoe Valley. Key activities in Phase 2 included additional data collection such as shallow temperature surveys, more detailed geological mapping, acquisition and evaluation of geophysical data, geological modeling, and water sampling for geochemical analysis. Phase 3 aims to validate the play fairway workflow developed in Phases 1 and 2 via confirmation (thermal gradient) drilling and more detailed geophysical surveys. Two locations were prioritized for Phase 3 work: southeastern Gabbs Valley (in Mineral County) and northern Granite Springs Valley in Pershing County.



Geothermal potential map produced from Phase 1 of the Nevada Geothermal Play Fairway Project (Faulds et al., 2017). Warmer colors indicate relatively higher favorability for geothermal resources, compared to cooler colors. Stippled areas indicate priority study areas for Phase 2 of the project.

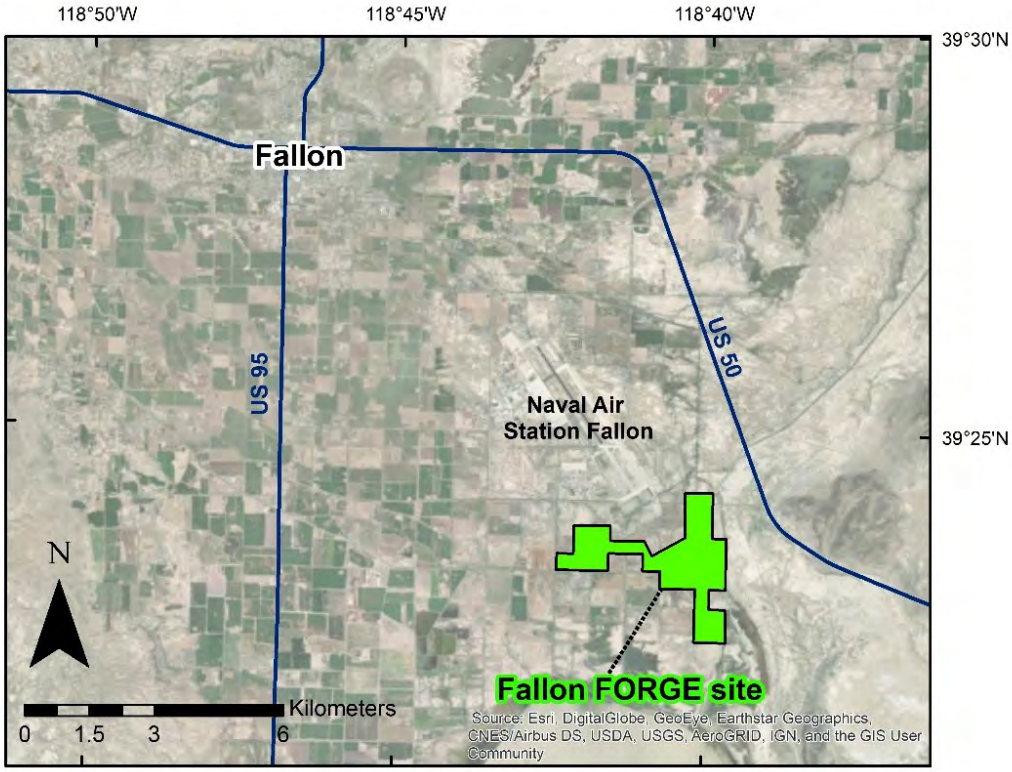
Find additional information on geothermal at the
Nevada Bureau of Mines and Geology website
http://www.nbmg.unr.edu/Geothermal/index.html

Geothermal

NBMG PROJECT SPOTLIGHT

Fallon Frontier Observatory for Research in Geothermal Energy (FORGE): Phase 1, 2a, 2b

The goal of this project was to select and demonstrate site viability to host the FORGE field research laboratory, where the scientific and engineering communities can conduct research and test technologies to make Engineered Geothermal Systems (EGS) commercially viable. FORGE will be a world-class, one-of-a-kind laboratory designed to test the most advanced technologies for EGS. Sandia National Laboratories is the lead on the entire Fallon FORGE project. However, NBMG is the lead on developing the geological model for the site, in collaboration with several other organizations, including the USGS, Navy Geothermal Program Office, and Ormat Nevada, Inc. This project spanned all of 2016 and 2017. In Phase 1, the Fallon FORGE site (see below map) was selected as a potential candidate for experiments related to developing deep, engineered geothermal reservoirs. Phase 1 activities included substantial compilation and review of the existing geological, geochemical, geophysical, environmental, logistical, and hydrological data from the Fallon site to determine the suitability of the site to host FORGE. In Phase 2, key activities included securing additional environmental permits and initiating an Environment Assessment (EA); extensive outreach with key local, regional and state stakeholders (see photo next page); preparing an induced seismicity mitigation plan (ISMP); acquisition of seismologic and geodetic baseline datasets; reprocessing and reinterpretation of preexisting seismic reflection profiles; acquisition of new, detailed gravity and magnetic data; refining the Phase 1 3D model of the site (see oblique model next page) based on the new geophysical data and reinterpreted seismic reflection profiles; geomechanical and reservoir modeling; and siting and drilling a deep well to provide additional certainty that the target reservoir has low permeability and is suitable for FORGE experiments.



General map of the Fallon FORGE site location (adjacent to the Naval Air Station Fallon).

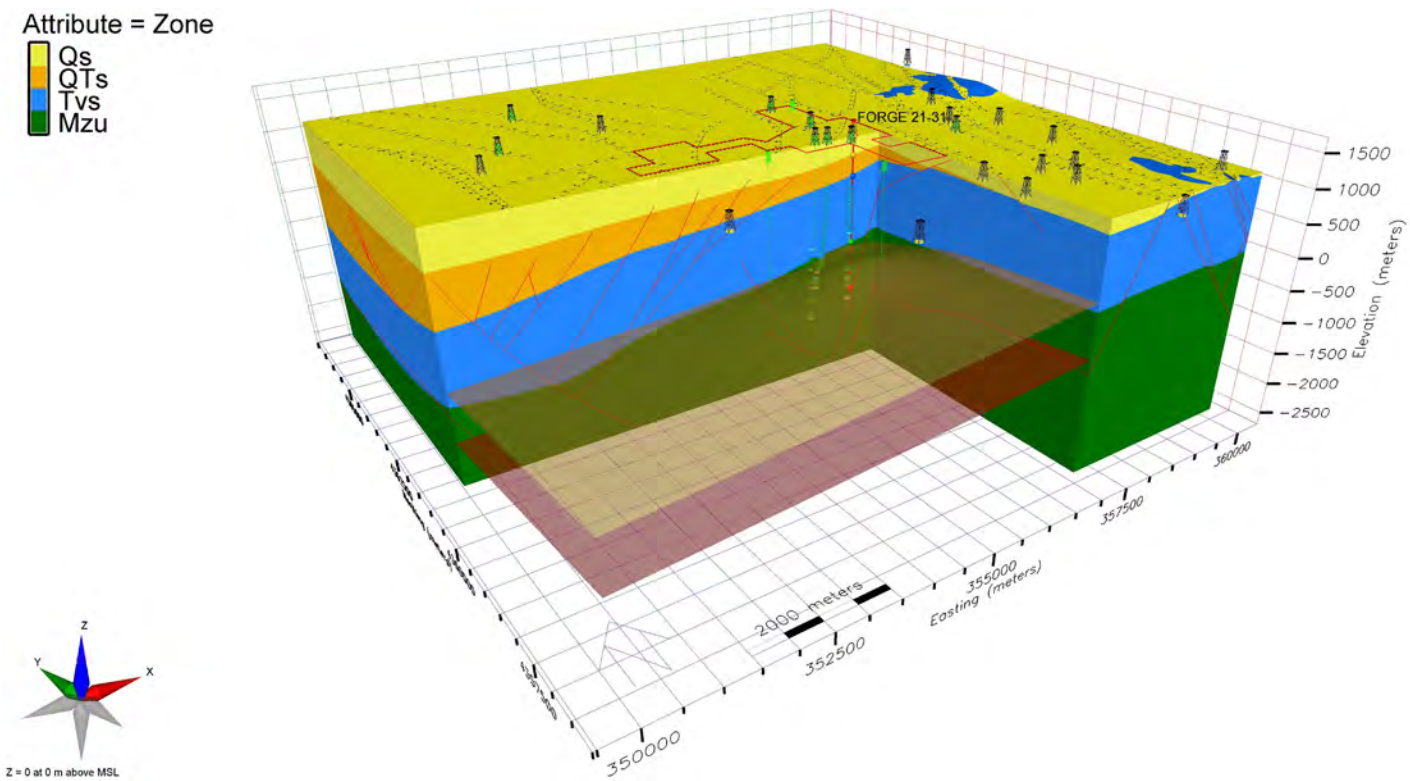
Find additional information on geothermal at the
Nevada Bureau of Mines and Geology website
http://www.nbmg.unr.edu/Geothermal/index.html

Geothermal

NBMG PROJECT SPOTLIGHT

Fallon Frontier Observatory for Research in Geothermal Energy (FORGE): Phase 1, 2a, 2b (continued)

The Fallon FORGE team participating in the annual Fallon Cantaloupe Festival and County Fair in August 2017, to raise awareness of the Fallon FORGE project and engage with the local community.



Oblique view of the Fallon FORGE 3D geologic model looking northeast. The model cut-out is sliced east-west and north-south through the Fallon FORGE site, as outlined in red at the surface. The 175°C (347°F) (orange, transparent) and 225°C (437°F) (red, transparent) modeled isosurfaces are shown. Black rig symbols indicate wells with lithologic data, and green rig symbols indicate wells with temperature data. The red well path is the FORGE 21-31 well. Mesozoic undivided basement (Mzu) is in green, Miocene volcanic rocks (Tvs) in blue, Quaternary/Tertiary sediments (QTs) in orange, and Quaternary in yellow.

Find additional information on geothermal at the
Nevada Bureau of Mines and Geology website
http://www.nbmg.unr.edu/Geothermal/index.html

Geothermal

NBMG PROJECT SPOTLIGHT

Field Research

NBMG/UNR students and faculty on a field trip to the Beowawe geothermal field with colleagues from the University of Utah in May 2017. The hole in the foreground is a fossil geyser (steam vent) that discharged boiling water onto the terrace below in historical times.

NBMG collaborators from Lawrence Berkeley National Laboratory (LBNL) sampling spring water for geochemistry analysis nears Wells, NV, in support of a low-temperature geothermal resource study for the City of Wells, May 2017.

A GeoProbe push-core rig in action at Wells in the spring of 2017 for a project involving NBMG researchers that evaluated the potential for low-temperature geothermal resources to contribute to the heating needs of the City of Wells. The goal of these surveys is to obtain shallow temperature measurements and identify a geothermal anomaly at depth.

Find additional information on geothermal at the
Nevada Bureau of Mines and Geology website
http://www.nbmg.unr.edu/Geothermal/index.html

Geologic Hazards

Nevada is at risk from numerous geologic hazards including earthquakes, flooding, landslides, and debris flows. NBMG scientists research these hazards to reduce exposure to potential risks and educate the public on hazard preparedness.

The state of Nevada lies within the Basin and Range Province, one of the most seismically active regions in the United States. Hundreds of active faults exist within Nevada, many of which are capable of generating damaging earthquakes. There have been over 20 strong earthquakes (magnitude ≥ 6) in the last ~160 years.

During 2016 and 2017, NBMG acquired funding and began numerous studies along active faults with the goal of generating information on the rates of movement (slip rates) and the timing and recurrence of past [prehistoric] earthquakes. The information developed in these studies is used for building codes and helps to better understand the size and location of future earthquakes. NBMG continued to participate in the Western States Seismic Policy Council and had an active role in writing policy statements aimed at reducing seismic risk. NBMG staff conducted new geologic mapping in geologic hazard areas as part of the USGS STATEMAP program and began to evaluate the locations of landslides and active faults on new high-resolution topographic data (lidar–3D Digital Elevation Program). Details on the geologic mapping program and recent lidar acquisitions are described elsewhere in this biennial report. NBMG staff also interacted with emergency management personnel, providing rapid response and situational monitoring during the January, 2017 floods in western Nevada along the Truckee and Carson rivers and the Hawthorne earthquake sequence (three M>5 earthquakes on Dec. 28, 2016).

NBMG also made significant contributions during 2016–2017 in developing broad hazard assessments and mitigation plans. The Nevada Hazards Mitigation Plan was updated by NBMG and is available through the NBMG website. Nevadans can obtain the most recent hazard information and maps from the updated MyHazards-Nevada website, which was developed and is maintained by NBMG.

A

B

C

Photographs of the January, 2017 flood that affected western Nevada. (A) Debris-flow deposits and road erosion on SR446 near Pyramid Lake. (B) Last Chance Ditch near Dryden Drive in Reno. Overflowing water conveyance systems caused flooding in several residential areas. (C) The Truckee River overflowing its banks near Lockwood. *Photographer: Jim Faulds*

Find additional information on geologic hazards in Nevada at the
Nevada Bureau of Mines and Geology website
http://www.nbmg.unr.edu/Geohazards/index.html

Geologic Hazards

NBMG also acquired funding to organize the Nevada Seismic Hazards Workshop, which will be held in Reno in February 2018. The workshop will be attended by geoscientists from academia, federal and state governments, and industry. Discussions and presentations at the workshop will focus on the state-of-knowledge on earthquakes aimed at developing a set of research priorities to strategically characterize seismic hazards in Nevada.

NBMG made significant progress in 2016–2017 in understanding earthquake hazards in several parts of the state. The most significant study involved an ongoing effort spearheaded by NBMG in analyzing potential earthquake-prone faults in Las Vegas. This work is funded by Clark County. It includes detailed analysis of all recent faulting in Las Vegas Valley, including substantial new mapping and geochronological analyses focused on defining the ages and frequency of recent major earthquakes. Additionally, studies funded by the U.S. Geological Survey National Hazards Reduction Program include a study of faults in the North Valleys of Reno, with trenching investigations along the Petersen Mountain, Freds Mountain, Warm Springs Valley, and Lemmon Valley faults, as well as the Kings Canyon fault in Carson City. Trenching in the Las Vegas Valley includes projects along the Eglington and Frenchman Mountain faults. Fault trenching involves using an excavator to expose the geologically young soils and sediments displaced by the fault. These trenching projects and their locations are described in greater detail below.

Photograph of damage that occurred to the historic Nine Mile Ranch house during the Hawthorne earthquake sequence in December, 2016, Mineral County. Note dislodged wall bricks on the roof and side of house.

HIGHLIGHTS OF THE GEOLOGIC HAZARDS PROGRAM

Earthquake Hazard Studies in Las Vegas Valley

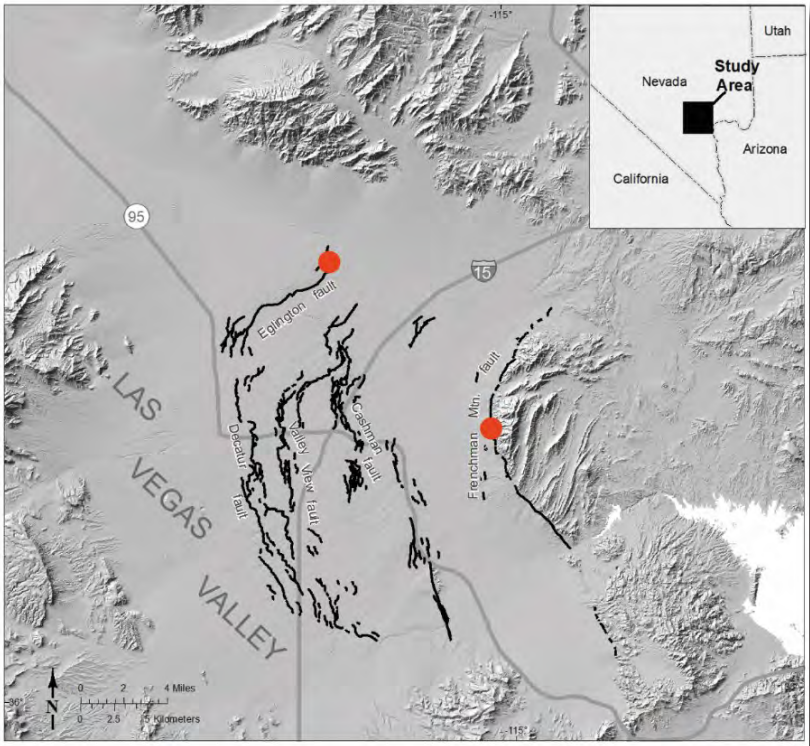
The earthquake hazards in Las Vegas Valley are being investigated through the study of young faults and paleoearthquakes. Las Vegas is located in a seismically active region, and active faults have been mapped throughout the basin. Movement along some of these local faults, such as the Decatur fault and Eglington fault, helped to produce the valley beginning over 14 million years ago, and youthful scarps along these faults are evident at the ground surface. But the origin of the scarps has been a long-standing debate among scientists and engineers. Were they created by earthquake ground offsets or compaction of sediments? Studying these poorly understood faults in a highly urbanized setting with limited natural exposures presents a set of challenges, and NBMG thus assembled an expert team of geologists from NBMG, UNLV, and the U.S. Geological Survey to address the problem. This research is funded by a grant from the Clark County Building Department. Preliminary results of the multi-year study include identification and dating of the last two or three paleoearthquakes along the Frenchman Mountain fault, interpretations of excavations and dating of soils along the Eglington fault, and drafting of a new geologic map of the valley. Rock chips from water wells in the valley that are housed at the NBMG's Great Basin Science Sample and Records Library have been examined at UNLV looking for clues in understanding sediment compaction potential. The results of this four-year study will give needed insight into the seismic potential of faults in the Las Vegas Valley and will provide appropriate levels of hazard assessment needed for developing building codes and land use planning in the valley.

Find additional information on geologic hazards in Nevada at the
Nevada Bureau of Mines and Geology website
http://www.nbmg.unr.edu/Geohazards/index.html

Geologic Hazards

Earthquake Hazard Studies in Las Vegas Valley (cont.)

A



B

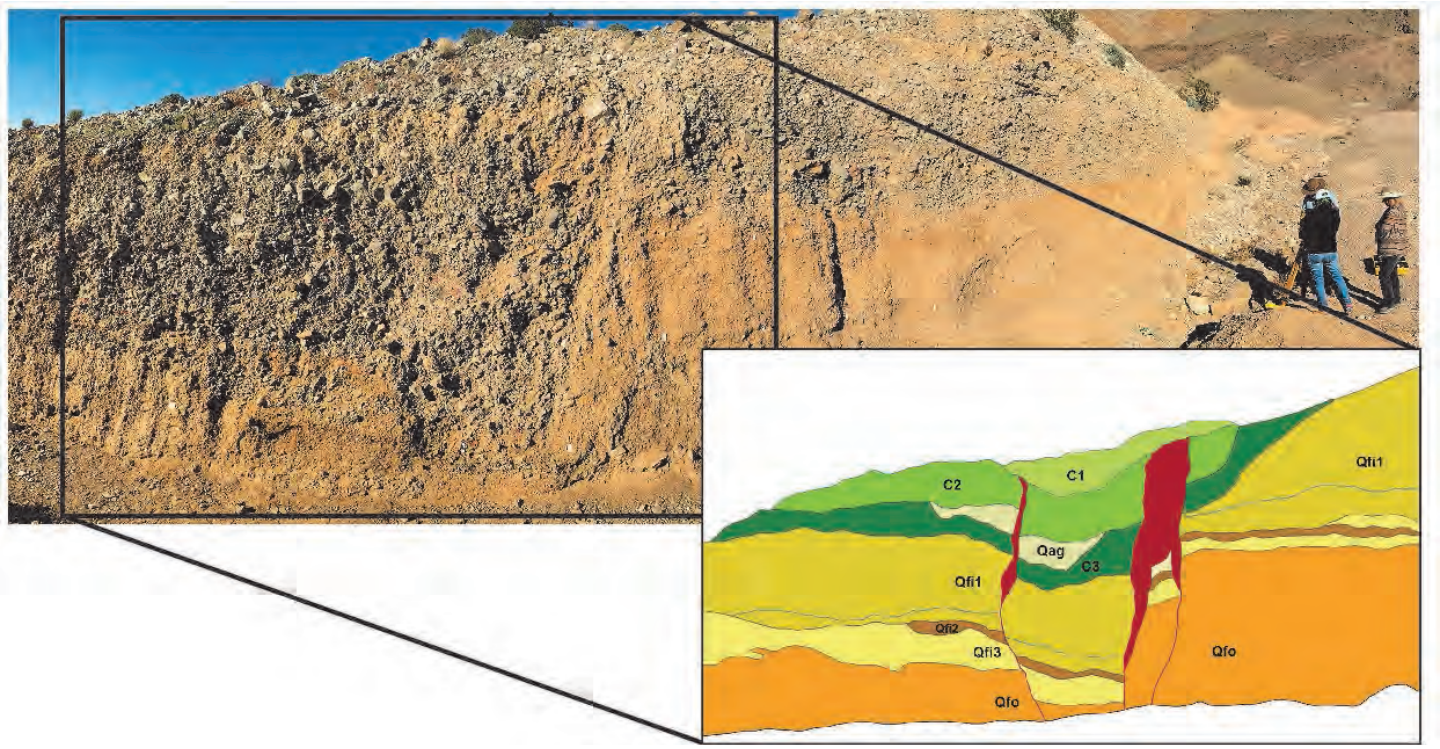
(A) Map showing faults in the Las Vegas Valley and location of paleoseismic trenching studies on the Eglington fault and Frenchman Mountain faults (red circles), and (B) photograph of 10-m-high (30 ft) scarp along the Decatur fault, where it crosses Alta Road in Las Vegas. Approximate location of the fault shown by dashed red line.

NBMG geologists mapping and characterizing sediments exposed in a trench excavated across the Eglington fault within the Las Vegas Valley fault system.

Find additional information on geologic hazards in Nevada at the
Nevada Bureau of Mines and Geology website
http://www.nbmg.unr.edu/Geohazards/index.html

Geologic Hazards

Earthquake Hazard Studies in Las Vegas Valley (cont.)



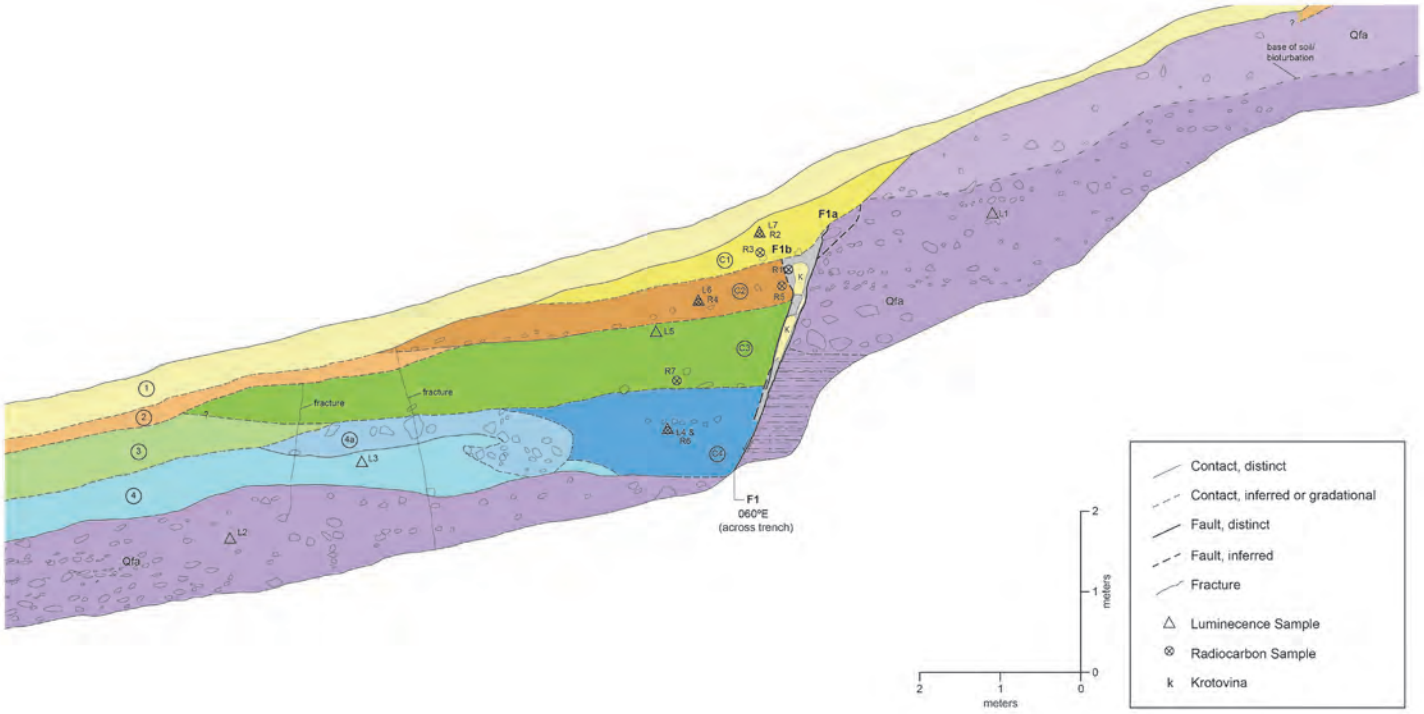
An excavation (above) at the foot of Frenchman Mountain, along the east side of Las Vegas Valley, exposes a recently active fault. Investigation of the exposure by NBMG and UNLV geologists yielded evidence for two to three paleoearthquakes, which will be used to understand the hazard posed by the fault. Interpretations of the faulted sediments is shown in the inset sketch.

Find additional information on geologic hazards in Nevada at the
Nevada Bureau of Mines and Geology website
http://www.nbmg.unr.edu/Geohazards/index.html

Geologic Hazards

Paleoearthquake Studies in Carson City

One of the most severe earthquakes in Nevada's history was the June 3, 1887 earthquake that damaged several buildings in Carson City. NBMG geologists, in coordination with the U.S. Geological Survey, analyzed the recent earthquake history along the Kings Canyon fault zone, which surfaces just west of Carson City but projects beneath the city in the subsurface. Careful mapping of the excavation walls and use of state-of-the-art radiocarbon and optical luminescence dating determined that four major earthquakes each offset the ground surface vertically by about 6 feet (2 meters) along this fault. The best estimates for these approximately magnitude 6.8 paleoearthquakes are 530 A.D., 320 A.D., 130 A.D., and 2010 B.C., making this one of the most active faults in Nevada. These findings, along with other fault and seismicity data, indicate that Carson City has one of the highest earthquake hazards in the Basin and Range Province. NBMG geologists work throughout the state developing data like this to characterize the earthquake hazard of Nevada communities for use in developing building codes and for earthquake preparedness.



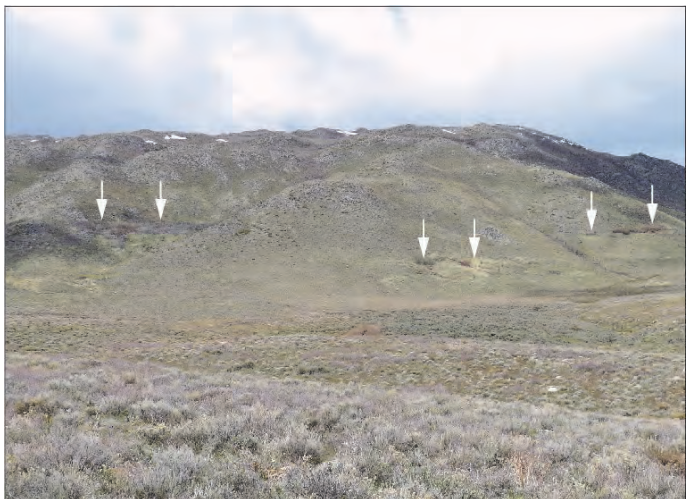
Log of a trench in western Carson City that shows evidence of four earthquakes along the Kings Canyon fault zone. The fault is the contact between the purple-colored alluvial fan deposits and the different-colored wedges of sediment that accumulated against the fault, when it accommodated displacement of the ground vertically by about six feet (2 meters). Thus, the yellow, orange, green, and blue wedges were each induced by an earthquake event. Dating of these wedges yielded the earthquake history.

Find additional information on geologic hazards in Nevada at the
Nevada Bureau of Mines and Geology website
http://www.nbmg.unr.edu/Geohazards/index.html

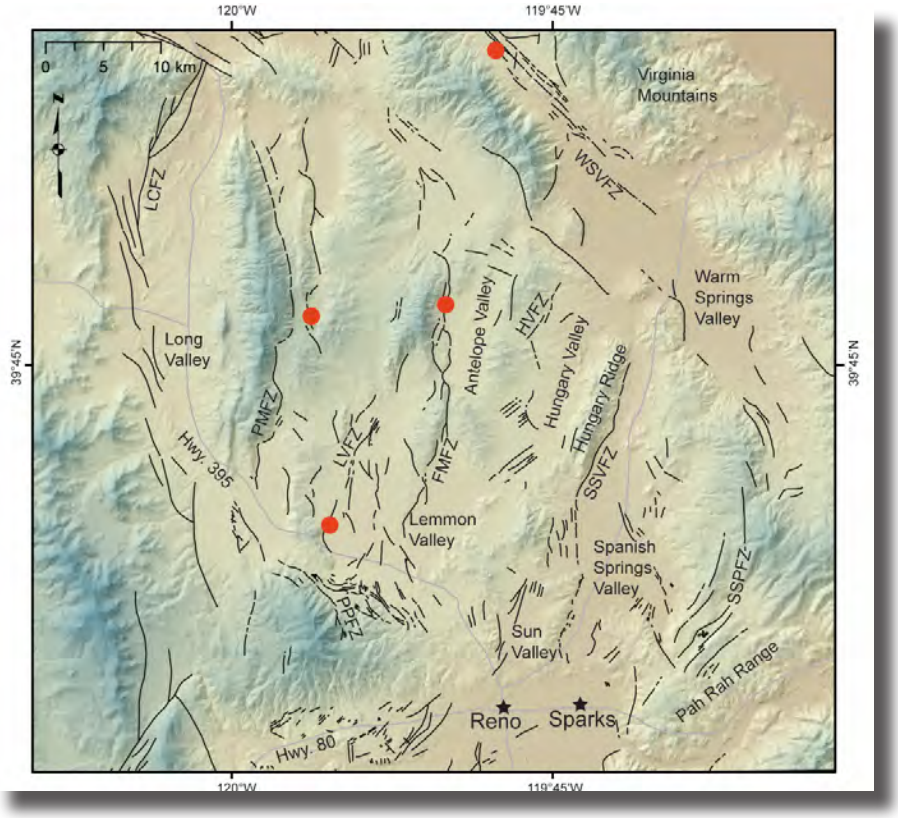
Geologic Hazards

Paleoseismic Studies in the North Valleys, Reno

The North Valleys are a series of valleys located just north of Reno. Active faults are mapped within each of these valleys, including the Petersen Mountain, Freds Mountain, and Spanish Springs Valley faults, but little detailed research has been done to understand the paleoearthquake history of these faults. Earthquakes along these faults pose surface fault rupture and ground-shaking hazards to the rapidly developing North Valleys and the greater Reno metropolitan area. The focus of the recent studies, funded by the USGS, include new mapping of the faults using recently acquired lidar topographic data and fault trenching. Additional trenching is anticipated to occur in 2018. Careful mapping of the exposure combined with various techniques for dating the sediments can produce a chronology of recent earthquakes on the fault. These data are used to better understand the modern seismic hazards in the region and assist planning efforts to minimize seismic risk.



Photograph of the Petersen Mountain fault, an active fault in the North Valleys. White arrows indicate the location of the fault along the mountainside evident by aligned springs and vegetation.



Digital elevation model of the North Valleys showing Quaternary active faults (black lines). This region is experiencing rapid suburban development. Better characterization of these faults is therefore an important aspect of planning efforts. Completed and ongoing investigation sites shown by red circles. LCFZ, Last Chance fault zone; PMFZ, Petersen Mountain fault zone; LVFZ, Lemmon Valley fault zone; FMFZ, Freds Mountain fault zone; SSVFZ, Spanish Springs Valley fault zone; HVFZ, Hungry Valley fault zone; SSPFZ, Spanish Springs Peak fault zone; PPFZ, Peavine Peak fault zone.

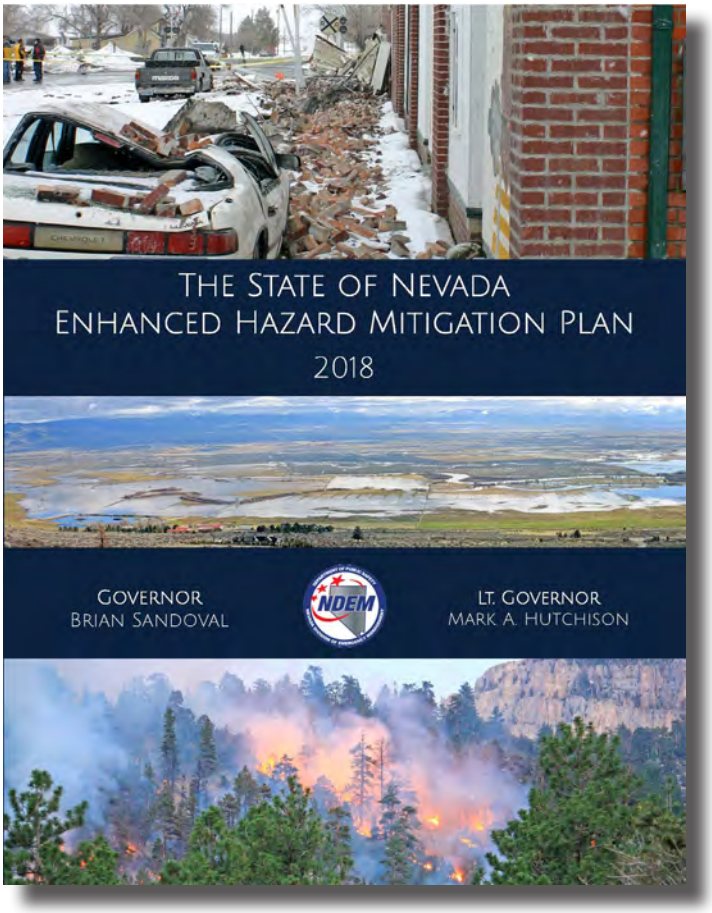
Find additional information on geologic hazards in Nevada at the
Nevada Bureau of Mines and Geology website
http://www.nbmg.unr.edu/Geohazards/index.html

Geologic Hazards

GEOLOGIC HAZARDS AND PUBLIC SAFETY, STATE HAZARD MITIGATION PLAN

Since 2015, NBMG staff have been assisting in the update of the Nevada Enhanced Hazard Mitigation Plan (EHMP) at the request of the Nevada Division of Emergency Management (DEM). The Nevada EHMP is updated every five years and includes state-of-the-art discussions of natural hazards that Nevada faces and mitigation strategies to reduce potential losses as a result of these hazards. The plan is a FEMA requirement for obtaining both disaster declarations following a natural disaster within the state and pre-disaster mitigation funding. The "enhanced" plan status of the hazard mitigation plan (currently 11 out of 50 states have an enhanced status) results in more mitigation funds to the state in the event of a disaster. The Nevada EHMP benefits the state as a whole in many ways and provides increased education and awareness about hazards, preparedness, and vulnerabilities. The Nevada EHMP also helps to identify strategies for risk reduction and builds partnerships with the public and private sectors.

Several hazard summaries were updated by NBMG in the 2016–2017 biennium, including revisions of the landslides, expansive soils, earthquakes, volcanoes, lake tsunami, and naturally occurring asbestos sections. In addition to hazard summary updates, DEM contracted with NBMG to assist in updating the entire Nevada EHMP for a 2018 deadline. This has involved working with other state, regional, local, and tribal entities to compile new statewide data and contributing to hazard education and outreach, among other tasks. It should be noted that local communities use the Nevada EHMP as a guide for their local plans. This revised 1200-page document was submitted to FEMA for review in June of 2018.



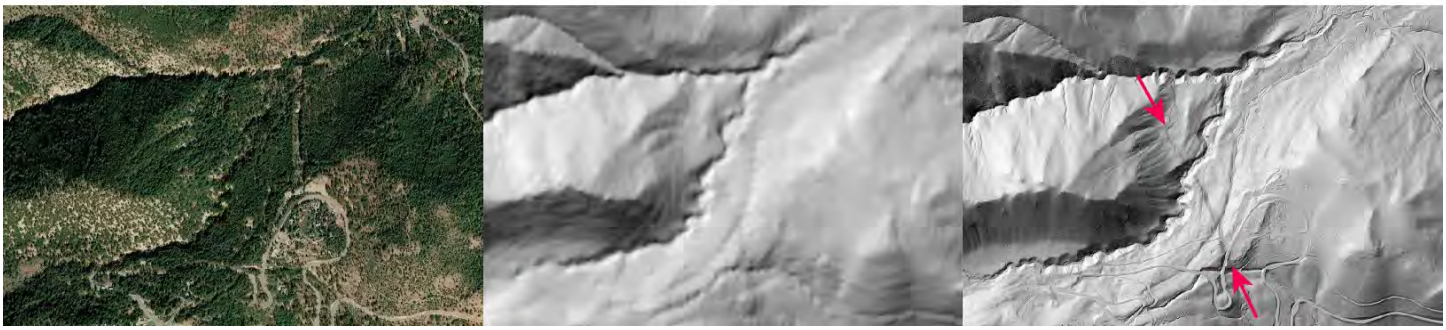
Cover of the 2018 State Hazard Mitigation Plan. The cover shows the top three natural hazards in Nevada: earthquake, flood, and wildfire.

Find additional information on geologic hazards in Nevada at the
Nevada Bureau of Mines and Geology website
http://www.nbmg.unr.edu/Geohazards/index.html

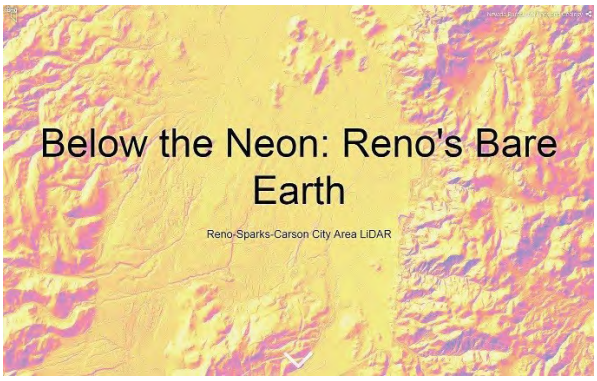
Lidar

High-resolution topographic data acquired via airborne lidar has become an indispensable data source for many of NBMG's key missions. Airborne lidar collections use a laser mounted on an aircraft to map the earth's surface in sub-meter detail. The laser pulses can penetrate vegetation producing a bare earth (vegetation free) topographic model. Lidar data have clear applications for numerous geologic topics including fault, landslide, and floodplain mapping. It is also commonly used for forestry, ecology studies, snowpack surveys, and infrastructure planning. Relative to other states, very little of Nevada has been covered by lidar. Las Vegas Valley and much of the Humboldt River drainage in northeast Nevada represent some of the few areas for which lidar data had been obtained prior to 2016. Notably, the rapidly growing Reno–Sparks–Carson City area had no publicly available data before 2016. In 2016 NBMG was awarded a significant monetary commitment from Research and Innovation at UNR as seed money to support building a consortium to fund lidar acquisition in the Reno–Sparks–Carson City area. This commitment enabled NBMG to subsequently seek and be awarded a grant from the U.S. Geological Survey via the 3D Elevation Program (3DEP) in December 2016. The 3DEP program aims to assist in the collection of lidar data throughout the United States. All data collected through the 3DEP program are made publicly available for download from the USGS National Map.

The initial grant was proposed to capture only QL2 level data (approximately 1-meter [~3 feet] DEM pixel-size coverage) for the Reno–Sparks–Carson City area. Previously, only 10-meter DEM (~30-foot digital elevation model) coverage was publicly available for the entire area. Through partnerships with the community, including the Washoe Regional Basemap Committee (Washoe County, the cities of Reno and Sparks, and NV Energy), the U.S. Forest Service, Lyon County, and Storey County, the proposal was expanded to cover a larger area. The expanded proposal also enhanced nearly half the area to QL1 level data (approximately 0.5-meter [~1.5 ft] DEM coverage). The data were collected in the fall of 2017 and made publicly available in summer 2018. This dataset has immediately been utilized at NBMG for geologic mapping and seismic hazard studies surrounding Reno.



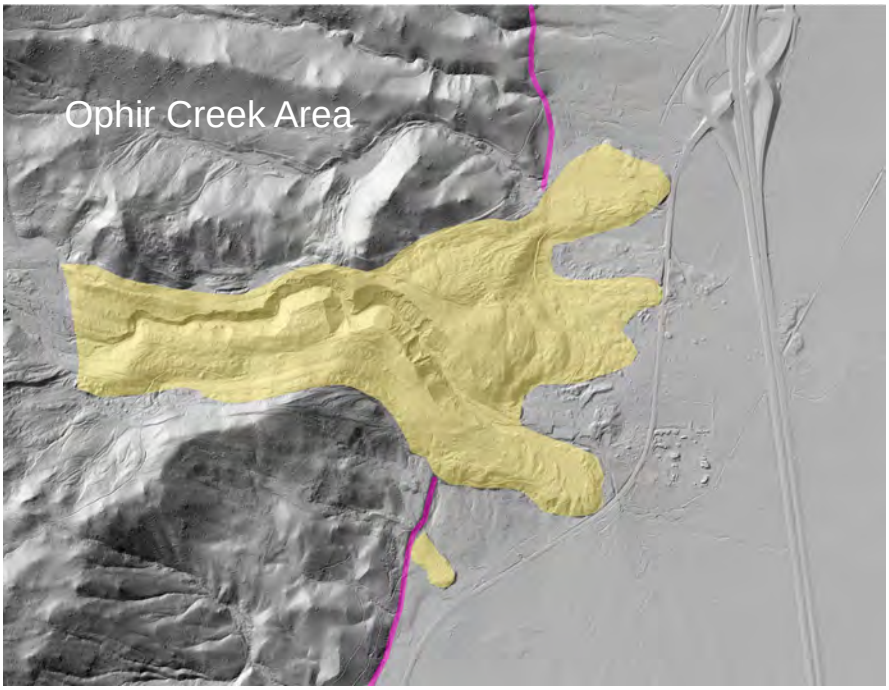
The Galena fault scarp—aerial image (left), 10m DEM (center), and new lidar (right). Prior to this lidar data acquisition, the best public elevation data available for the area were 10-meter DEMs (center) and the best available aerial imagery (left) were of limited use for analyzing detailed geologic, hydrologic, and geomorphology features such as fault scarps, flood plains, and landslides. The example above shows the Galena fault scarp (red arrows) that crosses the Mt. Rose Highway. This is an important geologic feature that was difficult to discern using previously available imagery and elevation data but is easy to identify using the new lidar data.



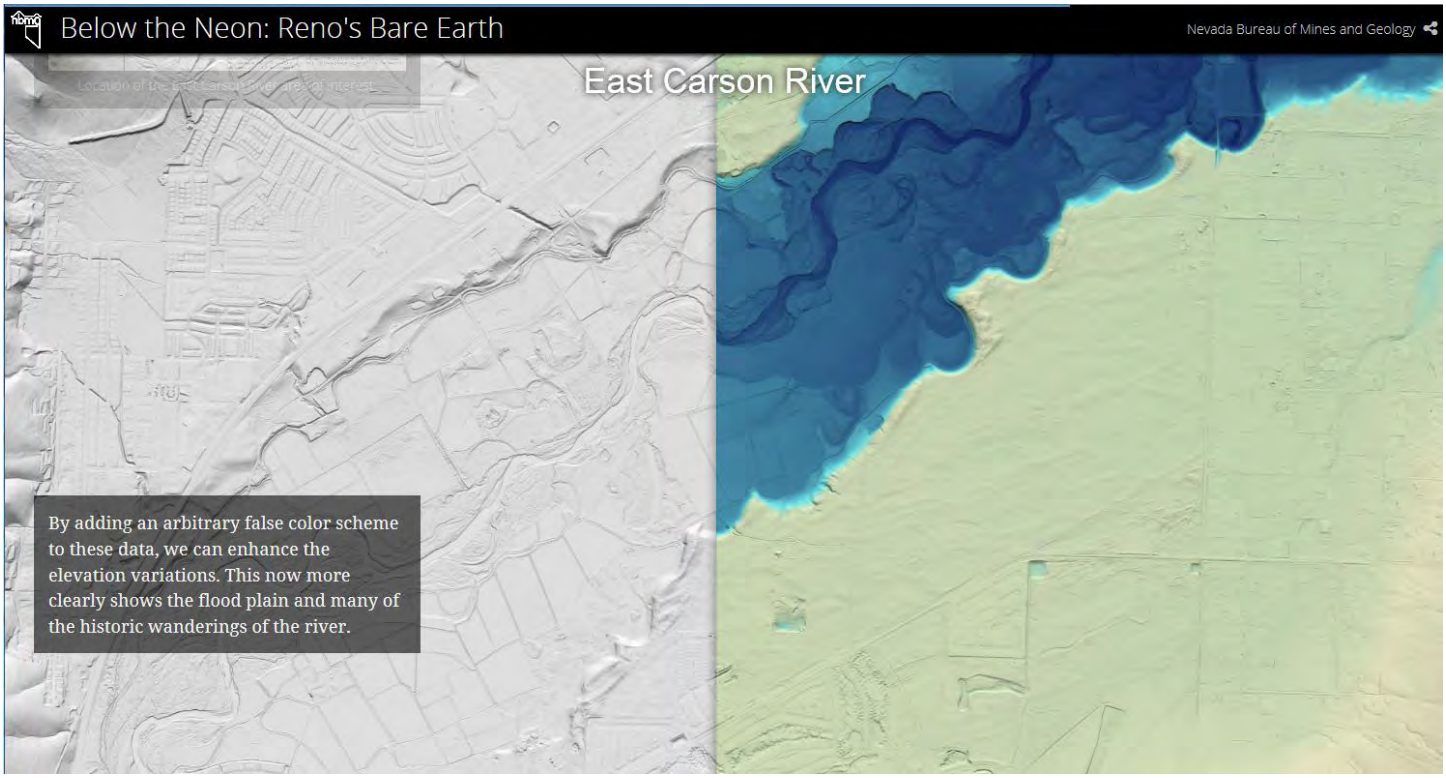
See "Below the Neon," our story map on the NBMG open data site about our recent lidar acquisition.

Find additional information on open data
at the **Nevada Bureau of Mines and Geology website**
https://data-nbmg.opendata.arcgis.com

Lidar



See "Below the Neon," our story map on the NBMG open data site about our recent lidar acquisition, including this landslide along Ophir Creek, Washoe County (left).



See "Below the Neon," our story map on the NBMG open data site about our recent lidar acquisition, including this flooding along the East Carson River, Douglas County (above).

Find additional information on open data
at the **Nevada Bureau of Mines and Geology website**
https://data-nbmg.opendata.arcgis.com

Nevada Geodetic Laboratory

The Nevada Geodetic Laboratory (NGL) conducts research in the field of space geodesy to study scientific problems that have local, regional, and global significance. The NGL is located within NBMG and interacts closely with the Department of Geological Sciences and Engineering, the Nevada Seismological Laboratory, and the Physics Department at the University of Nevada, Reno.

Research at NGL uses extremely precise measurements from the Global Positioning System (GPS) and Interferometric Synthetic Aperture Radar (InSAR) to study active Earth movement. Scientific studies cover a wide range of topics that relate to Earth deformation from natural and human-driven processes. Past and ongoing studies have elucidated Nevada's natural hazards from active faults, earthquakes, and volcanism and have supported Nevada's push for clean energy by monitoring surface deformation associated with geothermal development. More recent research is focusing on vertical movements, how they relate to hydrological conditions in mountains and aquifers, and what these movements may mean for active mountain growth, water resources, and climate change in Nevada. NGL is internationally recognized in its role of pushing forward the science of global geodesy, including patterns of surface mass loading and global-scale plate tectonics.

Research faculty within the NGL at NBMG are Professors Geoffrey Blewitt, William Hammond, and Corné Kreemer, all of whom participate in undergraduate and graduate education at UNR by teaching courses and advising graduate students. Learn more about NGL research, projects, and data products at http://geodesy.unr.edu. The more detailed descriptions below highlight some of the major research efforts by NGL in 2016–2017, including a review of our regional network of GPS stations and applications of data from that network to understanding crustal deformation induced by both plate tectonic motions, human activities, and other geophysical factors.

The GPS Station SEVN near the southern end of the Seven Troughs Range in Pershing County tracks the active tectonic strain that drives earthquake hazards in western Nevada. This station was installed in October 2004 and moves with respect to the rest of North America at a rate of 5.0±0.2 mm/yr. *Photographer: Eduard Nastase.*

Find additional information on the Nevada Geodetic Laboratory at the website:
http://geodesy.unr.edu

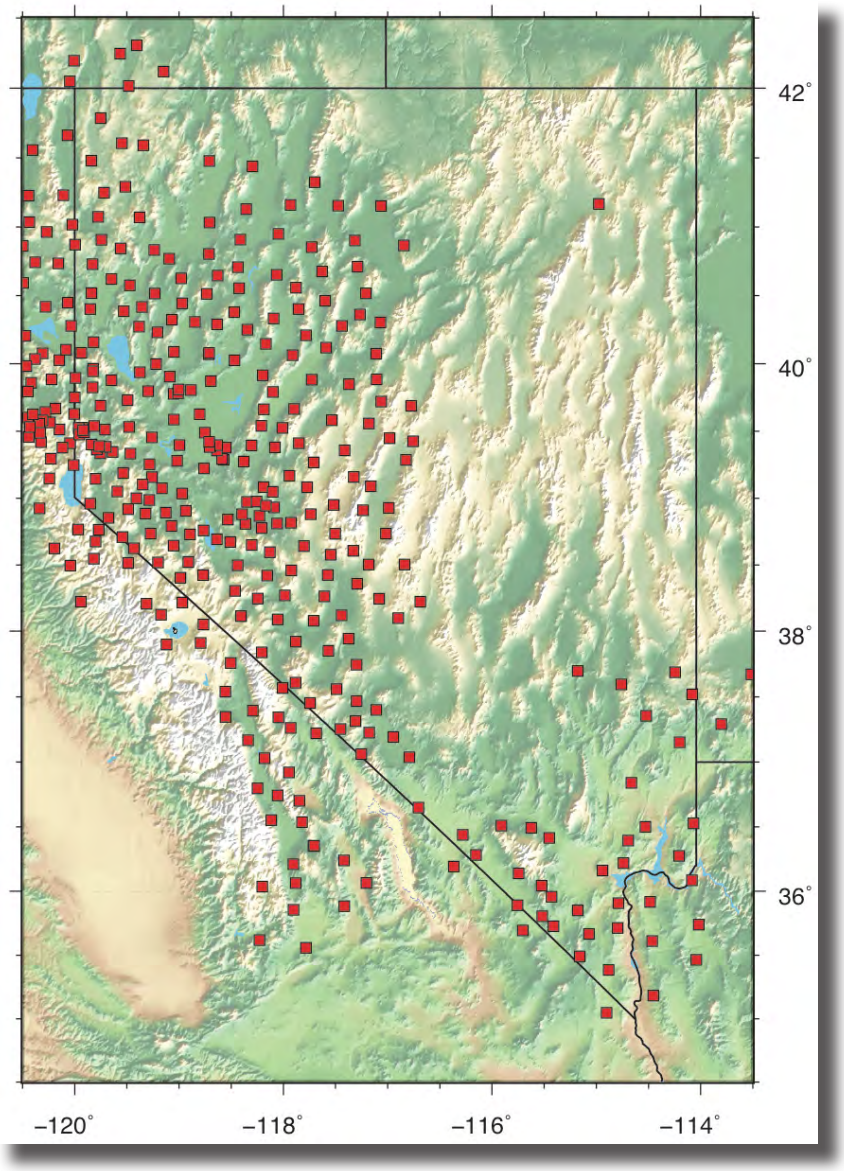
Nevada Geodetic Laboratory

NBMG RESEARCH HIGHLIGHT

The Mobile Array of GPS for Nevada Transtension (MAGNET)

The NGL operates the high-precision MAGNET GPS network in the western Great Basin. In operation since 2004, this network is an infrastructure for Earth science research and natural hazard assessment. MAGNET is comprised of 414 individual locations, where GPS surveys are performed, usually for several months per year. These data give precise location and movement that results from active plate tectonic stretching of the Earth's crust, or other more localized effects such as volcanic or aquifer-related deformation. The data collected in MAGNET are combined with those from other networks in the western United States and are used to assess strain across active faults, earthquake hazards, seismic swarms, geothermal energy potential, mountain uplift, magmatic processes, effects of climate change on the Earth system, and other phenomena of scientific and societal interest.

MAGNET measures motion with such incredible precision that it is usually expressed in tenths of a millimeter per year. At a speed near that resolution it would take ~10 million years to move one mile! Because of its high precision, MAGNET easily measures the active tectonic stretching of the Great Basin, which is connected to Pacific Plate motion on the west side of the San Andreas fault. With MAGNET we can show that the Great Basin increases in area by about an acre each year, as California moves further west relative to Utah. This new territory is, however, distributed over a very large area and so cannot be pinned down to any particular location. However, it does make Nevada the fastest-growing state in the U.S., tectonically speaking.



Map of MAGNET GPS network coverage in Nevada. The location of MAGNET stations is driven by the need for dense geodetic coverage in the western Great Basin, where crustal strain rates are highest. MAGNET covers most of western Nevada, but also touches parts of eastern California, western Arizona and Utah, and southern Oregon. Red squares are individual measurement locations.

Find additional information on the Nevada Geodetic Laboratory at the website:
http://geodesy.unr.edu

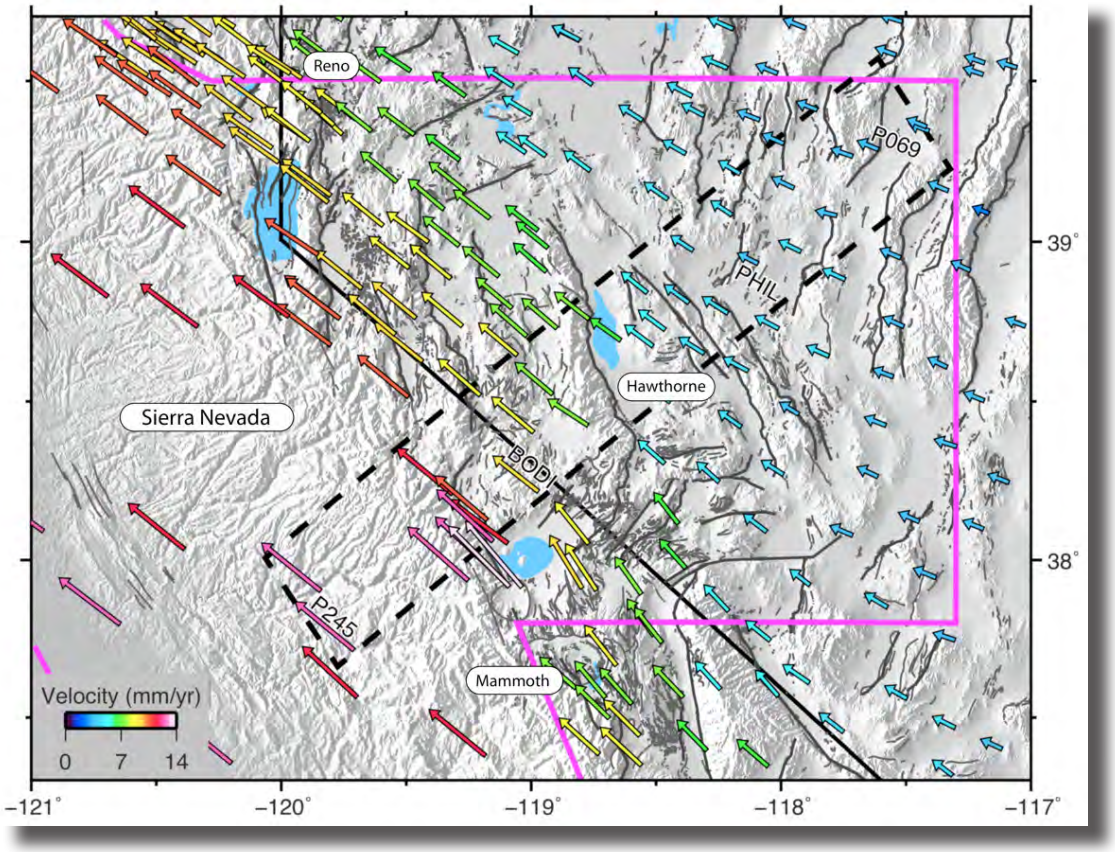
Nevada Geodetic Laboratory

NBMG RESEARCH HIGHLIGHT

Geodesy and the Central Walker Lane 'Missing' Shear Strain

In western Nevada the Walker Lane is a ~100 km-wide (~60 miles) zone of active transtensional faulting that lies between the Sierra Nevada and the extending Basin and Range Province. Transtension in this region involves a combination of right-lateral strike-slip faulting and normal faulting that accommodates the extension of the crust. The Walker Lane actually accommodates ~20% of the motion between the Pacific and North American plates. Earthquakes in this area are plentiful and often felt by residents. However, comparison of geodetic and geologic data in the Walker Lane has revealed a puzzling imbalance between rates of deformation measured by GPS and those expected from studies of earthquake geology. Geodesy has revealed the dominance of active crustal shear deformation (or strike-slip faulting) (figure below), yet the deformation found in the earthquake geology is dominated by extension (or normal faulting). This mismatch has important implications for the state of knowledge of earthquake hazard in Nevada. Among the reasons for the discrepancy are 1) incomplete geologic data on past faulting, or 2) rotations of crustal blocks that account for some of the apparent strike-slip motion measured by GPS.

A recent research project published by NGL graduate student Jayne Bormann shed light on this problem. She used careful modeling of block rotations and translations constrained by the GPS observations to show that while some rotation of blocks may be present, they are not sufficient to account for the 'missing' shear. This suggested that the source of the discrepancy is incomplete data on geologic faults.



Movement of the Sierra Nevada compared to central Nevada, as measured with GPS. Each vector shows how a certain location moves with respect to a fixed North America. Color indicates the rate of movement, and vector indicates direction, with a maximum near 14 mm/yr in California. The increasing rate of motion toward the west is largely accommodated by faulting within the Walker Lane.

Bormann, J., Hammond, W.C., Kreemer, C., Blewitt, G., 2016, Accommodation of missing shear strain in the Central Walker Lane, western North America: Constraints from dense GPS measurements, Earth and Planetary Science Letters, 440, 169–177, doi:10.1016/j.epsl.2016.01.015.

Find additional information on the Nevada Geodetic Laboratory at the website:
http://geodesy.unr.edu

Nevada Geodetic Laboratory

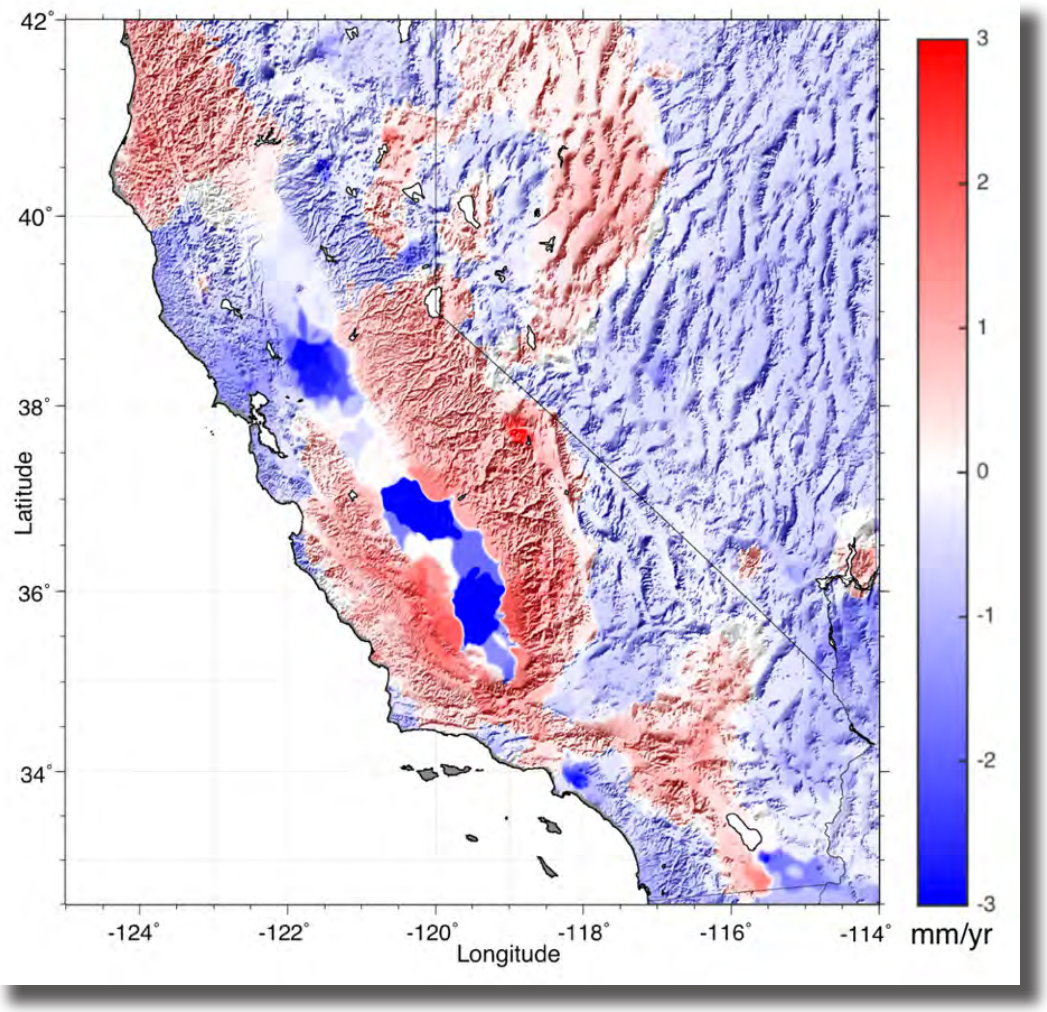
NBMG RESEARCH HIGHLIGHT

Geodetic Measurement of Sierra Nevada Uplift

Vertical motion of the solid Earth surface can occur as a consequence of ongoing tectonic, volcanic, hydrologic and earthquake cycle-related processes. Measurement of these motions reveals how the Earth behaves by providing information about the source and magnitude of forces and can be used to estimate the properties of Earth's materials. While mountains rise in response to tectonic forces, the contemporary geodetic signal can be overprinted by larger and shorter-lived signals that need to be understood before background tectonics are revealed.

In two recent studies (Blewitt et al., 2016; Hammond et al., 2016), the NGL developed a new analysis method called GPS Imaging that uses robust estimation to cope with measurement noise to enhance the signals of flex and flow in the solid Earth. We combined data from NBMG's MAGNET network with observations from about a dozen other networks in Nevada and California to generate a new summary field of vertical motion constrained by GPS observations. The resulting interpolation leads to better visualization, interpretation, impact and supports investigations of geodynamic processes, seismic hazard, and hydrological loading.

The adjacent figure shows where the Sierra Nevada experienced uplift of 1–2 mm/yr, and how this was distinct from other parts of Nevada and California that were stable or experienced downward motion. Uplift was especially rapid in the southern Sierra, with the rate decreasing northward towards zero at about the latitude of Reno. The image also reveals a large uplift feature in northwest Nevada that is attributable to a long lasting post-seismic response to the earthquakes that occurred in the Central Nevada Seismic Belt in 1915 and 1954. Subsidence in the southern Central Valley in California occurred because of groundwater pumping. Uplift of the southern Sierra Nevada near the Central Valley aquifers accelerated during the drought in years 2011 to 2016, as the increased pumping of groundwater unloaded the Earth's crust, allowing it to rebound upward more rapidly. These observations demonstrate the subtle but important effects of drought, climate change, and anthropogenic activities on crustal-scale deformational processes.



GPS Imaging of Sierra Nevada uplift. Colors represent vertical motion in a scale from -3 to 3 mm/yr, red=upward, blue=downward.

Hammond, W.C., G. Blewitt, C. Kreemer, 2016, GPS Imaging of vertical land motion in California and Nevada: Implications for Sierra Nevada uplift, Journal of Geophysical Research-Solid Earth, doi: 10.1002/2016JB013458.

Find additional information on the Nevada Geodetic Laboratory at the website:
http://geodesy.unr.edu

Cartography & GIS

The NBMG Cartography and GIS program is an almost entirely soft-funded operation that consists of dedicated cartographers and geographic information systems (GIS) analysts, who also have experience in graphic design, publications development, and web development. The strong mix of artistic talent and technical skills results in the production of user-friendly, visually appealing, and innovative products that continue to receive national attention and even earned the group a Special Achievement in GIS award in 2014.

The Cartography and GIS team supports all NBMG programs and as requested other internal UNR departments (e.g., Geological Sciences, Cooperative Extension, DeLaMare Library, etc.) and external organizations in Nevada and beyond (e.g., other state agencies, UNLV, U.S. Geological Survey, other state geological surveys, etc.).

The team assists research scientists with geologic map production, web GIS, publications, figures and scientific illustrations for journal articles and reports, in addition to general GIS support. They also routinely assist NBMG's sales office and Great Basin Science Sample and Records Library (GBSSRL) with publication and data dissemination as well as collaborate with the GBSSRL staff on new publication and data initiatives.

The Cartography and GIS team also serves a major role in NBMG's education and outreach mission. Members of the team regularly give K-12 classroom presentations, teach at Nevada Mining Association teacher workshops, give community presentations and demonstrations, and provide for activities during Earth Science Week each October. They also produce the highly informative and educational Nevada Geology Calendar every year in addition to developing many other educational products about geology.

The Cartography and GIS team also plays an important role in the educational mission of NBMG and UNR. They mentor and support graduate students from the geology program during their research and production of geologic maps for their theses and dissertations. They also work closely with graduate students, who opt to publish their maps through NBMG, and provide the students with information and support to bring maps to publication status, ensuring that publication standards are followed. Furthermore, undergraduate students from the geography, geology, and other programs at UNR are often employed by the Cartography and GIS team to gain hands-on GIS experience critical to a successful future in the GIS and/or geoscience industries.

Rachel Micander teaching grade school students about minerals. *Photographer: Jennifer Vlcan.*

NBMG cartographers Sydney Wilson and Irene Seelye. *Photographer: Jennifer Vlcan.*

2016 AND 2017 HIGHLIGHTS

A total of 17 new maps, 9 reports, and 2 calendars were published in 2016–2017, as shown on page 39. The Cartography & GIS team also contributed significantly to NBMG's response to the 2017 northern Nevada flooding and the Las Vegas Valley geologic mapping project. In addition to these accomplishments, highlights during 2016 and 2017 include the following:

Find additional information on Cartography and GIS at the
Nevada Bureau of Mines and Geology website
http://pubs.nbmg.unr.edu

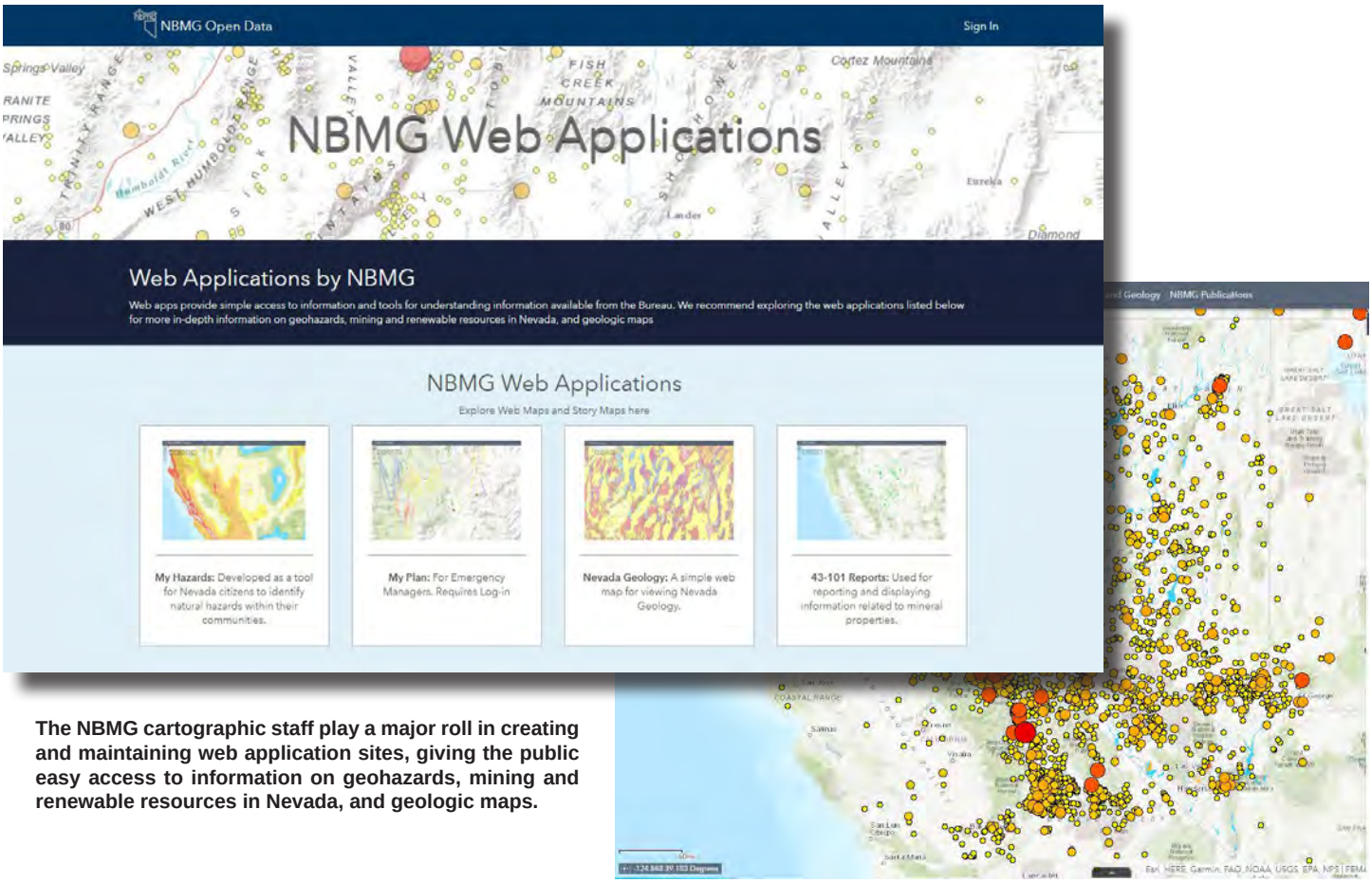
Cartography & GIS

• **Launched NBMG Open Data site:** Recognizing the value of sharing data in an easy-to-use format and advantages with the new Open Data platform available to NBMG and UNR, the Cartography & GIS team launched an effort to develop an Open Data site to support NBMG's data dissemination mission. The Open Data site went live in summer 2017, and the team has since assisted other state geological surveys with setting up their own Open Data sites. To learn more about this project, see page 36.

• **Nevada State Hazard Mitigation Plan update:** The NBMG Cartography & GIS team was contracted by the Nevada Division of Emergency Management to assist in updating the Nevada State Hazard Mitigation Plan. Updating the state plan was critical to ensure Nevada's eligibility of receiving FEMA support in the event of a natural disaster declaration in Nevada. The effort to update the plan was in full force during 2016 and 2017 in advance of the 2018 deadline. The bulk of updating the 1000+ page document and project management was primarily handled by the Cartography & GIS team. To learn more about this project, see pages 20 and 26.

• **Web GIS overhaul:** The team led a migration of web servers to University-supported systems coupled with launches of new web applications for geologic and topographic maps as well as major overhauls of existing web applications including MyHazards-Nevada, Nevada Mining Districts, and others. This work was critical to ensure a sustainable and scalable infrastructure to support NBMG's existing and future web GIS and data dissemination efforts.

• **Geospatial leadership and collaboration with national and state organizations:** Rachel Micander was appointed as State Representative for the National States Geographic Information Council. Jennifer Vlcan was elected to a 2-year term on the Board of Directors for the Nevada Geographic Information Society.



The NBMG cartographic staff play a major roll in creating and maintaining web application sites, giving the public easy access to information on geohazards, mining and renewable resources in Nevada, and geologic maps.

Find additional information on Cartography and GIS at the
Nevada Bureau of Mines and Geology website
http://pubs.nbmg.unr.edu

Great Basin Science Sample and Records Library

GBSSRL

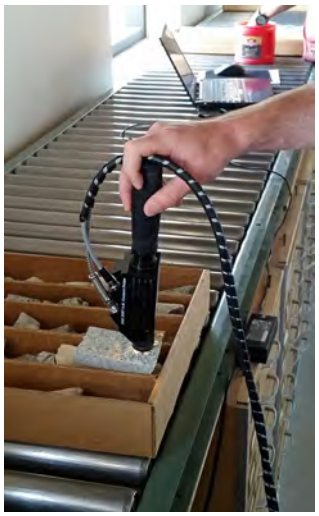
The Great Basin Science Sample and Records Library (GBSSRL), located at 2175 Raggio Parkway in Reno, is the Publication Sales and Information Office for the NBMG, as well as a public repository for geologic information for Nevada. This collection includes over 35,000 mining and geologic samples and records. In 2016 and 2017, the GBSSRL staff accessioned 114 boxes of geothermal well cuttings and about 1900 documents and maps, including many industrial mineral reports on topics such as lithium exploration.

This unique facility preserves the results of hundreds of millions of dollars of exploration and drilling in locations across Nevada—including some that are no longer accessible. The ability of future generations to reanalyze these archived samples is exceedingly valuable and has resulted in enhanced exploration that otherwise could not have been conducted.

The following resources are available from the Publication Sales and Information Office at the GBSSRL: NBMG and USGS maps and publications; aerial photographs; general geologic and mining information; and cuttings, core, and well records for oil, gas, geothermal, and mineral-exploration drill holes.

Many of the publications and collections at the GBSSRL are now accessible online through the NBMG website. In a typical year, the website is accessed by users in every state and many countries worldwide, which demonstrates the high value of the information stored at and disseminated through the GBSSRL. Data at the GBSSRL are critical for public safety, including research on geologic hazards, and for the mineral, geothermal, geotechnical, and petroleum industries.

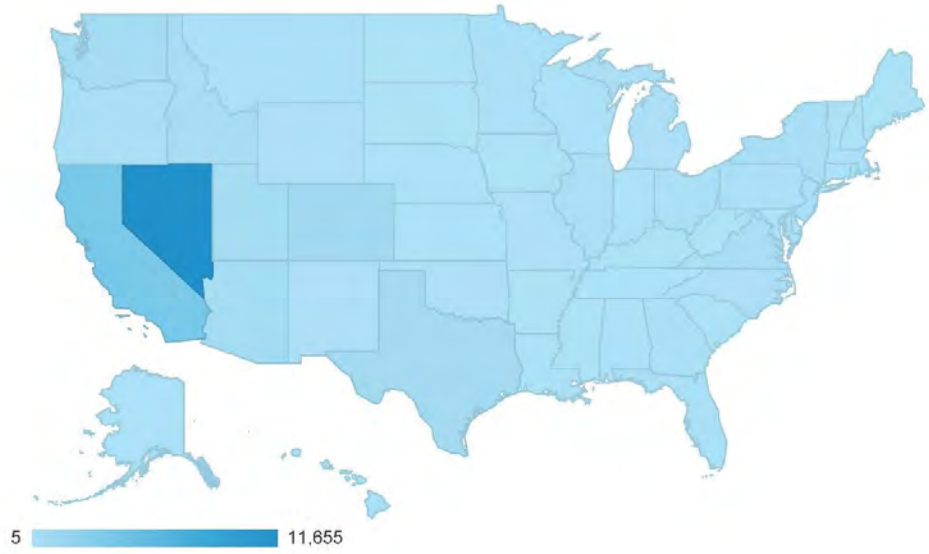
The Gold Building (GBSSRL) houses the NBMG Publication Sales and Information Office. The windows are covered with a thin reflective coating of gold for energy efficiency.



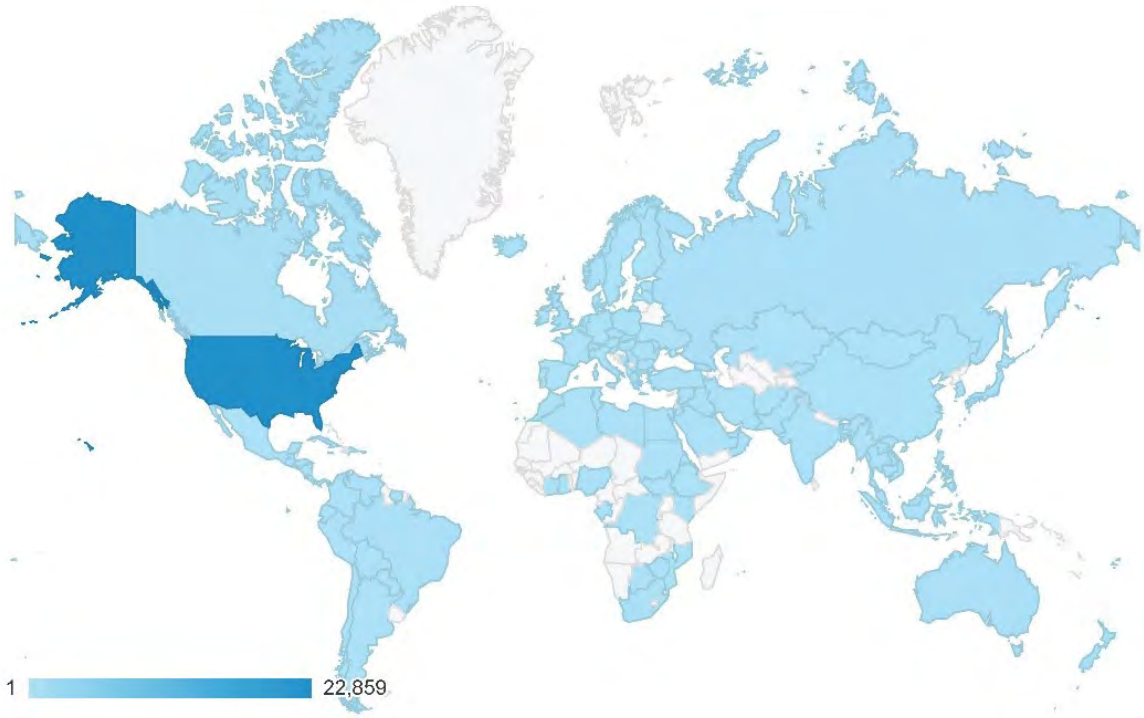
The GBSSRL has an average of 2,000 online visits monthly. Geoscientists from many states and countries visit the facility to study archived geological samples. *Photographer: Charlotte Stock*

Find additional information about the GBSSRL (aka the "Gold Building:) here:
http://pubs.nbmg.unr.edu/aboutus.asp

Great Basin Science Sample and Records Library



One year of activity from February 2016 to February 2017 on the NBMG website, which averaged ~500 sessions per week. Users from all states and countries shown in blue accessed the website during this period. The top 10 states in descending order were Nevada, California, Colorado Texas, Arizona, Utah, Washington, Idaho, Oregon, and Virginia. The top 9 countries were the USA, Canada, United Kingdom, Russia, Australia, Brazil, France, India, and Germany.



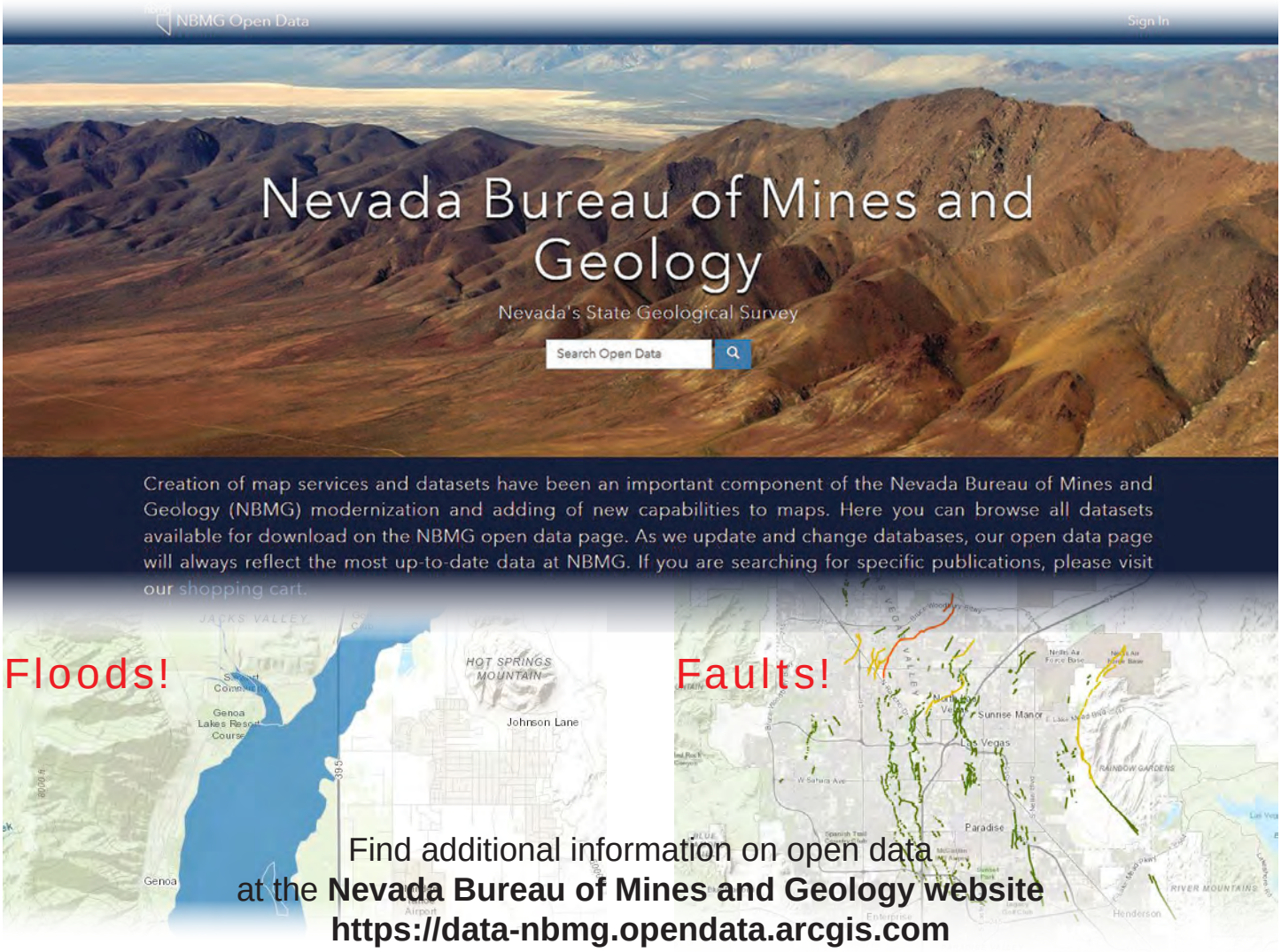
Find additional information about the GBSSRL (aka the “Gold Building:) here:
http://pubs.nbmg.unr.edu/aboutus.asp

Open Data

As Nevada's state geological survey, the production of map services and datasets has been an important part of NBMG modernization and organization. Many of these datasets are freely available, and in an effort to better disseminate these data, NBMG staff developed and launched an open data website in 2017. Features of this website include

- Data search: allows the public to search and download GIS data (https://data-nbmg.opendata.arcgis.com/).
- Web applications: interactive web maps that allow GIS and non-GIS users to view and query different layers and to make educated decisions based on these data.
- Story maps: interactive stories that engage and inspire people with maps, places, locations, and geography.
- Publications: maps, reports, and other products available from NBMG.
- Other GIS data: data available from other state and federal agencies as well as Nevada county GIS—where available.

Open Data can be freely used and reused by anyone and provides users with a single location to source these data. NBMG GIS datasets can be searched for and downloaded in various digital formats, including Excel spreadsheets, KML (Google Earth) files, or ESRI shapefiles within the NBMG Open Data site. Since it was implemented, the amount of data hosted on the NBMG Open Data site increased from 50 datasets (when the site was first launched in August 2017) to 63 datasets by the end of 2017. The Open Data site is a rapidly evolving resource, and NBMG staff are continuing to make datasets more easily accessible to the public, contractors, and companies alike in order to further collaboration with other agencies, industry, and scientific research. The NBMG Open Data site reflects the most recent and up-to-date data and web applications that are publicly available from the Bureau. Some of these datasets include earthquakes, Quaternary faults (young, earthquake-prone faults), flood data, Nevada geology, data related to geothermal energy, mineral exploration, and topographic maps and indices.



Education and Outreach

NBMG staff are involved in a variety of teaching and outreach missions that enrich geology education at UNR and the entire state. The faculty are involved in teaching core courses for the Geology program at UNR, including economic geology, field methods, and the capstone summer field class. Instruction in economic geology is provided by NBMG through the Ralph J. Roberts Center for Research in Economic Geology (CREG). Roughly one-third of the Geology graduate students are advised by NBMG faculty, and these students are focused on a variety of diverse topics, including geothermal research, regional tectonics, fault studies, and economic geology. NBMG also offers field trips, teacher workshops, and other outreach opportunities.

Students from the 2017 UNR Geology Field Camp investigating an excavation of the Butte Range fault in Long Valley, White Pine County, Nevada. The exposure revealed evidence of three late Pleistocene earthquakes. *Photographer: Rich Koehler*

Undergraduate Geology at UNR and Summer Field Camp

NBMG faculty teach core curriculum classes in the Geology program at UNR. In 2016–2017, 5 undergraduate geology courses were taught by NBMG faculty. Andrew Zuza is Director of the required capstone "Summer Field Course," which is a 6-unit, 5.5 week field-intensive geologic mapping course that is based out of a field station in Ruth, NV. The class involves themed exercises that train undergraduate students in geologic mapping, field interpretations, and effective report writing. NBMG faculty teach different levels of field methods courses, including 260 (Introductory Field Geology, Andrew Zuza) and 450 (Advanced Geologic Mapping, Rich Koehler). John Muntean and Mike Ressel of the CREG program teach the Economic Geology courses. In addition, exciting extracurricular courses on geothermal energy are taught by NBMG faculty Bridget Ayling and Jim Faulds.

Graduate Education

A variety of practical and specialized graduate-level courses are offered by NBMG faculty to train our Masters and PhD students. Some courses include Geothermal Exploration, Geodesy, Economic Geology, Physics of GPS, and a Geodynamics seminar. Class projects in the Geothermal Exploration course ultimately led to the discovery of a new blind geothermal system! In 2016–2017, 10 graduate courses were taught by NBMG faculty, and 4 Masters and 1 PhD were completed by students advised by these faculty.

Students from the UNR Geology Field Camp examining the stratigraphy of Kodachrome Basin (top photo, *by Joel DesOrmeau*) and mapping plutonic contacts in Tuolumne Meadows of Yosemite National Park (bottom photo, *by Andrew Zuza*). The field camp explores a variety of geologic topics that ultimately culminates in the students learning the tectonic history of the Western US over the last 500 million years.

Find additional information on the Great Basin Science and Sample and Records Library at the **Nevada Bureau of Mines and Geology website**
http://www.nbmg.unr.edu/ScienceEducation/ScienceEducation.html

Education and Outreach

Earth Science Week

The NBMG hosts field trips each year during the National Earth Science Week (second full week of October). These field trips are free and open to the public. They encourage people of all ages to explore the natural world and learn about the geosciences. Participants learn how geologists use geologic maps to unravel the history of Nevada geology, assess geologic hazards including flooding impacts and earthquake hazards from evidence of recent faulting, evaluate the potential for mineral and geothermal resources, and learn how landscapes are formed. Participants are given the opportunity to collect mineral and rock specimens during these field trips. A field trip guide is published each year by the Nevada Bureau of Mines and Geology and given to the field trip participants. Field trip guides from past trips are available for free on the NBMG website in the Educational Series listings: http://pubs.nbmg.unr.edu/Educational-Series-s/1856.htm

Jim Faulds discusses the geology of the Truckee River Canyon (above), and participants exam an outcrop (below) during the 2016 Earth Science Week field trip. *Photographer: Charlotte Stock.*

Teacher Workshops

NBMG staff participate in the highly effective and popular Mineral Education Workshops that are jointly sponsored by the Nevada Mining Association the Nevada Division of Minerals. These workshops occur twice a year—one in northern Nevada and one in southern Nevada—and are open to all K-12 teachers, free of charge. The 2016 Northern Nevada workshop was held in Reno and saw teachers attend from across northern Nevada. The 2017 Northern Nevada workshop was held in Winnemucca, again with teachers attending from all over northern Nevada with some joining from northern California. Both 2016 and 2017 southern Nevada workshops took place in Las Vegas. These workshops aim to educate K-12 teachers about rocks, minerals, mining, renewable resources, and earth sciences. In addition to hands-on classroom activities, the teachers attend half-day field trips to various mine sites, museums, national recreation areas, or other earth science related locations. The goal is to provide teachers with Nevada standards-based science lessons to take back to their classrooms to teach their students about geology, rocks, minerals, and natural resources in Nevada. Teachers can receive continuing education credit for attending these workshops.

Participants inspecting flash flood deposits near Hot Springs Mountain, during the 2017 Earth Science Week field trip in Douglas County. *Photographer: Jennifer Vlcan.*

Find additional information on Earth Science Week field trips
at the **Nevada Bureau of Mines and Geology website**
http://www.nbmg.unr.edu/ScienceEducation/Geotripping.html
http://pubs.nbmg.unr.edu/Educational-Series-s/1856.htm

Education and Outreach

Classroom Presentations

In addition to teaching during the Mineral Education Workshops, NBMG staff also conduct classroom presentations in K-12 schools. These classroom presentations aim to share information on rocks and minerals with Nevada students and assist teachers in their lesson plans by providing detailed geologic information based on grade level.

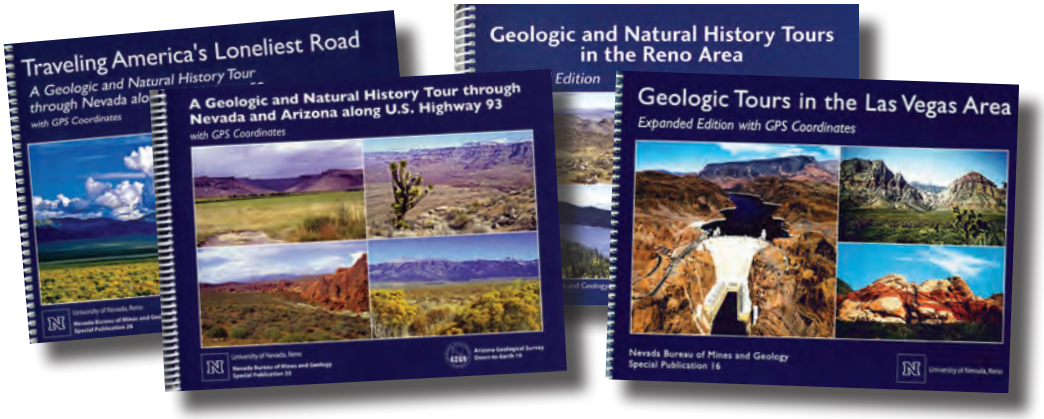
Rachel Micander assists teachers in identifying minerals during the 2016 Southern Nevada Mineral Education Workshop in Las Vegas, Nevada. *Photographer: Garrett Wake*

Geologic Tour Guide Book Series

NBMG also produces publications specifically for the general public, such as our popular field guides on the geology and natural history of U.S. Highways 50 and 93, Reno-Carson City-Lake Tahoe, and Las Vegas regions.

Nevada Geology Calendar

NBMG publishes a calendar packed with information on the geology of Nevada. This 12-month calendar is full of beautiful photos highlighting Nevada's scenic wonders and features a different geologic topic each month.



Find additional information on the tour guide books and the Nevada geology calendars at the **Nevada Bureau of Mines and Geology website**
https://pubs.nbmg.unr.edu/category-s/1973.htm
https://pubs.nbmg.unr.edu/Calendars-s/1853.htm

APPENDIX: NBMG 2016–2017 ACTIVITIES

NBMG Activities by the Numbers 2016–2017

PUBLICATIONS

27 Total number of NBMG publications produced

76 Total number of scientific journals, conference proceedings, guidebooks, and other external publications

37 Number of separate journals, conferences, and books, where NBMG personnel have published

GRANTS

~$3.36M Grant expenditures in fiscal years 2016 and 2017

75+ Number of active research grants

26 Number of organizations from which grants were received

EDUCATION

30 Graduate and undergraduate students advised

53 Graduate and undergraduate classes taught

ACCOLADES

5 NBMG personnel who serve as Directors of centers/labs at UNR

10 Individual honors and awards earned

COMMUNITY ENGAGEMENT

20 Public presentations by NBMG personnel

15 Field trips led by NBMG personnel

MEDIA

7 Television or Radio appearances/broadcasts

10 Online, magazines, or newspaper article features

PRESENTATIONS

100 Total number of professional presentations given

221 Presentations, abstracts, contract reports, and websites

15 Total number of invited international presentations

ONLINE

6/15/17 MyHAZARDS-Nevada web app was dubbed "Map of the Day" by American Geosciences Institute Critical Issues Program on Twitter

>22,000 Number of U.S. visitors to NBMG website in one year

60% Percentage of NBMG website visitors from Nevada

Publications, Reports, Maps, and Books by NBMG in 2016

Bolded names indicate NBMG authors, * indicates first author is a student

Bohannon, R.G., 2016, Preliminary geologic map of the Apex quadrangle, Clark County, Nevada: Nevada Bureau of Mines and Geology Open-File Report 16-3, scale 1:24,000, 5 p.

Dee, S., and **Ressel, M.W.**, 2016, Preliminary geologic map of the Herder Creek quadrangle, Elko County, Nevada: Nevada Bureau of Mines and Geology Open-File Report 16-5, scale 1:24,000, 5 p.

Dee, S., **Hinz, N.H.**, Anderson, R.E., and Johnsen, R., 2016, Preliminary geologic map of the Boulder City quadrangle, Clark County, Nevada: Nevada Bureau of Mines and Geology Open-File Report 16-4, 1:24,000 scale, 6 p.

Foy, T.A., Frankel, K.L., and Lifton, Z.M., 2016, Preliminary surficial geologic map of selected parts of Clayton Valley and the northwest Montezuma Range piedmont, Esmeralda County, Nevada: Nevada Bureau of Mines and Geology Open-File Report 16-2, scale 1:24,000, 3 p.

Henry, C.D., Castor, S.B., Starkel, W.A., Ellis, B.S., Wolff, J.A., McIntosh, W.C., and Heizler, M.T., 2016, Preliminary geologic map of the McDermitt caldera, Humboldt County, Nevada and Harney and Malheur counties, Oregon: Nevada Bureau of Mines and Geology Open-File Report 16-1, scale 1:70,000, 8 p.

Hinz, N.H., and **Ramelli, A.R.** 2016, Preliminary geologic map of the south half of the Mount Rose NW quadrangle, Washoe County, Nevada: Nevada Bureau of Mines and Geology Open-File Report 16-6, scale 1:24,000, 3 p.

Hursh, J.P., **Vlcan, J.M.**, **Henry, C.D.**, and **Hinz, N.H.**, 2016, Nevada geology calendar 2017.

Koehler, R.D., **Zuza, A.V.**, and **Faulds, J.E.**, 2016, A river runs through it—geology along the Truckee River valley from Reno to Pyramid Lake: Nevada Bureau of Mines and Geology Educational Series 59, 19 p.

Muntean, J.L., **Davis, D.A.**, and **Shevenell, L.A.**, 2016, The Nevada mineral industry 2014: Nevada Bureau of Mines and Geology Special Publication MI-2014, 171 p.

Perry, R. and Visher, M., 2016, Major mines of Nevada 2016—mineral industries in Nevada's economy: Nevada Bureau of Mines and Geology Special Publication P-27, 28 p.

*Sadowski, A. J., and **Faulds, J.E.**, 2016, Preliminary geologic map of the Truckee Range, Black Warrior geothermal area, Washoe and Churchill counties, Nevada: Nevada Bureau of Mines and Geology Open-File Report 16-7, scale 1:24,000, 12 p.

Publications, Reports, Maps, and Books by NBMG in 2017

*Carlson, C.W., 2017, Preliminary geologic map of the Red Ridge area, Churchill and Mineral counties, Nevada: Nevada Bureau of Mines and Geology Open-File Report 17-2, scale 1:24,000, 7 p.

Dee, S., **Ayling, B.F.**, and **Henry, C.D.**, 2017, A land in transition! Ancient river courses, young volcanoes, recent earthquakes, and modern debris flows in the Carson Valley: Nevada Bureau of Mines and Geology Educational Series 61, 23 p.

Dee, S., **Henry, C.D.**, **Ressel, M.W.**, and **Zuza, A.V.**, 2017, Preliminary geologic map of the north half of the Independence Valley NW quadrangle and the adjacent part of the Independence Valley NE quadrangle, Elko County, Nevada: Nevada Bureau of Mines and Geology Open-File Report 17-6, scale 1:24,000, 4 p.

Faulds, J.E., **Ramelli, A.R.**, Coolbaugh, M.F., **Hinz, N.H.**, Garside, L.J., and Queen, J.H., 2017, Preliminary geologic map of the Bradys geothermal area, Churchill County, Nevada: Nevada Bureau of Mines and Geology Open-File Report 17-4, scale 1:12,000, 6 p.

Hinz, N.H., **Dee, S.**, and Johnsen, R., 2017, Preliminary geologic map of the Boulder City NW quadrangle, Clark County, Nevada: Nevada Bureau of Mines and Geology Open-File Report 17-5, scale 1:24,000, 5 p.

Hursh, J.P., **Vlcan, J.M.**, **Henry, C.M.**, and **Hinz, N.H.**, 2017, Nevada geology calendar 2018.

Muntean, J.L., and **Davis, D.A.**, 2017, Nevada Active Mines and Energy Producers: Nevada Bureau of Mines and Geology Educational Series 60, 1 inch = 40 miles.

Muntean, J.L., and **Davis, D.A.**, 2017, Nevada Active Mines and Energy Producers: Nevada Bureau of Mines and Geology Open-File Report 17-1, compilation scale 1:1,000,000.

Muntean, J.L., **Davis, D.A.**, and **Ayling, B.F.**, 2017, The Nevada mineral industry 2015: Nevada Bureau of Mines and Geology Special Publication MI-2015, 190 p.

Muntean, J.L., **Davis, D.A.**, and **Ayling, B.F.**, 2017, The Nevada mineral industry 2016: Nevada Bureau of Mines and Geology Special Publication MI-2016, 187 p.

Muntean, J.L., **Dee, S.**, Hill, T.J., Hannink, R.L ., Smith, M., Urie, G., and Raabe, K., 2017, Preliminary geologic map of the Kinsley Mountains, Elko and White Pine counties, Nevada: Nevada Bureau of Mines and Geology Open-File Report 17-7, scale 1:12,000, 5 p.

Perry, R. and Visher, M., 2017, Major mines of Nevada 2016—mineral industries in Nevada's economy: Nevada Bureau of Mines and Geology Special Publication P-28, 28 p.

*Price, T., Evans, M., Muhammad, M., Hinson, M., McIntyre, A., Peck, A., Hahn, P., and Taylor, W.J., 2017, Preliminary geologic map of the Lower Pahranagat Lake NW quadrangle, Lincoln County, Nevada:

Nevada Bureau of Mines and Geology Open-File Report 17-3, scale 1:24,000.

Ramelli, A.R., Wrucke, C.T., and House, P.K., 2017, Geologic map of the Bateman Spring quadrangle, Lander County, Nevada: Nevada Bureau of Mines and Geology Map 185, scale 1:24,000, 6 p.

Ressel, M.W., and **Davis, D.A.**, 2017, Nevada mineral and energy resource exploration survey 2015/2016: Nevada Bureau of Mines and Geology Exploration Survey ES-2016, 16 p.

Rowley, P.D., Dixon, G. L., Mankinen, E.A., Pari, K.T., McPhee, D.K., McKee, E.H., Burns, A.G., Watrus, J.M., Ekren, E.B., Patrick, W.G, and Brandt, J.M., 2017, Geology and geophysics of White Pine and Lincoln counties, Nevada, and adjacent parts of Nevada and Utah—the geologic framework of regional groundwater flow systems: Nevada Bureau of Mines and Geology Report 56, scale 1:250,000, 4 plates, 146 p.

External Journals, Reports, Proceedings, and Guidebooks by NBMG Staff in 2016

Ayling, B.F., Hogarth, R.A., and Rose, P.E., 2016, Tracer testing at the Habanero EGS site, central Australia: Geothermics, v. 63, p. 15–26.

Ayling, B.F., Huntington, J., Smith, B., and Edwards, D., 2016, Hyperspectral logging of middle Cambrian marine sediments with hydrocarbon prospectivity—a case study from the southern Georgina Basin, northern Australia: Australian Journal of Earth Sciences, v. 63(8), p. 1069–1085.

Blewitt, G., 2016, GPS, Reference Systems, *in* Grafarend, E.W. (editor), Encyclopedia of Geodesy, Springer International Publishing.

Blewitt, G., and Böhm, J., 2016, Commission 1—reference frames: Journal of Geodesy, v. 90(10), p. 987–1001.

Blewitt, G., **Kreemer, C.W.**, **Hammond, W.C.**, and Gazeaux, J., 2016, MIDAS robust trend estimator for accurate GPS station velocities without step detection: Journal of Geophysical Research, v. 121, p. 2054–2068.

*Bormann, J., **Hammond, W. C.**, **Kreemer, C. W.**, and **Blewitt, G**., 2016, Accommodation of missing shear strain in the Central Walker Lane, western North America—constraints from dense GPS measurements: Earth and Planetary Science Letters, v. 440, p. 169–177.

Faulds, J. E., **Hinz, N.H.**, Coolbaugh, M. F., Shevenell, L. A., and Siler D. L, 2016, The Nevada play fairway project — Phase II—initial search for new viable geothermal systems in the Great Basin region, western USA: Geothermal Resources Council Transactions, v. 40, p. 535–540.

Faulds, J.E., **Hinz, N.H.**, Coolbaugh, M.F., Siler, D.L., Shevenell, L.A., Queen, J.H., **dePolo, C.M**., **Hammond, W.C.**, and **Kreemer, C.W.**, 2016, Discovering geothermal systems in the Great Basin region—an integrated geologic, geochemical, and geophysical approach for establishing geothermal play fairways: Proceedings, 41st Workshop on Geothermal Reservoir Engineering, Stanford University, Stanford, CA, February 22–24, 2016, 15p.

Faulds, J.E., Schreiber, B.C., Langenheim, V.E., **Hinz, N.H.**, Shaw, T.H., Heizler, M.T., Perkins, M.E., El Tabakh, M., and Kunk, M.J., 2016, Paleogeographic implications of late Miocene lacustrine and nonmarine evaporite deposits in the Lake Mead region—immediate precursors to the Colorado River: Geosphere, v. 12, no. 3, p. 721–767, doi:10.1130/GESO1143.1.

Gualandi, A., Avouac, J.P., Galetzka, J., Genrich, J.F., **Blewitt, G.**, Adhikari, L.P., Koirala, B.P., Gupta, R., Upreti, B.N., Pratt-Sitaula, B., and Liu-Zeng, J., 2016, Pre- and post-seismic deformation related to the 2015, Mw 7.8 Gorkha earthquake, Nepal: Tectonophysics, Vol. 714–715, p. 90–106.

Hamlington, B. D., Thompson, P., **Hammond, W. C.**, **Blewitt, G**., and Ray, R., 2016, Assessing the impact of vertical land motion on estimates of 20th century global mean sea level: Journal of Geophysical Research, v. 121, p. 4980–4993.

Hammond, W.C., **Blewitt, G.**, and **Kreemer, C.W.**, 2016, GPS Imaging of vertical land motion in California and Nevada—implications for Sierra Nevada uplift: Journal of Geophysical Research Solid Earth, v. 121, p. 7681–7703.

Hinz, N.H., Coolbaugh, M., **Faulds, J.E**., Shevenell, L., and Stelling, P., 2016, Regional quantitative play fairway analysis—methodology, global examples, and application for the East African Rift System, *in* 6th African Rift Geothermal Conference, Addis Ababa, Ethiopia, November 2–4, 2016, 12 p.

Hinz, N.H., Coolbaugh, M., Shevenell, L., Melosh, G., Cumming, W., and Stelling, P., 2016, Structural–tectonic settings for globally productive subduction arc volcanic centers, *in* 41st Workshop on Geothermal Reservoir Engineering, Stanford University, Stanford, CA, February 22–24, 2016, 8 p.

Hinz, N.H., **Faulds, J.E**., Siler, D.L., Tobin, B., Blake, K., Tiedeman, A., Sabin, A., Blankenship, D., Kennedy, M., Rhodes, G., Nordquist, J., Hickman, S., Glen, J., Williams, C., Robertson-Tait, A., and Calvin, W., 2016, Stratigraphic and structural framework of the proposed Fallon FORGE site, Nevada *in* 41st Workshop on Geothermal Reservoir Engineering, Stanford University, Stanford, CA, February 22–24, 2016, 12 p.

Ito, G., Frazier, N., Lautze, N., Thomas, D., **Hinz, N.H.,** Waller, D., Whittier, R., and Wallen, E., 2016, Play fairway analysis of geothermal resources across the State of Hawaii—2. Resource Probability Mapping: Geothermics,

http://dx.doi.org/10.1016/j.geothermics.2016.11.004.

Koehler, R.D., 2016, Reconnaissance geologic observations along the Petersen Mountain fault zone northwest of Reno, Nevada, U.S.A. *in* 7th International INQUA meeting on paleoseismology, active tectonics, and archeoseismology, guidebook no. 12, p. 136–139.

Koehler, R.D., Reger, R.D., Spangler, E., and Gould, A.I., 2016, Investigation of potentially active tectonic faults along the route of the proposed ASAP pipeline, Livengood to Anchorage, Alaska: State of Alaska Division of Geological & Geophysical Surveys, Report of Investigation 2015-4, 71 p.

Large, S.J.E., Bakker, E.Y., Weis, P., Walle, M., **Ressel, M.W.**, and Heinrich, C.A., 2016, Trace-element in fluid inclusions of sediment-hosted gold deposits indicate a magmatic-hydrothermal origin of the Carlin ore trend: Geology/Geological Society of America, v. 44 (12), p. 1015–1018.

Lautze, N., Thomas, D., Hill, G., Wallin, E., Whittier, R., Martel, S., Ito, G., Frazer, N., and **Hinz, N.,** 2016, Phase 2 activities to improve a 2015 play fairway analysis of geothermal potential across the State of Hawaii: Geothermal Resources Council Transactions, v. 40, p. 559–565.

Lautze, N., Thomas, D., **Hinz, N.,** Ito, G., Frazer, N., and Waller, D., 2016, Hawaii play fairway analysis—discussion of phase 1 results, *in* 41st Workshop on Geothermal Reservoir Engineering, Stanford University, Stanford, CA, February 22–24, 2016, 7 p.

Nicolsky, D.J., Freymueller, J.T., Witter, R.C., Suleimani, E.N., and **Koehler, R.D.,** 2016, Evidence for shallow megathrust slip across the Unalaska seismic gap during the great 1957 Andreanof Island earthquake, central Aleutian Islands, Alaska: Geophysical Research Letters, v. 43, p. 10,328–10,337.

Nicolsky, D.J., Suleimani, E.N., and **Koehler, R.D.**, 2016, Tsunami inundation maps for the communities of Chignik and Chignik Lagoon, Alaska: Alaska Division of Geological & Geophysical Surveys, Report of Investigation 2016-8, 48 p., 2 sheets, scale 1:12,500.

Nicolsky, D.J., Suleimani, E.N., and **Koehler, R.D.**, 2016, Tsunami inundation map of the village of Nikolski, Alaska: Alaska Division of Geological & Geophysical Surveys, Report of Investigation 2016-7, 34 p., 1 sheet, scale 1:25,000.

Sabin A., Blake, K., Lazaro, M., Meade, D., Blankenship, D., Kennedy, M., McCulloch, J., DeOreo, S., Hickman, S., Glen, J., Kaven, O., Schoenball, M., Williams, C., Phelps, G., **Faulds, J.E**., **Hinz, N.H**., Calvin, W., Siler, D., and Robertson-Tait, A., 2016, Geologic setting of the West Flank—a FORGE site adjacent to the Coso geothermal field *in* 41st Workshop on Geothermal Reservoir Engineering, Stanford University, Stanford, CA, February 22–24, 2016, 11 p.

Siler, D. L., Blake, K., Sabin, A., Lazaro, M., Meade, D., Blankenship, D., Kennedy, B.M., McCulloch, J., DeOreo, S., Hickman, S., Glen, J., Kaven, O., Schoenball, M., Williams, C., Phelps, G., **Faulds, J.E.**, **Hinz, N.H.**, Robertson-Tait, A., and Pettitt, W., 2016, The geologic framework of the west flank FORGE site: Geothermal Resources Council Transactions, v. 40, p. 585–596.

Siler, D. L., **Hinz, N. H.**, **Faulds, J. E**., Tobin, B., Blake, K., Tiedeman, A., Sabin, A., Lazaro, M., Blankenship, D., Kennedy, M., Rhodes, G., Nordquist, J., Hickman, S., Glen, J., Williams, C., Robertson-Tait, A., Calvin, W., and Pettitt, W., 2016, The geologic framework of the Fallon FORGE site: Geothermal Resources Council Transactions, v. 40, p. 573–584.

Siler, D.L., **Faulds, J.E.**, **Hinz, N.H.**, and Queen, J., 2016, 3D analysis of geothermal fluid flow favorability—Brady's, Nevada, USA, *in* 41st Workshop on Geothermal Reservoir Engineering, Stanford University, Stanford, CA, February 22–24, 2016, 10 p.

Siler, D.L., **Faulds, J.E**., Mayhew, B., and McNamara, D.D, 2016, Analysis of the favorability for geothermal fluid flow in 3D—Astor Pass geothermal prospect, Great Basin, northwestern Nevada, USA: Geothermics, v. 60, p. 1–12.

Smith, B. R., Huntington, J., Bruna, P.O., **Ayling, B. F.**, and Green, A., 2016, Australia's National Virtual Core Library—examples of integrating data across geological terranes to highlight prospectivity *in* 35th International Geological Congress Proceedings, Cape Town, South Africa, August 27–September 4, 2016.

Stelling, P., Shevenell, L., **Hinz, N.H.,** Coolbaugh, M., Melosh, G., and Cumming, W., 2016, Geothermal systems in volcanic arcs I—volcanic characteristics and surface manifestations as indicators of geothermal potential and favorability worldwide: Journal of Volcanology and Geothermal Research, v. 324, p. 57–72.

Suleimani, E.N., Nicolsky, D.J., and **Koehler, R.D.**, 2016, Tsunami inundation maps of Yakutat, Alaska: Alaska Division of Geological & Geophysical Surveys, Report of Investigation 2016-2, 47 p., 1 sheet, scale 1:10,000.

Suleimani, E.N., Nicolsky, D.J., **Koehler, R.D.**, Freymueller, F.T., and Macpherson, A.E., 2016, Tsunami inundation maps of King Cove and Cold Bay communities, Alaska: Alaska Division of Geological & Geophysical Surveys, Report of Investigation 2016-1, 73 p., 2 sheets, scale 1:63,360.

Watts, K.E., Coble, M.A., Vasquez, J.A., **Henry, C.D.**, Colgan, J.P., and John, D.A., 2016, Chemical abrasion-SIMS (CA-SIMS) U-Pb dating of

zircon from the late Eocene Caetano caldera: Chemical Geology, v. 439, p. 139–151.

Watts, K.E., John, D.A., Colgan, J.P., **Henry, C.D.**, Bindeman, I.N., and Schmitt, A.K., 2016, Probing the volcanic-plutonic connection and the genesis of crystal-rich rhyolite in a deeply dissected supervolcano in the Nevada Great Basin—source of the late Eocene Caetano Tuff: Journal of Petrology, *57*, p. 1599–1644.

Witter, J.B., Siler, D.L., **Faulds, J.E**., and **Hinz, N.H.**, 2016, 3D Geophysical inversion modelling of gravity data to test the 3D geological model of the Bradys geothermal area, Nevada, USA: Geothermal Energy, v. 4, no. 14, 21 p.

Witter, J.B., Stelling, P., Knapp, P., and **Hinz, N.H.,** 2016, 3D geophysical inversion modelling of gravity data as a subsurface exploration tool with an example from the Akutan (Alaska, USA) geothermal area: Geothermal Resources Council Transactions, v. 40, p. 647–657.

Wu, C., Yin, A., **Zuza, A. V.**, Zhang, J., Liu, W., and Ding, L., 2016, Pre-Cenozoic Geologic History of the Central and Northern Tibetan Plateau and the Role of Wilson Cycles in Constructing the Tethyan Orogenic System: Lithosphere, v. 8, no. 3, p. 254–292.

Yin, A., **Zuza, A. V.**, and Pappalardo, R. T., 2016, Mechanics of evenly spaced strike-slip faults and its implications for the formation of tiger-stripe fractures on Saturn's moon Enceladus: Icarus, v. 266, p. 204–216.

Zuza, A. V., and Yin, A., 2016, Continental deformation accommodated by non-rigid passive bookshelf faulting: An example from the Cenozoic tectonic development of northern Tibet: Tectonophysics, v. 677–678, p. 227–240.

Zuza, A. V., Cheng, X., and Yin, A., 2016, Testing models of Tibetan Plateau formation with Cenozoic shortening estimates across the Qilian Shan-Nan Shan thrust belt: Geosphere, v. 12, no. 2, p. 501–532.

External Journals, Reports, Proceedings, and Guidebooks by NBMG Staff in 2017

Ayling, B.F., Eggins, S., McCulloch, M.T., Chappell, J., Grün, R., and Mortimer, G., 2017, Uranium uptake history, open-system behaviour and uranium-series ages of fossil *Tridacna gigas* from Huon Peninsula, Papua New Guinea: Geochimica et Cosmochimica Acta, v. 213, p. 475–501

Bailey, A., Tenthorey, E., and **Ayling, B.**, 2017, Characterising the present-day stress regime of the Georgina Basin: Australian Journal of Earth Sciences, v. 64, no. 1, p. 121–136

Blake, K., Lowry, T., Lazaro, M., Tiedman, A., **Ayling, B.F**., Arguello, R.,and Meade, D, 2017, Hawthorne Army Depot—update of geothermal exploration and direct use applications *in* Geothermal Resources Council Transactions, v. 41, p. 1031–1041, https://www.geothermallibrary.org/index.php?mode=pubs&action=view&record=1033783

Blankenship, D., Kennedy, M., Majer, E.L., **Hinz, N.**, **Faulds, J.E.**, **Ayling, B.**, Blake, K., Tiedeman, A., Sabin, A., Lazaro, M., Akerley, J., Siler, D., Kaven, J.O., Phelps, G., Hickman, S., Glen, J., Williams, C., Robertson-Tait, A., Hackett, L., and Pettit, W., 2017, Proposed Fallon FORGE site—Phase 2 update, *in* 42nd Workshop on Geothermal Reservoir Engineering, Stanford University, Stanford, CA, February 13–15, 2017, SGP-TR-212, 7p.

Blewitt, G., and Böhm, J., 2017, Reference Frames, *International Association of Geodesy TRAVAUX, 40*, 5-75. (**Note:** This is a 71-page research report commissioned/reviewed/approved/published by the IAG Executive Committee) https://iag.dgfi.tum.de/fileadmin/IAG-docs/Travaux_2015-2017.pdf

Blewitt, G., and Schöne, T, 2017, Scientific Applications of IGS Products, *in* International Global Navigation Satellite System Service Workshop, http://igsworkshop2017.ign.fr/sessions.

Colgan, J.P., John, D.A., **Henry, C.D.**, and Watts, K.E., 2017, Insights into the emplacement of upper-crustal plutons and their relationships to large silicic calderas, from field relationships, geochronology, and zircon trace element geochemistry in the Stillwater-Clan Alpine caldera complex, western Nevada, USA: Journal of Volcanology and Geothermal Research, v. 349, p. 163–176.

*Craig, J.W., **Faulds, J.E.**, Shevenell, L.A., and **Hinz, N.H.**, 2017, Discovery and analysis of a potential blind geothermal system in southern Gabbs Valley, western NV: Geothermal Resources Council Transactions, v. 41, p. 2258–2264.

Faulds, J.E., Coolbaugh, M.F., **Hinz, N.H.**, Sadowski, A., Shevenell, L.A., McConville, E., Craig, J., Sladek, C., and Siler, D.L., 2017, Progress report on the Nevada Play Fairway Project—integrated geological, geochemical, and geophysical analyses of possible new geothermal systems in the Great Basin region *in* 42nd Workshop on Geothermal Reservoir Engineering, Stanford University, Stanford, CA, February 13–15, 2017, 12 p.

Faulds, J.E., **Hinz, N.H.**, Coolbaugh, M.F., and Shevenell, L.A., 2017, Discovering new geothermal systems in the Great Basin region, Western USA—an integrated approach for establishing geothermal Play Fairways *in* Proceedings 39th New Zealand Geothermal Workshop, November 21–25, 2017, Rotorua, New Zealand, 7 p.

Hammond, W. C., Burgette, R. J., Johnson, K. M., and **Blewitt, G.**, 2017, Uplift of the Western Transverse Ranges and Ventura Area

of Southern California—a four-technique geodetic study combining GPS, InSAR, leveling and tide gauges: Journal of Geophysical Research, v. 123, p. 836–858. http://onlinelibrary.wiley.com/doi/10.1002/2017JB014499/full

Henry, C.D., Castor, S.B., Starkel, W.A., Ellis, B.S., Wolff, J.A., Laravie, J.A., McIntosh, W.C., and Heizler, M.T., 2017, Geology and evolution of the McDermitt caldera, northern Nevada and southeastern Oregon, USA: Geosphere, v. 13, p. 1066–1112.

*Hollingsworth, E.R., **Ressel, M.W.**, and **Henry, C.D.**, 2017, Age and depth of Carlin-type gold deposits in the southern Carlin Trend—Eocene mountain lakes, big volcanoes, and widespread, shallow hydrothermal circulation: Geological Society of Nevada Special Publication, no. 64, 149–173 p.

Kipngok, J., Magnússon, R., Melosh, G., **Hinz, N.H.**, Cumming, W., Haizlip, J., Harvey, M., Lopeyok T., Mwakirani, R., Wamalwa A.M., Malimo S.J. and Auko L.O., 2017, Geothermal conceptual model of Suswa Volcano, Kenya: Geothermal Resources Council Transactions, v. 41, p. 1153–1171.

Koehler, R.D., 2017, Castle Mountain fault, south-central Alaska—observations on slip partitioning from LIDAR and paleoseismic trenching, p. 206–209, *in* Clark, K.J., Upton, P., Langridge, R., Kelly, K., Hammond, K., 2017, *in* 8th International INQUA Meeting on Paleoseismology, Active Tectonics, and Archeoseismology, Handbook and Programme, 13–16 November, 2017, Lower Hutt (NZ): GNS Science Miscellaneous Series 110, 441 p., doi: 10.21420/G2H061

Lautze, N., Thomas, D., **Hinz, N.**, Apuzen-Ito, G., Frazer, N., and Waller, D., 2017, Play fairway analysis of geothermal resources across the State of Hawaii—1. Description and justification of geological, geophysical, and geochemical datasets: Geothermics, https://doi.org/10.1016/j.geothermics.2017.02.001

Lautze, N., Thomas, D., Waller, D., **Hinz, N.**, Frazer, N., and Apuzen-Ito, G., 2017, Play Fairway analysis of geothermal resources across the State of Hawaii—3. Use of Development Viability as one criteria to prioritize future exploration activities: Geothermics, https://doi.org/10.1016/j.geothermics.2017.07.005

Lautze, N., Thomas, D., Whittier, R., Martel, S., Ito, G., Frazer, N., Hill, G., Martin, T., Wannamaker, P., and **Hinz, N.H.**, 2017, Improving a 2015 map of geothermal resource probability across the State of Hawaii *in* 42nd Workshop on Geothermal Reservoir Engineering, Stanford University, Stanford, CA, February 13–15, 2017, 8 p.

Clark Maroun, L.R., Cline, J.S., Simon, A., Anderson, P., and **Muntean, J.L.**, 2017, High-grade gold deposition and collapse breccia formation, Cortez Hills Carlin-Type gold deposit, Nevada, USA: Economic Geology, v. 112, p. 707–740.

*McConville, E.G., **Faulds, J.E.**, **Hinz, N.H., Ramelli, A.R.**, Coolbaugh, M.F., Shevenell, L., Siler, D.L., and Bourdeau-Hernikl, J., 2017, A play fairway approach to geothermal exploration in Crescent Valley, Nevada: Geothermal Resources Council Transactions, v. 41, p. 1213–1221.

Muntean, J. L., Bonner, W., and Hill, T., 2017, Carlin-style gold-silver mineralization at the Cove deposit in Nevada, USA—possible missing link between Carlin-type gold deposits and magmatic-hydrothermal systems *in* 14th Biennial Meeting of the Society for Geology Applied to Mineral Deposits, August 20–23, 2017, Quebec City, Canada, p. 71–74.

Nicolsky, D.J., Suleimani, E.N., and **Koehler, R.D.**, 2017, Potential maximum permanent flooding maps for Chenega, Alaska, *in* Nicolsky, D.J., Suleimani, E.N., and **Koehler, R.D.**, Tsunami inundation maps of the villages of Chenega Bay and northern Sawmill Bay, Alaska: Alaska Division of Geological & Geophysical Surveys Report of Investigation 2014-3A, 1 sheet, scale 1:3,500.

Nicolsky, D.J., Suleimani, E.N., and **Koehler, R.D.**, 2017, Tsunami inundation maps for the city of Sand Point, Alaska: Alaska Division of Geological & Geophysical Surveys, Report of Investigation 2017-3, 61 p., 4 sheets, scale 1:15,000.

Nicolsky, D.J., Suleimani, E.N., Freymueller, J.T., and **Koehler, R.D.**, 2017, Potential maximum permanent flooding maps for Unalaska and Akutan, Alaska, *in* Nicolsky, D.J., Suleimani, E.N., Freymueller, J.T., and **Koehler, R.D.**, Tsunami inundation maps of Fox Islands communities, including Dutch Harbor and Akutan, Alaska: Alaska Division of Geological & Geophysical Surveys, Report of Investigation 2015-5A, 2 sheets, scale 1:12,500.

Nicolsky, D.J., Suleimani, E.N., **Koehler, R.D.**, and Salisbury, J.B. 2017, Tsunami inundation maps for Juneau, Alaska: Alaska Division of Geological & Geophysical Surveys, Report of Investigation 2017-9, 66 p., 5 sheets.

Roberts, B. M., **Blewitt, G.**, Dailey, C., Murphy, M., Pospelov, M., Rollings, A., Sherman, J., Williams, W., and Derevianko, A., 2017, Search for domain wall dark matter with atomic clocks on board global positioning system satellites: Nature Communications, v. 8(1195), https://www.nature.com/articles/s41467-017-01440-4

Rose, P., Moore, J., Bradford, J., Mella, M., **Ayling, B.F**., and McLennan, J., 2017, Tracer Testing to Characterize Hydraulic Stimulation Experiments at the Raft River EGS Demonstration Site *in* Geothermal Resources Council Transaction, v. 41, p. 934–944. https://www.geothermal-library.org/index.php?mode=pubs&action=view&record=1033775

Suleimani, E.N., Nicolsky, D.J., and **Koehler, R.D.**, 2017, Updated tsunami inundation maps of the Kodiak area, Alaska: Alaska Division of Geological & Geophysical Surveys, Report of Investigation 2017-8, 38 p., 10 sheets.

Tian, K., Luo, K., and **Zuza, A. V.**, 2017, The trace element distribution patterns of Ediacaran-Early Cambrian black shales and the origin of selenium in the Guangning Area, Western Guangdong Province, South China: Acta Geologica Sinica, v. 91, p. 1978–1991.

Wannamaker, P., Hill, G., Stodt, J., Maris, V., Ogawa, Y., Selway, K., Boren, G., Bertrand, E., Uhlmann, D., **Ayling, B.F.**, Green, A.M., and Feucht, D., 2017, Uplift of the central transantarctic mountains: Nature Communications, v. 8, doi:10.1038/s41467-017-01577-2.

Weldon, R., de Lamare, G., Yule, D., **Hammond, W.C.**, Streig, A., Sarmiento, A., Freeman, T., Shamma, J., Beikaie, M., and Rodriguez, A., *in* Anderson, R., and Ferriz, H., (editor), Chapter 8: San Andreas Fault-South Branch surface deformation modeling, peer reviewed book chapter Applied Geology in California, Special Publication Number 26, available at http://www.appliedgeologybook.com

Wu, C., Wang, B., Zhou, Z., Wang, G., **Zuza, A.V.**, Liu, C., Jiang, T., Liu, W., and Ma, S, 2017, The relationship between magma and mineralization in Chaobuleng iron polymetallic deposit, Inner Mongolia: Gondwana Research, v. 45, p. 228–253.

Wu, C., **Zuza, A.V.**, Yin, A., Liu, C., Reith, R.C., Zhang, J., Liu, W., and Zhou, Z., 2017, Geochronology and geochemistry of the Neoproterozoic granitoids in the central Qilian Shan of northern Tibet and constraints on Reconstructing the amalgamation processes and history of Asia, Lithosphere, v. 9, p. 609–636.

Zaliapin, I., and **Kreemer, C.W.**, 2017, Systematic fluctuations in the global seismic moment release: Geophysical Research Letters, v. 44, p. 4820–4828.

Zuza, A.V., and Yin, A., 2017, Balkatach hypothesis—a new model for the evolution of the Pacific, Tethyan, and Paleo-Asian oceanic domains: Geosphere, v. 13, p. 1664–1712.

Research Grants Active in 2016 and 2017

Barrick Gold, Fault trenching support of the Barrick Goldstrike N. Carlin Trend Structure Project, 7/17–2/18, $24,522, **Koehler, R.D.**

Clark County Building Department, Earthquake fault analysis of Las Vegas Valley, 8/16–3/21, $1,714,704, **dePolo, C.M.**, **Dee, S.**, Taylor, W.J., and **Faulds, J.E.**

Dajin Resources, Inc.: Analysis of seismic reflection data and potential lithium resources in Teels Marsh, Nevada: 7/16–9/16, $5,436, **Faulds, J.E.**

Federal Emergency Management Agency, Developing the earthquake section of the Churchill County hazard mitigation plan, 12/15–6/16, $42,794, **dePolo, C.M.**

Geologica Geothermal Group, Inc., Structural geology mapping of the Star Peak geothermal field, Nevada, 11/17–8/18, $9,495, **Hinz, N.H.**, and **Ramelli, A.R.**

German Space Agency, InSAR studies of contemporary crustal deformation in the western Basin and Range using TerraSar-X, 10/13–continuing, $27,000, **Bell, J.W.**, and **Hammond, W.C.**

Governor's Office of Energy, State of Nevada: Supplemental funds for analyses and drilling at the Fallon FORGE site: 10/15/2017–6/30/2018. $1,000,000; funds passed through UNR to Ormat Nevada, Inc. for drilling at the FORGE site, **Faulds, J.E.**

NASA ROSES, A.15 Sea Level, Observation-driven projections of future regional sea level change, 6/14–6/17, $162,985, **Hammond, W.C.**, **Blewitt, G.**, and Nerem, S.

NASA Sea Level Change Team, Global interconnections of cryosphere and solid Earth, sea-level change and ice mass balance, 10/17–9/20, $203,875, **Blewitt, G.**, and **Hammond, W.C.**

NASA, ACCESS, Plug-and-play GPS for earth scientists—providing immediate access to low-latency geodetic products for rapid modeling and analysis of natural hazards, 5/14–5/16, $164,436, Meertens, C., **Kreemer, C.W.**, **Blewitt, G.**, and **Hammond, W.C.,** and Ackerman, G.

NASA, pass-through University of Colorado, Boulder, Using satellite measurements to improve regional estimates of the impacts of sea level change, 9/17–4/20, $225,519, **Hammond W.C.**, and **Blewitt, G.**

NASA, ROSES, Extending the global geodetic observing system to high frequencies and low latencies, 6/12–6/16, $362,910, **Blewitt, G.**, and **Hammond, W.C.**

NASA, University of Colorado, Observation driven projections of future regional sea level change, 6/14–6/17, $146,686, **Blewitt, G.**, and **Hammond, W.C.**

NASA, University of Nevada, Reno, GPS imaging of solid Earth's flex and flow, 7/16–6/19, $416,950, **Blewitt, G.**, **Hammond, W.C.**, and **Kreemer, C.W.**

National Science Foundation Earthscope, Geodetic constraints on the kinematics of the Colorado Plateau and its western and southern margin, 7/10–6/16, $285,505, **Kreemer, C.W.**, Bennett, R.A., and Eriksson, S.

National Science Foundation EarthScope, Revealing the nature of contemporary uplift and collapse in the Sierra Nevada–Great Basin System (II), 7/13–6/16, $452,397, **Blewitt, G.**, and **Hammond, W.C.**

National Science Foundation Physics, Topological dark matter search, 8/15–7/18, $5,000, **Blewitt, G.**

National Science Foundation, Collaborative research: Using GPS to unravel the long-term kinematics and dynamics of the American Southwest from and ever-changing deformation field, 6/16–11/18, $246,500, **Kreemer, C.W., Blewitt, G.,** and Bennett, R.

National Science Foundation, Neotectonics and structural development of the northern Walker Lane, 7/14–6/17, $191,627, Wesnousky, S., and **Faulds, J.E.**

National Science Foundation, Search for topological dark matter with atomic clocks and GPS constellation, 8/15–7/18, $453,286, **Blewitt, G.**, and Derevianko, A.

National Science Foundation, University of Nevada, Reno, Revealing the nature of uplift and collapse in the Sierra Nevada-Great Basin System (II), 7/13–6/16, $361,665, **Blewitt, G.**, and **Hammond, W.C.**

Nevada Division of Emergency Management, Pre-Disaster Mitigation 2014 - Nevada Hazard Mitigation Plan Update, 1/15–12/16, $103,360, **Faulds, J.E., dePolo, C.M.**, and **Vlcan, J.M.**

Nevada Division of Emergency Management, Pre-Disaster Mitigation 2018 - State Hazard Mitigation Plan Update 2018, 5/17–4/18, $100,666, **dePolo, C.M.**, **Faulds, J.E.**, and **Vlcan, J.M.**

Nevada Division of Minerals: NBMG Sample curation, MI Reports, and Special Projects, 8/1/17–6/30/19, $170,000, **Faulds, J.E.**

Newmont Mining Corp., University of Nevada, Reno, Corporate donation: Age and petrology of the Phoenix-Fortitude gold skarn system, 3/17–2019, $60,000, **Ressel, M.W.**, and Johnson, C.

Newmont Mining Corp., University of Nevada, Reno, Corporate donation: Structural setting of Carlin-type gold deposits in the Pequop Mountains, northeast Nevada, 1/14–12/17, $120,000, **Ressel, M.W.**, and Milliard, A.

Newmont Mining Corp., University of Nevada, Reno, Corporation donation: Shallow Carlin-type gold deposits of the Southern Carlin Trend, and the Carlin to Epithermal Transition, 1/15–12/18, $120,000, **Ressel, M.W.**, and Hollingsworth, E.R.

Ralph J. Roberts Center for Research in Economic Geology, Annual CREG Donations, 2016, $42,901, **Muntean, J.L.**

Ralph J. Roberts Center for Research in Economic Geology, Annual CREG Donations, 2017, $187,000, **Muntean, J.L.**

Royal Dutch Academy of Sciences, Visiting Professor Fellowship, $6,950, 5/16–8/16, **Kreemer, C.W**

Southern California Earthquake Center, Effect of loading-induced horizontal deformation on the community geodetic model, 2/16–1/17, $20,140, **Kreemer, C.W.**, and Borsa, A.

Southern California Earthquake Center, University of Nevada, Reno, Estimating seismic coupling in southern California using aftershock productivity and geodetic constraints, 2/17–1/18, $20,000, Zaliapin, I., and **Kreemer, C.W.**

Southern Nevada Water Authority, Publication of geologic and geophysical studies in eastern Nevada related to groundwater assessments, 3/1/15–3/15/17, $41,400, **Faulds, J.E.**

Summit Mining Corporation, University of Nevada, Reno, Foundation Donation to Center for Research in Economic Geology, 3/15–5/16, $30,000, **Ressel, M.W.**, and Freedman, D.

U.S. Department of Energy, Comprehensive analysis of Hawaii's geothermal potential through Play Fairway integration of geophysical, geochemical, and geologic data, Phase II, subcontract to University of Nevada, Reno from University of Hawaii, 12/16–9/17, $13,500 (Principle Investigator of subcontract - $13.5K), **Hinz, N.H.**

U.S. Department of Energy, Comprehensive analysis of Hawaii's geothermal potential through Play Fairway integration of geophysical, geochemical, and geologic data, Phase III, subcontract to the University Of Nevada, Reno from the University of Hawaii, 10/17–3/19, $10,000, **Hinz, N.H**.

U.S. Department of Energy, Deep direct-use feasibility study for the Hawthorne, Nevada Army Depot and surrounding community, 10/17–9/19, $560,000 (sub-award to University of Nevada, Reno $57,000, Lowry, T., **Ayling, B.F.**, Sabin, A., Arguello, R., and **Hinz, N.H.**

U.S. Department of Energy, Discovering Blind Geothermal Systems in the Great Basin Region: An Integrated Geologic and Geophysical Approach for Establishing Geothermal Play Fairways: 10/1/14–4/30/16, $499,992, **Faulds, J.E.**

U.S. Department of Energy, Discovering blind geothermal systems in the Great Basin region: An integrated geologic and geophysical approach for establishing geothermal play fairways: Phase 2: 4/16–9/17, $825,000, **Faulds, J.E.**, and **Hinz, N.H.**

U.S. Department of Energy, Discovering blind geothermal systems in the Great Basin region—an integrated geologic and geophysical approach for establishing geothermal play fairways, Phase III, 10/17–9/19, $1,500,000, **Faulds, J.E**., and **Hinz, N.H.**

U.S. Department of Energy, Frontier Observatory for Research in Geothermal Energy: Fallon, Nevada: Lead by Sandia National Labs, collaboration with Lawrence Livermore National Labs, Berkeley National Labs, United States

Geological Survey, Navy Geothermal Program Office, and University of Nevada Reno, 7/15–6/16, $100,000, **Faulds, J.E.**, Calvin, W., and **Hinz, N.H.**

U.S. Department of Energy, Frontier Observatory for Research in Geothermal Energy (FORGE): Fallon, Nevada—Phase 2A: 10/16–3/18, $8,500,000 (PI of UNR part; co-PI with Sandia National Laboratories as lead of entire project), UNR portion is $24,000. Note that most of the funding in Phase 2 is allocated for drilling through Sandia Laboratories. Our UNR team is the lead on developing the geological model for the site. Fallon is one of two sites in the country under investigation for FORGE, **Faulds, J.E., Hinz, N.H., and Ayling, B.F.**

U.S. Department of Energy, Identification of hidden, high-enthalpy geothermal systems in extensional regimes through an exploration technology paradigm incorporating magnetotellurics, soil gas geochemistry, and structural analysis, 9/11–9/16, $209,902, **Faulds, J.E.**

U.S. Department of Energy, Lawrence Berkeley National Laboratory, Structural mapping around Wells, NV and implications for geothermal exploration, 3/17, $9,776, **Zuza, A.V.**

U.S. Department of Energy, Poroelastic tomography by adjoint inverse modeling of data from seismology, geodesy, and hydrology, 10/14–9/17, $65,154, **Kreemer, C.W.**

U.S. Department of Energy: Frontier Observatory for Research in Geothermal Energy (FORGE): Fallon, Nevada—Phase 2B: 3/1/17–9/19 $8,500,000 UNR portion on Phase 2B is $675,000. Note that most of the funding in Phase 2 is allocated for drilling through Sandia Laboratories. Our UNR team is the lead on developing and refining the geological model for the site. Fallon is one of two sites in the country under investigation for FORGE, **Faulds, J.E., Ayling, B.F.,** and **Hinz, N.H.**

U.S. Department of State, Strengthening the capacity of foreign countries to develop their geothermal energy resource base, 10/17–9/20, $1,199,822, **Ayling, B.F.**, and **Hinz, N.H.**

U.S. Geological Survey, Development of earthquake chronology and recurrence data for the southern Warm Springs Valley fault using new-high resolution lidar data and trenching, Washoe County, Nevada, 12/17, $40,526, **Koehler, R.D.**

U.S. Geological Survey, Earthquake hazard of the Washoe shear zone, Reno, 2/15–1/16, $46,899, **dePolo, C.M.**

U.S. Geological Survey, National Earthquake Hazard Reduction Program, University of Nevada, Reno, Robust estimation of fault slip, block rotation and off-fault strain rates in the Walker Lane from GPS data, 12/16–11/17, $70,938, **Hammond, W.C.**

U.S. Geological Survey, National Earthquake Hazards Reduction Geodetic Networks program, Western Great Basin seismic and geodetic network operations, 2015–2020, 3/15–2/20, $327,854, **Hammond, W.C.**, and **Blewitt, G.**

U.S. Geological Survey, National Earthquake Hazards Reduction Program, Pilot paleoseismic investigation of faults in the North Valleys, Reno, NV, 10/15–2/17, $59,375, **Ramelli, A.R.**, and **Dee, S.**

U.S. Geological Survey, Nevada collection inventory and metadata for the National Catalog 2016, 9/16–8/17, $32,262**, dePolo, C.M.,** and **Davis, D.**

U.S. Geological Survey, New lidar mapping and paleoseismic characterization of the Peterson Mountain fault zone, north of Reno, Nevada, 12/17, $62,683, **Koehler, R.D**., and **Dee, S.**

U.S. Geological Survey, STATEMAP 2015, Digital conversions, 7/15–9/16, $13,000, **Henry, C.D.**, and **Vlcan, J.M.**

U.S. Geological Survey, STATEMAP 2015, Geologic mapping of the Boulder City quadrangle, Clark County, Nevada, 7/15–9/16, $44,878, **Dee, S.**, and **Hinz, N.H.**

U.S. Geological Survey, STATEMAP 2015, Geologic mapping of the Herder Creek quadrangle, 7/15–7/16, $63,823, **Dee, S.**, and **Ressel, M.W.**, and **Henry, C.D.**

U.S. Geological Survey, STATEMAP 2015, Geologic mapping of the Mount Rose NW quadrangle, 7/15–9/16, $45,068, **Hinz, N.H.**, and **Ramelli, A.R.**

U.S. Geological Survey, STATEMAP 2016, Digital conversions, 7/16–9/17, $17,173, **Dee, S.,** and **Vlcan, J.M.**

U.S. Geological Survey, STATEMAP 2016, Geologic mapping of the Boulder City NW quadrangle, Clark County, Nevada: 7/16–9/17, $72,469, **Dee, S.**, and **Hinz, N.H**.

U.S. Geological Survey, STATEMAP 2016, Geologic mapping of the Independence Valley NW quadrangle, 7/16–9/17, $34,646, **Dee, S.**, **Ressel, M.W.**, and **Henry, C.D.**

U.S. Geological Survey, STATEMAP 2016, Geologic mapping of the Kinsley Mountains North, 7/16–9/17, $42,901, **Muntean, J.L.,** and **Dee, S.**

U.S. Geological Survey, STATEMAP 2017, Digital conversions, 6/17–9/18, $17,304, **Dee, S.,** and **Vlcan, J.M.**

U.S. Geological Survey, STATEMAP 2017, Geologic mapping of the Independence Valley NE quadrangle, 6/17–9/18, $54,830, **Dee, S.**, **Ressel, M.W.**, **Henry, C.D.,** and **Zuza, A.V.**

U.S. Geological Survey, STATEMAP 2017, Geologic mapping of the Mount Rose NW quadrangle, 6/17–9/18, $45,943, **Dee, S.**, **Hinz, N.H.**, and **Ramelli, A.R.**

U.S. Geological Survey, STATEMAP 2017, Geologic mapping of the Ravens Nest quadrangle, 6/17–9/18, $55,409, **Dee, S.**, and **Ressel, M.W.**

U.S. Geological Survey, University of Nevada, Reno, Nevada collection and metadata for the national catalog, 9/15–8/16, $8,470, **Depolo, C.M.**, and **Davis, D.**

U.S. Geological Survey, Working group on Nevada seismic hazards, 6/17–11/18, $23,172, **Koehler, R.D.** and Anderson, J.G.

U.S. Gold Corporation, Corporate Research Support-Igneous and economic geology of the Keystone project, Battle Mountain-Eureka gold belt, Eureka County, Nevada, 10/16, $57,000, **Ressel, M.W.**, and Aliaga, G.

University of Nevada, Office of Vice President for Research and Innovation (VPRI), Lidar Acquisition for the Reno/Carson City, NV Urban Corridor and Surrounding Areas: **Jim Faulds** secured match funding ($150,000) for LiDAR acquisition for 1,370 square miles in western Nevada from VPRI office, which facilitated funding from 3DEP program of the U.S. Geological Survey; total award $349,605 (**Seth Dee** prepared USGS 3DEP proposal).

University of Nevada, Reno, Research and Innovation New Scholarly Endeavor Grant Program, What can a tilted pluton tell us about basin and range extension?, 7/17, $2,500, **Zuza, A.V**., and Cao, W.

University of Nevada, Reno: International Activities Grant: Comparative analysis of magmatic and non-magmatic geothermal systems: New Zealand and the Great Basin Region, Western USA, $2,500, 7/1/2017–6/30/2018

NBMG Honors, Awards, and Special Appointments in 2016 and 2017

Ayling, B.F., Director, Great Basin Center for Geothermal Energy

Ayling, B.F., Elected to **Board of Directors**, Geothermal Resources Council

Blewitt, G., Chair, AGU Geodesy Section Executive Committee

Blewitt, G., Chair, European Geosciences Union Vening Meinesz Medal Committee

Blewitt, G., Director, Nevada Geodetic Laboratory

Blewitt, G., Governing Board Member, International Laser Ranging Service

Blewitt, G., Kreemer, C.W., Hammond, W.C., Awarded Certificate for Highly Cited Research from the Journal of Geodynamics (2014–2016).

- **Blewitt, G.**, **Kreemer, C.W.**, **Hammond, W.C.**, and Goldfarb, J.M., 2013, Terrestrial reference frame NA12 for crustal deformation studies in North America: Journal of Geodynamics, 72, p. 11–24, ISSN 0264-3707, doi:10.1016/j.jog.2013.08.004

Blewitt, G., Member, Global Geodetic Observing System (GGOS) Science Panel

Blewitt, G., Member, International Association of Geodesy Executive Committee

Blewitt, G., Member, International Association of Geodesy Joint Working Group 2.2: "Relativistic Geodesy"

Blewitt, G., President, 2016, Committee on Space Research (COSPAR) Sub-Commission B2: International Coordination of Space Techniques for Geodesy

Blewitt, G., President, 2017, Committee on Space Research (COSPAR) Sub-Commission B2: International Coordination of Space Techniques for Geodesy

Blewitt, G., President, American Geophysical Union Geodesy Section

Blewitt, G., President, International Association of Geodesy Commission 1: Reference Frames

Dee, S., Member, Nevada Working Group on Seismic Hazards

Dee, S., Member, USGS Earthquake Hazards Program CEUS funding review panel

Dee, S., Member, Utah Working Group on Seismic Hazards

Dee, S., Reviewer, USGS strategic plan for the National Cooperative Geologic Mapping Program

dePolo, C.M., Chair, Nevada Hazard Mitigation Planning Committee

dePolo, C.M., Chair, Nevada Unreinforced Masonry Building Committee

dePolo, C.M., Contributor, Handbook for rural earthquake disasters for emergency responders, assisted the Western States Seismic Policy Council and the Utah Division of Emergency Management

dePolo, C.M., Editor, Nevada Enhanced Hazard Mitigation Plan

dePolo, C.M., Member, Nevada Earthquake Safety Council

dePolo, C.M., Member, Nevada Hazard Mitigation Planning Subcommittee

Faulds, J.E., Chair, Association of American State Geologists Geothermal Committee.

Faulds, J.E., Contributor, Committee on Natural Resources for House of Representatives to amend the Geothermal Steam Act of 1970 to increase the allowable depth of geothermal exploration drill holes to ease the permitting requirements and thus facilitate more efficient geothermal exploration.

Faulds, J.E., Member, Advisory Board for IMAGE (Integrated Methods for Advanced Geothermal Exploration), a major geothermal program funded by the European Union.

Faulds, J.E., Member, National Cooperative Geologic Mapping Program (NCGMP) committee that prepared report aimed at reviewing, revising, and reauthorizing the NCGMP (funds STATEMAP, EDMAP, and FEDMAP)

Faulds, J.E., Member, Nevada Earthquake Safety Council

Hammond, W.C., Member, Editorial Review Board Associate Editor of the Bulletin of the Seismological Society of America

Hammond, W.C., Member, External Grant Review Panel, NASA NISAR Science Definition Team program

Hammond, W.C., Member, UNVACO GNSS Geodetic Data Services subcommittee

Henry, C.D., Editorial Board Member, Revista Mexicana de Ciencias Geologicas, Universidad Nacional Autonoma de Mexico

Hinz, N.H., Invited Presenter, United Nations Environmental Program, Geologic Development and Geophysics of the Western Branch of the Greater East African Rift Region, Kigali, Rwanda

Hursh, J.P., Member, Nevada State Board on Geographic Names

Koehler, R.D., Committee Chair, Western States Seismic Policy Council Basin and Range subcommittee

Koehler, R.D., Member, Editorial Review Board, 7th International INQUA workshop on Paleoseismology, Active Tectonics, and Archaeoseismology

Koehler, R.D., Member, Nevada Earthquake Safety Council

Koehler, R.D., Member, Nevada Quaternary faults working group, compiling paleoseismic data on active faults in the Reno-Carson urban area.

Koehler, R.D., Panel member, National Earthquake Hazards Program

Kreemer, C.W., Board Member, Lithosphere journal editorial board.

Kreemer, C.W., Committee Member, International Association of Geodesy, Global Crustal Deformation working group

Kreemer, C.W., Committee Member, International Association of Geodesy, Regional Dense Velocity Fields working group

Kreemer, C.W., Visiting Professor Fellowship from Royal Dutch Academy of Sciences

Micander, R.E., Member, Nevada Hazard Mitigation Planning Subcommittee

Micander, R.E., State Representative, National States Geographic Information Council

Muntean, J.L., Chair, Arthur Brant Chair in Exploration Geology

Muntean, J.L., Contributor, mineral resource data for the Nevada Congressional delegation to help with policy decisions regarding the sage grouse

Muntean, J.L., Director, Ralph J. Roberts Center for Research in Economic Geology

Muntean, J.L., Editor, Society of Economic Geologists, Diversity of Carlin-style Gold Mineralization

Ressel, M.W., Board of Directors, Geological Society of Nevada Foundation

Ressel, M.W., Foundation Member, Geological Society of Nevada

Ressel, M.W., Member, State of Nevada Mining Corporate Guarantee Committee

Ressel, M.W., Member, State of Nevada Mining Oversight and Accounting Commission

Vlcan, J.M., Board Member, Nevada Geographic Information Society

Vlcan, J.M., Executive Secretary, Nevada State Mapping Advisory Committee

Wilson, S.C., Member, Nevada Hazard Mitigation Planning Subcommittee

Zuza, A.V., Director, Summer Field Course for Department of Geological Sciences and Engineering at UNR

Graduate students measuring a fault surface along the margin of Crescent Valley in north-central Nevada. *Photographer: Jim Faulds*

NBMG geologist, Chris Henry, inspecting an outcropping in the Cobble Cuesta area, Nye County, Nevada. *Photographer: Jack Hursh*

Nevada System of Higher Education 2018

Board of Regents

Patrick R. Carter
Amy J. Carvalho
Carol Del Carlo
Mark W. Doubrava
Jason Geddes, Vice Chairman
Trevor Hayes
Sam Lieberman
Cathy McAdoo
Donald S. McMichael Sr.*
John T. Moran
Kevin J. Page, Chairman
Laura E. Perkins*
Rick Trachok

Thom Reilly, *Chancellor*

University of Nevada, Reno

Marc Johnson, *President*

College of Science

Jeffrey Thompson, *Dean*

Nevada Bureau of Mines and Geology

James E. Faulds, *Director/State Geologist*

Scientific Research Staff

Economic Geology, Geologic Mapping, and Geologic Framework

James E. Faulds, *Professor*
Christopher D. Henry, *Research Geologist*
Nicholas H. Hinz, *Geologic Mapping Specialist***
John Muntean, *Associate Professor-Research Economic Geologist*
Mike Ressel, *Assistant Professor-Research Economic Geologist*
Andrew Zuza, *Assistant Professor-Structural Geologist*

Geologic Hazards and Engineering Geology

Seth Dee, *Geologic Mapping Specialist*
Craig M. dePolo, *Research Geologist*
Rich Koehler, *Assistant Professor*
Alan Ramelli, *Research Geologist***

Nevada Geodetic Laboratory

Geoffrey Blewitt, *Research Professor*
William C. Hammond, *Research Professor*
Corné W. Kreemer, *Research Professor*

Great Basin Center for Geothermal Energy

Bridget Ayling, *Director, Associate Professor*
Rozena Brecke, *Administrative Assistant**
Steve DeOreo, *Drilling Manager, Nevada Geothermal Play Fairway project*
Cary Lindsey, *Postdoctoral Scholar**
Elijah Mlawsky, *Geoscience Data Manager*

Ralph J. Roberts Center for Research in Economic Geology

John Muntean, *Director, Associate Professor-Research Economic Geologist*

Research and Administrative Support Staff

Cartography and Publication Support

Jennifer Vlcan, *Cartographic/GIS Manager*
Jack Hursh, *Cartographer/Publications Specialist*
Rachel Micander, *Analyst - GIS and Cartography*
Irene Seelye, *Cartographer/GIS Specialist*
Sydney Wilson, *Cartographer/GIS Specialist*

Data Management

Emily O'Dean, *Geoscience Data Manager**

Publication Sales and Information

Craig M. dePolo, *Supervisor*
David Davis, *Geologic Information Specialist*
Charlotte Stock, *Sales Manager*
Bret Pecoraro, *Development Technician*

Administration

Alex Nesbitt, *Administrative Assistant*
Linda Goar, *Accounting Assistant***

Advisory Board (2016–2017)

Alan Coyner
Del Fortner
David Gaskin
Shawn Gooch
Kyle House
Ronald Lynn
Ronald Parratt
Richard Perry
Richard Reid
John Snow
Debbie Struhsacker
Wanda Taylor
James Watrus
James Werle
Elizabeth Zbinden

*joined NBMG since 2017
**no longer on NBMG staff in 2018

The University of Nevada, Reno is an Equal Opportunity/Affirmative Action employer and does not discriminate on the basis of race, color, religion, sex, age, creed, national origin, veteran status, physical or mental disability, and in accordance with university policy, sexual orientation, in any program or activity it operates. The University of Nevada, Reno employs only United States citizens and aliens lawfully authorized to work in the United States.