NEVADA BUREAU OF MINES AND GEOLOGY

OPEN-FILE REPORT 16-8

Biennial Report of the Nevada Bureau of Mines and Geology 2014–2015

Nevada Bureau of Mines and Geology

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Cover photo:
Multiple faults cut through Mount Rose. One of the largest, a north-south, down-to-east fault is visible in this photo displacing the thickest ledge-forming andesite lava flow near the top of Mount Rose, Washoe County (above, upper right). *Photographer: Nick Hinz*

James E. Faulds
Director and State Geologist

PREPARED FOR
The Board of Regents of the Nevada System of Higher Education
2016

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

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Suggested Citation:
Faulds, J.E., 2016, Biennial report of the Nevada Bureau of Mines and Geology, 2014–2015: Nevada Bureau of Mines and Geology Open-File Report 16-8, 45 p.

NBMG Mission Statement

The Nevada Bureau of Mines and Geology (NBMG) is a research and public service unit of the University of Nevada and is the state geological survey. NBMG is part of the Mackay School of Earth Sciences and Engineering within the College of Science at the University of Nevada, Reno. NBMG scientists conduct research and publish reports on mineral resources, engineering geology, environmental geology, hydrogeology, geologic hazards, and geologic mapping.

Current activities in geologic mapping and mineral resources include detailed geologic mapping and stratigraphic studies in Nevada, comparative studies of bulk-mineable precious-metal deposits, geochemical investigations of mining districts, metallic and industrial mineral resource assessments, igneous petrologic studies, hydrothermal experiments, and research on the origin of mineral deposits.

Engineering geology, environmental geology, and hydrogeology projects include investigations of earthquake hazards and related aspects of neotectonics, examination of geological issues involved in disposing nuclear and hazardous wastes, mapping of geomorphic features, radon hazard studies, studies of landslide hazards, geochemical characterization of natural environmental hazards, investigations of the fate of mercury from processing Comstock ores by amalgamation in late 1800s, and investigation of land subsidence, primarily in Las Vegas Valley.

Earth science education projects include writing guidebooks for laymen, teachers, and students; presenting lectures, short courses, and workshops; and assisting with science fairs, curriculum development, and conferences. Geologic and geographic information activities include creating and updating databases on mining districts, active mines and prospects, and geothermal and petroleum exploration and production; implementation and development of statewide geographic information systems and the digital maps needed for these systems; and 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.

NBMG cooperates with numerous state and federal agencies in conducting 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 addition to addressing the needs for geologic information by conducting research, publishing reports and maps, and creating computer databases, staff members assist the public, industry, and government agencies by answering specific questions regarding Nevada geology and resources and by providing some chemical and mineralogical analyses.

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

NBMG History

The following paragraphs are excerpted from the chapter "The Nevada Bureau of Mines and Geology" by Joseph V. Tingley (in *The State Geological Surveys: A History*, edited by Arthur A. Socolow, published by Association of American State Geologists, 1988, pages 282–295)

To read the entire chapter on the history of the Nevada Bureau of Mines and Geology, see the following link on the Nevada Bureau of Mines and Geology website:

http://www.nbmg.unr.edu/_docs/HistoryOfNBMG.pdf

On March 20, 1865, during its first session, the Nevada Legislature created the position of state geologist; an act was passed that provided for appointment by the Board of Regents of a State Geologist of Nevada who,

> ... shall proceed to make a preliminary and superficial geological survey of the mineral regions of the state, ...and to prepare a map, marked and colored in such a manner as to indicate the general geological divisions, as developed in the country examined.

The following year (1866), during the second session of the legislature, an act was passed which created the office of State Mineralogist. The State Mineralogist was to serve under the Board of Regents and was, among other things, to be superintendent of a state mining school; to visit and examine mineral properties within the state; to collect, mark, and catalog mineral specimens; to devise the course of studies at the mining school; to teach at the school; and to collect information concerning the different modes of working mines and reducing ores.

In 1869, the position of State Mineralogist was removed from the control of the Board of Regents and was made an elective office; White was appointed to continue in the position until the general elections of 1870. H.R. Whitehill was elected to the position and took office in January 1871. Whitehill held the job until 1878 when the office was abolished by the Legislature. The reports of the State Mineralogist, issued biennially during the 12-year life of the office, are in some cases the only surviving records of many mining operations in remote parts of the state.

In 1888, a School of Mining was formally organized at the new Reno campus of the University of Nevada with Robert D. Jackson as its first Director. In 1895 the Nevada legislature charged the University with the responsibility of providing an assay service for citizens of the state and the Mining Analytical Laboratory was established. As the first public service division of the University, the laboratory was the organizational predecessor of the Nevada Bureau of Mines and Geology.

In 1929, under Fulton's directorship, the Nevada Bureau of Mines was formed as the second public service division of the University of Nevada. Fulton took personal credit for initiating legislation which led to the formation of the Bureau. In a letter to the President of the University in 1939, Fulton stated:

> The mining states of the West all have a Bureau of Mines...The services performed by these Bureaus are of great value to the mining industry and inasmuch as mining is the paramount industry in Nevada, it seemed to me important to have such an agency here. ... I therefore, after discussing the matter with the President [of the university], had a bill introduced in the 34th legislature in 1929 establishing a Bureau of Mines. ...

NBMG History

Assembly Bill No. 83, approved March 29, 1929, brought the Nevada Bureau of Mines into existence. It was to be under the direction of the Board of Regents of the University and "a competent mining engineer" was to be appointed director. Clearly spelled out in the bill were objectives that Director Fulton must have had in mind. The first listed was:

> To, by questionnaire or otherwise, conduct a thorough mineral survey of the state and to catalog each and every mineral deposit and occurrence, both metallic and nonmetallic of whatsoever nature ... and to serve as a bureau of information and exchange on Nevada mining.

This still remains as one of the prime functions of the organization.

The Nevada Bureau of Mines was now set in a form that would carry it through the depression, a world war, and up to its next major transition. The Bureau and the Mining Analytical Laboratory, both public service organizations, along with the teaching departments, made up the Mackay School of Mines.

In 1963, the Bureau moved into offices in the new Scrugham Engineering-Mines Building constructed directly east of the old Mackay School of Mines Building. Dean Scheid, through persistent negotiations with Nevada legislators, had managed to have an entire wing of the new building earmarked for the use of the Nevada Bureau of Mines and the State Analytical Laboratory. The Bureau in 1987 (and presently in 2012) occupies most of the four floors of the mines wing of this building.

Directors and Acting Directors since 1987:

James L. Hendrix, 1987–88, Acting Director
Harold F. Bonham, Jr., 1993–95, Acting Director
Jonathan G. Price, 1988–1993, and 1995–2012, Director and State Geologist
James Faulds, 2012–present, Director and State Geologist

Titles, Organizational Directors, and Dates Served in Historical Sequence from 1865–1987:

State Geologist, 1865
(Position not filled)

State Mineralogist, 1866–78
Richard H. Stretch, 1866
A.F. White, 1867–70
H.R. Whitehill, 1871–78

State Analytical Laboratory, 1895-1985
Directors:
Robert D. Jackson, 1895–1899
Charles P. Brown, 1899
George J. Young, 1900–14
Francis Church Lincoln, 1914–24
Walter S. Palmer, 1924–51
Vernon E. Scheid, 1951–72
John H. Schilling, 1973–85

Nevada Bureau of Mines, 1929–71
Directors:
John A. Fulton, 1929–39
Jay A. Carpenter, 1939–51
Vernon E. Scheid, 1951–71

Nevada Bureau of Mines and Geology, 1971–present
Directors:
Vernon E. Scheid, 1971–72
John H. Schilling, 1972–87

For the complete history of the Nevada Bureau of Mines and Geology, see the following link on the **Nevada Bureau of Mines and Geology website**
http://www.nbmg.unr.edu/_docs/HistoryOfNBMG.pdf

NBMG Director Awarded Fellowship

From NEVADAToday, by Patrick Harris, 1/28/2014
http://www.unr.edu/nevada-today/news/2014/jim-faulds-fellowship

Jim Faulds, a research professor for the University of Nevada, Reno and director for the Nevada Bureau of Mines and Geology, has been elected a Fellow of the Geological Society of America for his work on tectonics and structural geology.

"I am very honored that my peers have chosen me as a Fellow for the Geological Society of America," Faulds said. "The Society is one of the most prominent geological organizations in North America."

One of 63 recipients from universities across the North American continent and abroad, Faulds was awarded his fellowship at an awards ceremony in Colorado last fall. He was nominated for the award by fellow colleague, state geologist emeritus and Geological Society of America member, Jonathan Price.

"Faulds was recognized for fundamental work on the tectonics and structural geology of the Great Basin region and Basin and Range province in the western U.S.," Price said. "An accomplished mapper, Faulds has integrated detailed geologic mapping into nearly all his work, which has had direct applications to earthquake hazards, industrial minerals, metallic ore deposits and geothermal resources."

Faulds first came to love geology as a child watching ice on lakes break up during springtime and collide with one another. He turned this interest toward the earth's crust and began studying geology. He began teaching at the University for the Nevada Bureau of Mines and Geology in 1997 and became the director in 2012.

"Being director is challenging, but rewarding," Faulds said. "I have the opportunity to guide the Bureau in the analysis of Nevada geology and better understand natural resources and hazards of the area."

Nevada is often prone to earthquakes due to tectonic shifts. As a structural geologist, Faulds studies how the area's crust deforms and extends, thereby producing earthquakes, tremors, hot water deposits and mineral precipitation. Of his many contributions to tectonics, Faulds most enjoys studying the association between fault patterns and geothermal resources, or areas of flowing hot water. Whether at the surface or underground, the hot water is an accessible energy source that can be used to produce electricity, heat buildings and homes or provide appropriately temperatured waters for greenhouses and fish hatcheries.

"The research on geothermal resources felt very relevant and applicable to society's use," Faulds said. "A geothermal plant could run consistently, develop energy, and not deplete the resource."

Faulds' tectonic research is just one example of his work that earned him the Fellowship from the Geological Society of America.

"I have been very fortunate to spend so much of the past 30 years studying the amazing geology and landscapes of Nevada and surrounding regions," Faulds said. "This award should really go to those landscapes, which have and will continue to intrigue the curiosity of myself and others for many generations to come."

The Geological Society of America is a coalition of academic, government, business and industry professionals dedicated to studying the earth. Annual fellowships are granted to current members in recognition of their outstanding contributions to the geosciences.

Jim Faulds discussing blind geothermal systems at the 2014 NBMG Earth Science Week open house at the Great Basin Science Sample and Records Library. *Photographer: Jack Hursh*

Find additional information on Jim Faulds' research at the
Nevada Bureau of Mines and Geology website
http://www.nbmg.unr.edu/Staff/Faulds.html

NBMG Current and Future Benefits

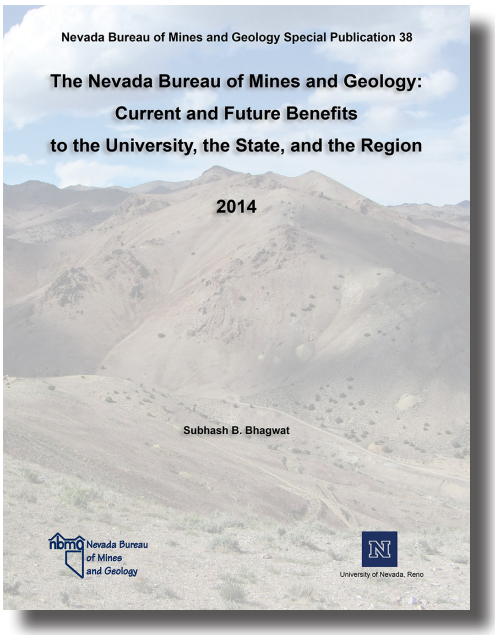
NBMG Publication Spotlight

NBMG Special Publication 38

The Nevada Bureau of Mines and Geology: Current and Future Benefits to the University, the State, and the Region

Includes 64 pages of text

by Subhash B. Bhagwat, Ph.D.



This study was commissioned by the College of Science, University of Nevada Reno (UNR), to assess the benefits of geological research and service by the Nevada Bureau of Mines and Geology (NBMG) and to consider future synergies between NBMG and the other geoscience units at UNR, while maintaining the core mission of NBMG.

The study involved two steps: 1) review and assess the benefits derived from NBMG's past geologic research and services, and 2) assess how best to focus available resources in the future. After studying NBMG's past publications, a questionnaire was sent to over 1,800 users of geologic information in Nevada. The purpose of the campaign was to assess how users perceive the usefulness of geologic research and services of NBMG, both in terms of its quality as well as in monetary terms. The results of the questionnaire are reported in this publication.

Some observations from the review:

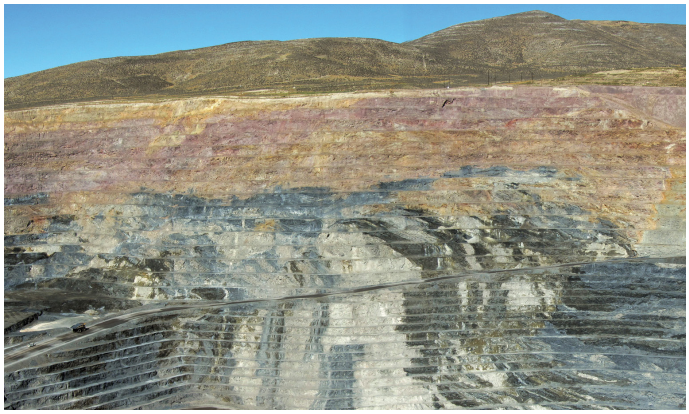
- Geologic information is used in every area of human activity, including industry, government agencies at all levels, public safety agencies, tourism and education.
- NBMG's geologic research and services are valued for their independent, accurate, and unbiased nature and the scientific reputation of its scientists.
- Geologic research conducted by NBMG has economically benefited industries in Nevada, especially gold, various other minerals, and geothermal energy. NBMG's detailed geologic mapping contributed in a major way to the development of these industries, making Nevada a leading producer of gold and geothermal power. These industries have produced high-paying jobs and generated millions of dollars in revenues for the State.
- As an earthquake-prone state, Nevada has benefited from NBMG's research, which has identified geologic faults, studied histories of past earthquakes, compiled guidelines to mitigate damage, and educated the public about possible damage and injury from earthquakes. Geologic research has also helped to identify environmental concerns, such as indoor radon gas concentrations, and provided geologically oriented guidebooks for tourism, the second largest economic sector in Nevada.
- User survey indicated that NBMG's geologic research and services are especially beneficial to financially weaker, small companies and individuals.
- Quantitatively, user responses indicated that detailed geologic maps, publications, and geologic databases are highly valued NBMG products.
- In spite of its productive past, NBMG needs to redouble its geologic efforts, because only about 20% of the state has been adequately mapped for assessment of natural hazards and mineral and energy resources.

Find additional information on NBMG SP 38 at the
Nevada Bureau of Mines and Geology website
http://pubs.nbmg.unr.edu/NBMG-current-and-future-p/sp038.htm

Mineral Industry

The value of overall mineral and energy production in Nevada in 2015 was just over $7.5 billion, about the same as in 2014. Gold production in 2015 was just under 5.34 million ounces (166 tonnes), an 8.1% increase from 2014. The average gold price in 2015 was $1160/ounce. Gold's share of the value of Nevada's mineral and energy production decreased slightly to 81.8%. Nevada led the nation in the production of gold and barite ($63.6 million). Additionally, Nevada was the only state that produced lithium ($25.6 million), magnesite ($6.7 million), and the specialty clays, sepiolite and saponite ($6.87 million).

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



The Conelea Anticline ore-controlling structure at Newmont Mining Corporation's "Megapit" at Twin Creeks Mine, Humboldt County. *Photographer: John Muntean*

Chemetall Foote lithium operation at Silver Peak in Clayton Valley, Esmeralda County. *Photographer: Steve Castor*

Chris Henry discussing geology during a Nevada Petroleum and Geothermal Society field trip. *Photographer: Jack Hursh*

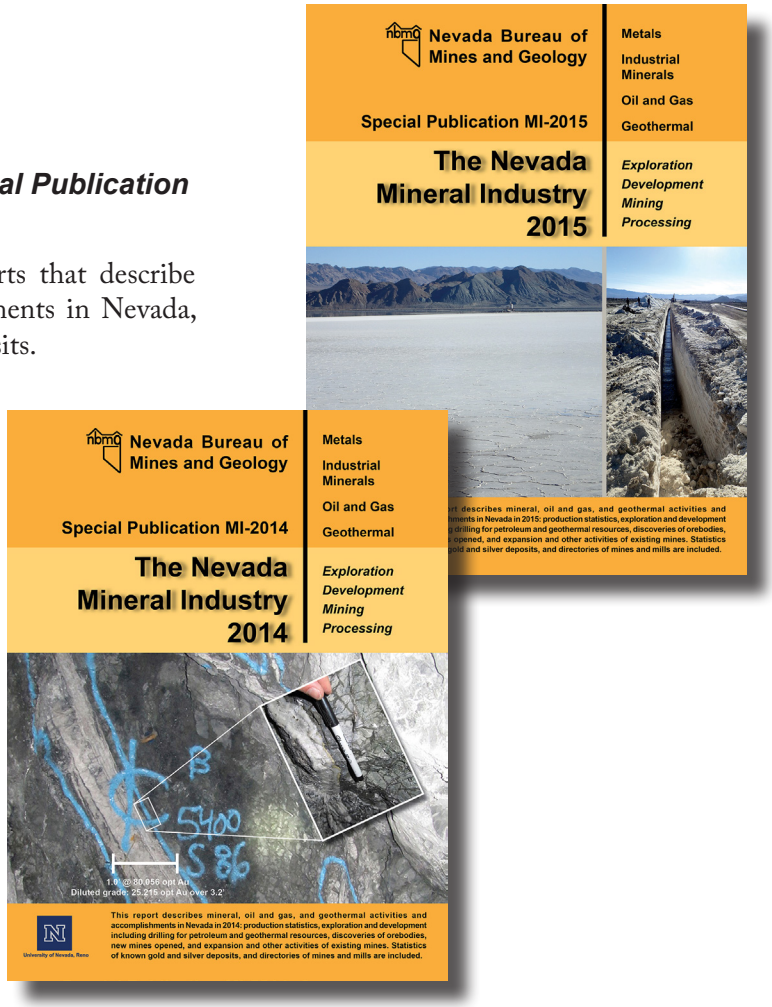
Find additional reports and data on Nevada's mineral industry at the
Nevada Bureau of Mines and Geology website
http://pubs.nbmg.unr.edu/Mineral-Industry-s/1860.htm

Mineral Industry

NBMG Publication Spotlight

Nevada Bureau of Mines and Geology Special Publication MI-2014 and MI-2015

Starting in 1979, NBMG has issued annual reports that describe mineral and geothermal activities and accomplishments in Nevada, and include statistics of known gold and silver deposits.



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

Special Publication MI-2014, 171 pages
https://pubs.nbmg.unr.edu/The-NV-mineral-industry-2014-p/mi2014.htm

Special Publication MI-2015, 190 pages
https://pubs.nbmg.unr.edu/The-NV-mineral-industry-2015-p/mi2015.htm

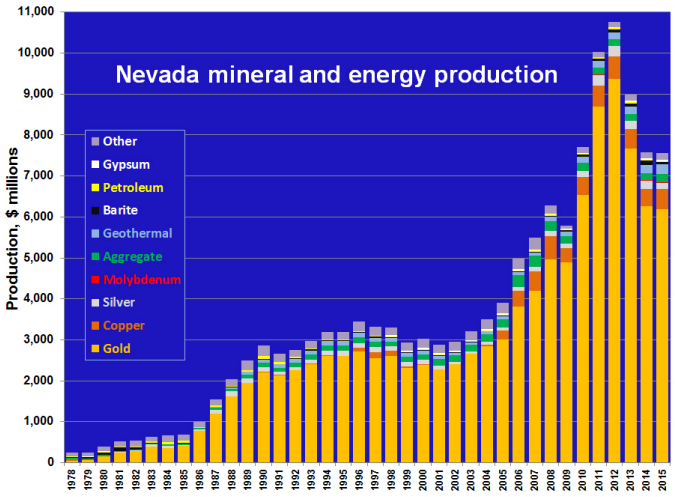
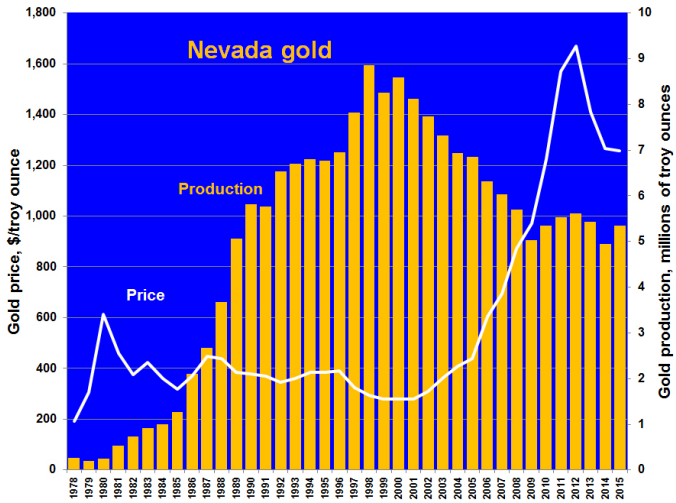


Chart showing relative values of Nevada production of gold, copper, silver, molybdenum, aggregate, geothermal energy, barite, petroleum, gypsum, and other minerals from 1978 to 2015.



Graph of Nevada gold production and price of gold (US dollars per troy ounce) from 1978 to 2015.

Find a listing of the annual Nevada Mineral Industry reports at the
Nevada Bureau of Mines and Geology website
http://pubs.nbmg.unr.edu/Mineral-Industry-s/1860.htm

Mineral Industry

NBMG Geologist Spotlight

John Muntean
Associate Professor
Research Economic Geologist
Nevada Bureau of Mines and Geology

Areas of Expertise

Geology and geochemistry of ore deposits, especially Carlin-type gold deposits, epithermal gold-silver deposits, and porphyry copper-gold deposits
Mineral exploration
Mine geology
Geologic mapping
Aqueous geochemistry
Magmatic-hydrothermal processes
Metallogeny of Nevada

Professional Activities

Director, Ralph J. Roberts Center for Research in Economic Geology.
Chair, Geological Society of Nevada 2015 Symposium.
Committee Chair, Society of Economic Geologists Forum on Diversity of Carlin-Style Gold Mineralization.
Student Advisor, Society of Economic Geologists.
Editorial Reviewer: Diversity of Carlin-style Gold Mineralization, Society of Economic Geologists.
External Grant Reviewer: National Science Foundation.
Invited Manuscript Reviewer: Minerallium Deposita, and Economic Geology.

Publication Citations

Di Fiori, R.V., Long, S.P., **Muntean, J.L.**, and Edmondo, G.P., 2014, Preliminary geologic and alteration maps of Lookout Mountain, Ratto Ridge, and Rocky Canyon, southern Eureka mining district, Eureka County, Nevada: Nevada Bureau of Mines and Geology Open-File Report 14-8, 1:10,000-scale, 2 plates.

Long, S.P., Henry, C.D., **Muntean, J.L.**, Edmondo, G.P., and Thomas, R.D., 2014, Geologic map of the southern part of the Eureka mining district, and surrounding areas of the Fish Creek Range, Mountain Boy Range, and Diamond Mountains, Eureka and White Pine counties, Nevada: Nevada Bureau of Mines and Geology Map 183, 1:24,000-scale, 2 plates, 36 p.

Muntean, J., Hinz, N., Cramer, T., Davis, D., Dering, G., and Sladek, C., 2014, An updated mineral and energy resource assessment of the Desert National Wildlife Range, Clark and Lincoln counties, Nevada: Nevada Bureau of Mines and Geology Open-File Report 14-3, 162 p.

Muntean, J., and Davis, D., 2014, Nevada active mines and energy producers: Nevada Bureau of Mines and Geology Open-File Report 14-1, compilation scale 1:1,000,000.

Muntean, J., 2014, Overview, *in* The Nevada mineral industry 2012: Nevada Bureau of Mines and Geology Special Publication MI-2012, p. 3–12.

Muntean, J., Hill, T., Hannink , R., Smith, M., Raabe, K., and Shabestari, P., 2015, Preliminary geologic map of the South Kinsley Mountains, Elko and White Pine counties, Nevada: Nevada Bureau of Mines and Geology Open-File Report 15-9, scale 1:12,000, 3 p.

Muntean, J., 2015, Overview, *in* The Nevada mineral industry 2013: Nevada Bureau of Mines and Geology Special Publication MI-2013, p. 3–12.

Awards

Awarded Arthur Brant Chair in Exploration Geology from Mackay School of Earth Sciences and Engineering.
Ralph J. Roberts Center for Research in Economic Geology student, Tyler Hill won second place for best student talk, Geological Society of Nevada Symposium.

Find additional information on John Muntean's research at the
Nevada Bureau of Mines and Geology website
http://www.nbmg.unr.edu/staff/johnmuntean.html

Mineral Industry

NBMG Publication Spotlight

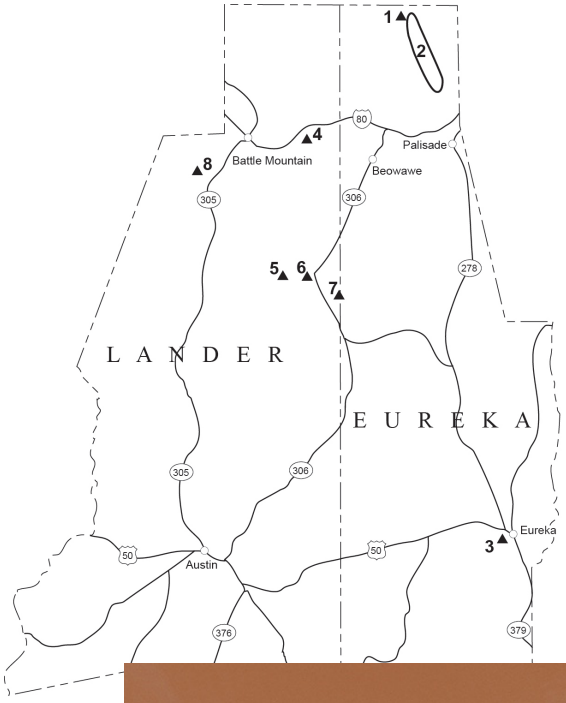
NBMG Special Publication P-27

Major Mines of Nevada 2015, Mineral Industries in Nevada's Economy

by Rich Perry and Mike Visher

Published by the Nevada Bureau of Mines and Geology for the Nevada Division of Minerals:
http://minerals.nv.gov

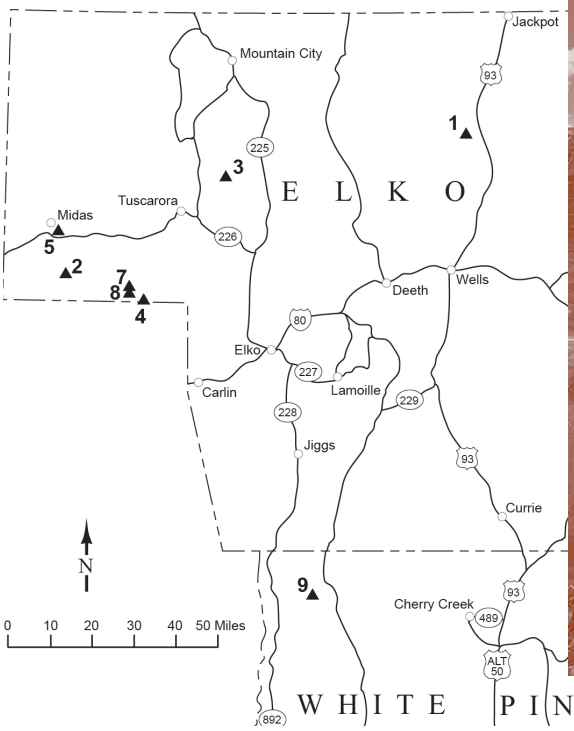
This annual series of reports on the major mines and mills in Nevada lists the names and addresses of operators, numbers of employees, and annual production. Map locations of all major mines are shown and an overview of mineral production and its effect on Nevada's economy is presented.

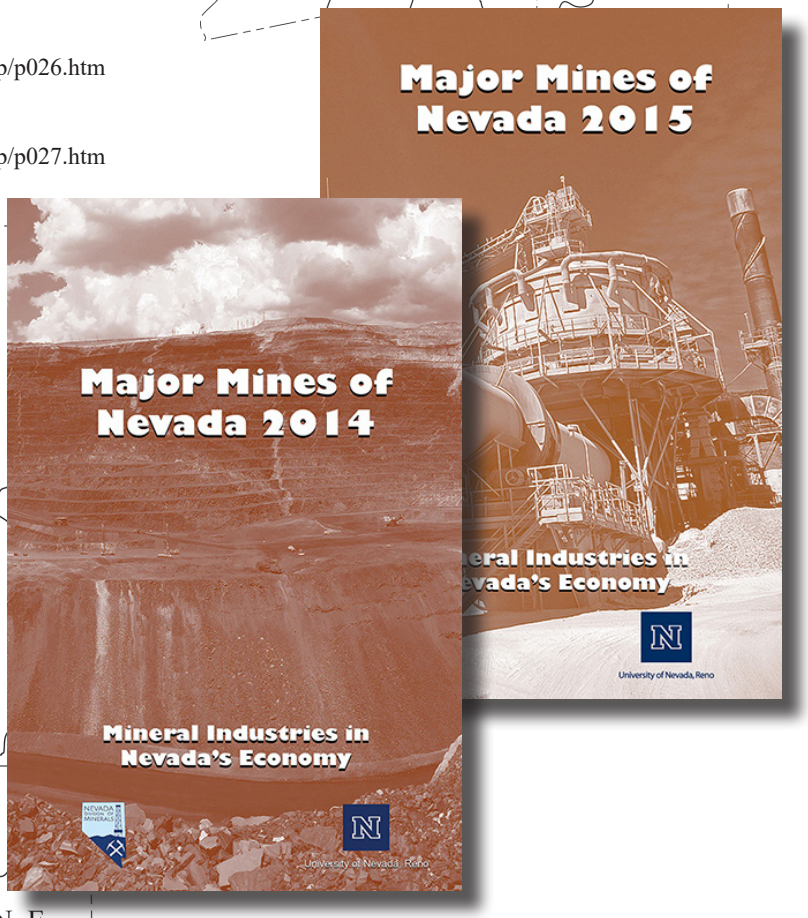


Available on the Web:

Special Publication P-26 (2014), 28 pages.
https://pubs.nbmg.unr.edu/Major-mines-of-Nevada-2014-p/p026.htm

Special Publication P-27 (2015), 28 pages.
https://pubs.nbmg.unr.edu/Major-mines-of-Nevada-2015-p/p027.htm





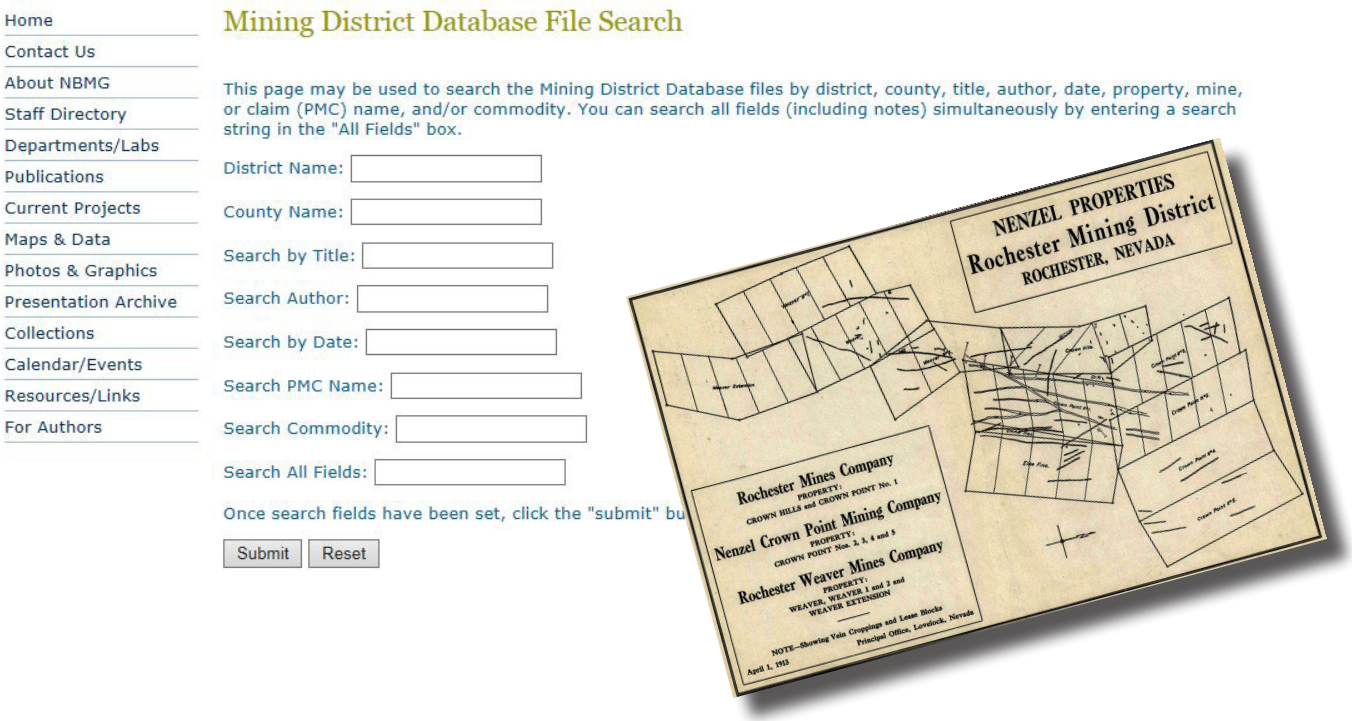
Find a listing of the annual Nevada Mineral Industry reports at the
Nevada Bureau of Mines and Geology website
http://pubs.nbmg.unr.edu/Pamphlets-s/1862.htm

Mineral Industry

Online Mining District File Collection with Index, Search Index, Search Engine, and Other Nevada Mineral-and Energy-Related Files

The Mining District Files consist largely of historical and current maps, reports, articles, photographs, correspondence, assays, production reports, and reserve information on all aspects of mining in Nevada. These have largely been donated to the NBMG over the years from individuals, companies, and other government agencies. The files were originally created, named, and numbered using NBMG Map 37, Metal Mining Districts of Nevada (Schilling, 1976), as an index. In this system, the files are divided alphabetically by county and then alphabetically by district name within each county. The districts are numbered from 1 to 344. Each district has a file, and each county has a general file for things that cannot easily be included in a district file. Map 37 has been superseded by NBMG Report 47, Mining Districts of Nevada, (Tingley, 1998), which is much more complete than Map 37 and is very useful in conjunction with this database.

An online version of the mining district index, search engine, and files are accessible on the NBMG website at **http://www.nbmg.unr.edu/Collections/MiningDistricts/MiningDistricts.html**



Find the online version of the mining district files at the
Nevada Bureau of Mines and Geology website
http://www.nbmg.unr.edu/Collections/MiningDistricts/MiningDistricts.html

Mineral Industry

NBMG Publication Spotlight

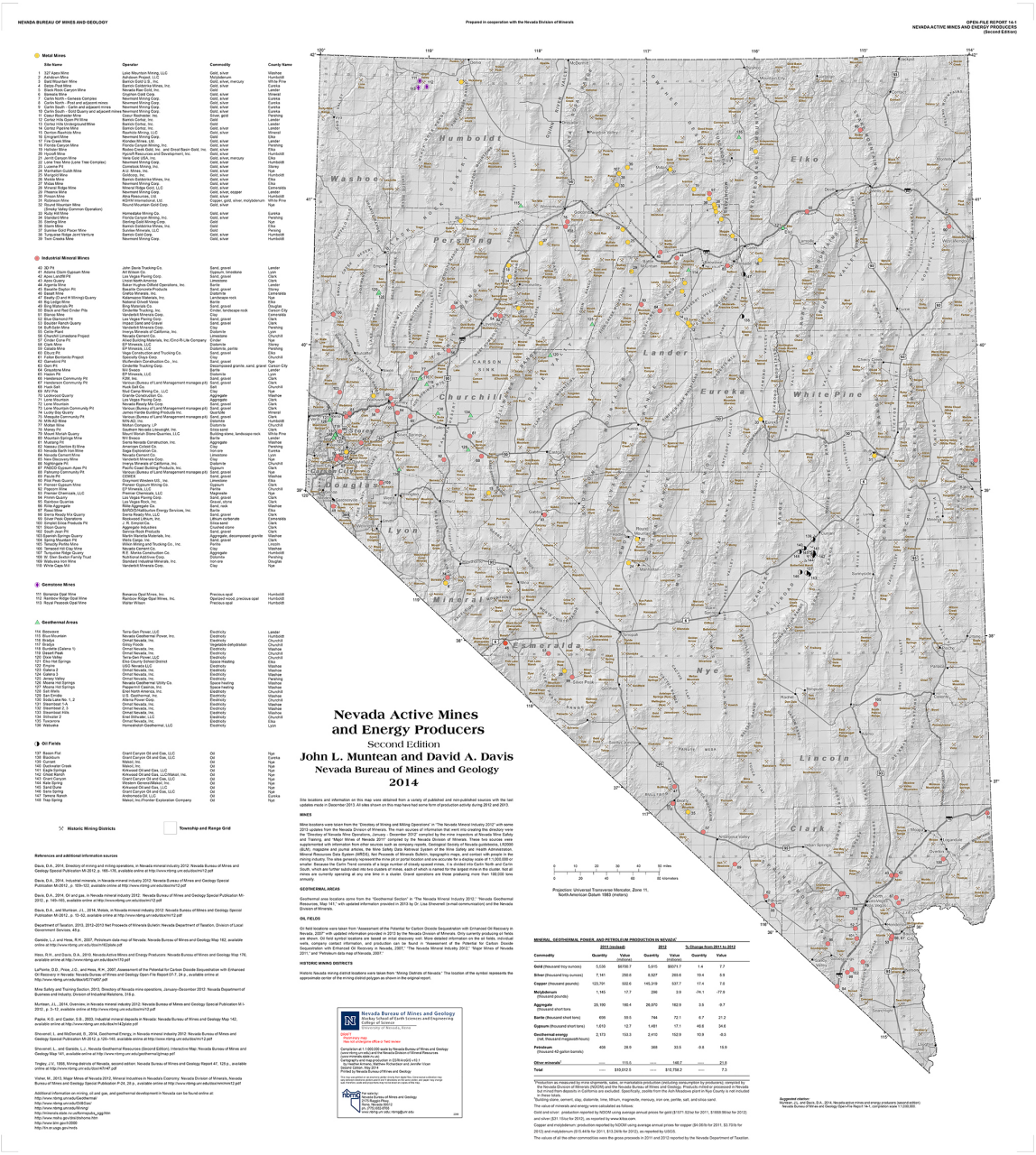
NBMG Open-File Report 2014-01

Nevada active mines and energy producers (second edition)

Includes one plate, scale 1:1,000,000

by John L. Muntean and David A. Davis

Site locations and information on this map were obtained from a variety of published and non-published sources with the last updates made in December 2013. All sites shown on this map have had some form of production activity during 2012 and 2013. The second edition includes the names of the mining districts, which were only shown as a symbol marking the center of the district on the first edition map.



Find additional information on NBMG OFR 14-1 at the

Nevada Bureau of Mines and Geology website

http://pubs.nbmg.unr.edu/Active-mines-and-energy-2014-p/of2014-01.htm

Mineral Industry

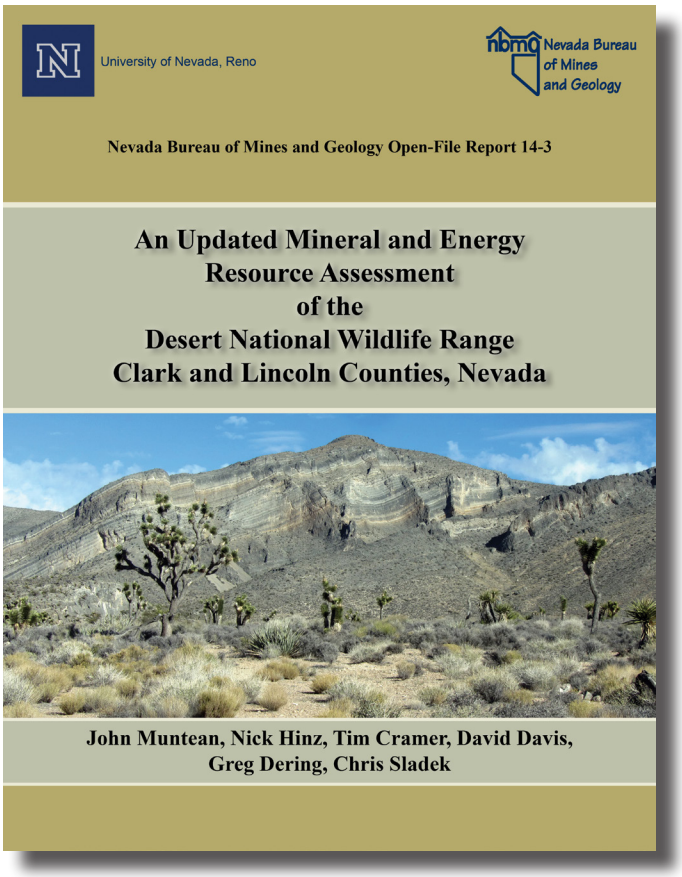
NBMG Publication Spotlight

Nevada Bureau of Mines and Geology Open-File Report 14-3

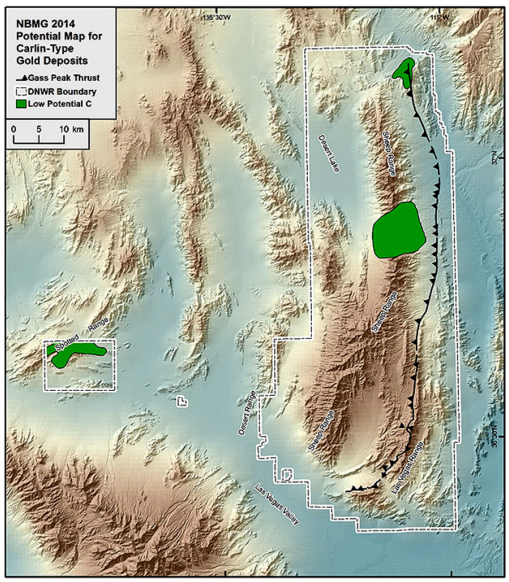
An updated mineral and energy resource assessment of the Desert National Wildlife Range, Clark and Lincoln counties, Nevada

Includes 162 pages of text

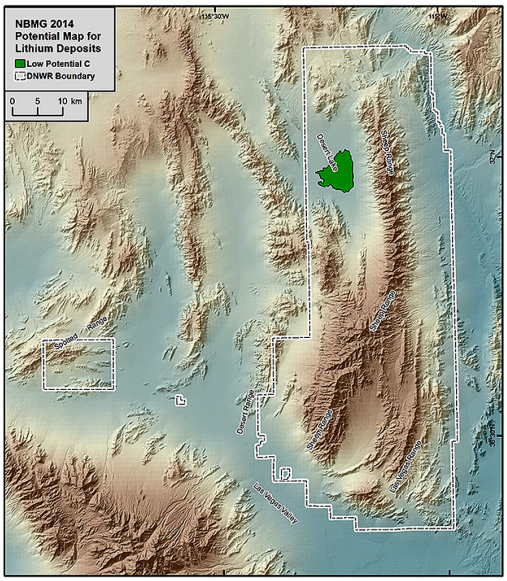
by John Muntean, Nick Hinz, Tim Cramer, David Davis, Greg Dering, and Chris Sladek



In March 2013, the U.S. Fish and Wildlife Service (USFWS) contracted the Nevada Bureau of Mines and Geology (NBMG) to update the mineral and energy resource assessment of the Desert National Wildlife Range (DNWR). The first such assessment of the DNWR was completed by NBMG in January of 1993 and was published as NBMG Open-File Report 93-2, Energy and mineral resource assessment of the Desert National Wildlife Range, Eastern Section, Clark and Lincoln counties, Nevada. The assessment covered approximately 740,000 acres managed by USFWS east of the Nellis South Range military complex and was required to evaluate lands within the DNWR for withdrawal from mineral entry. In order to extend the period of withdrawal from entry for another 20 years, an updated assessment and report is required. This report provides the needed assessment.



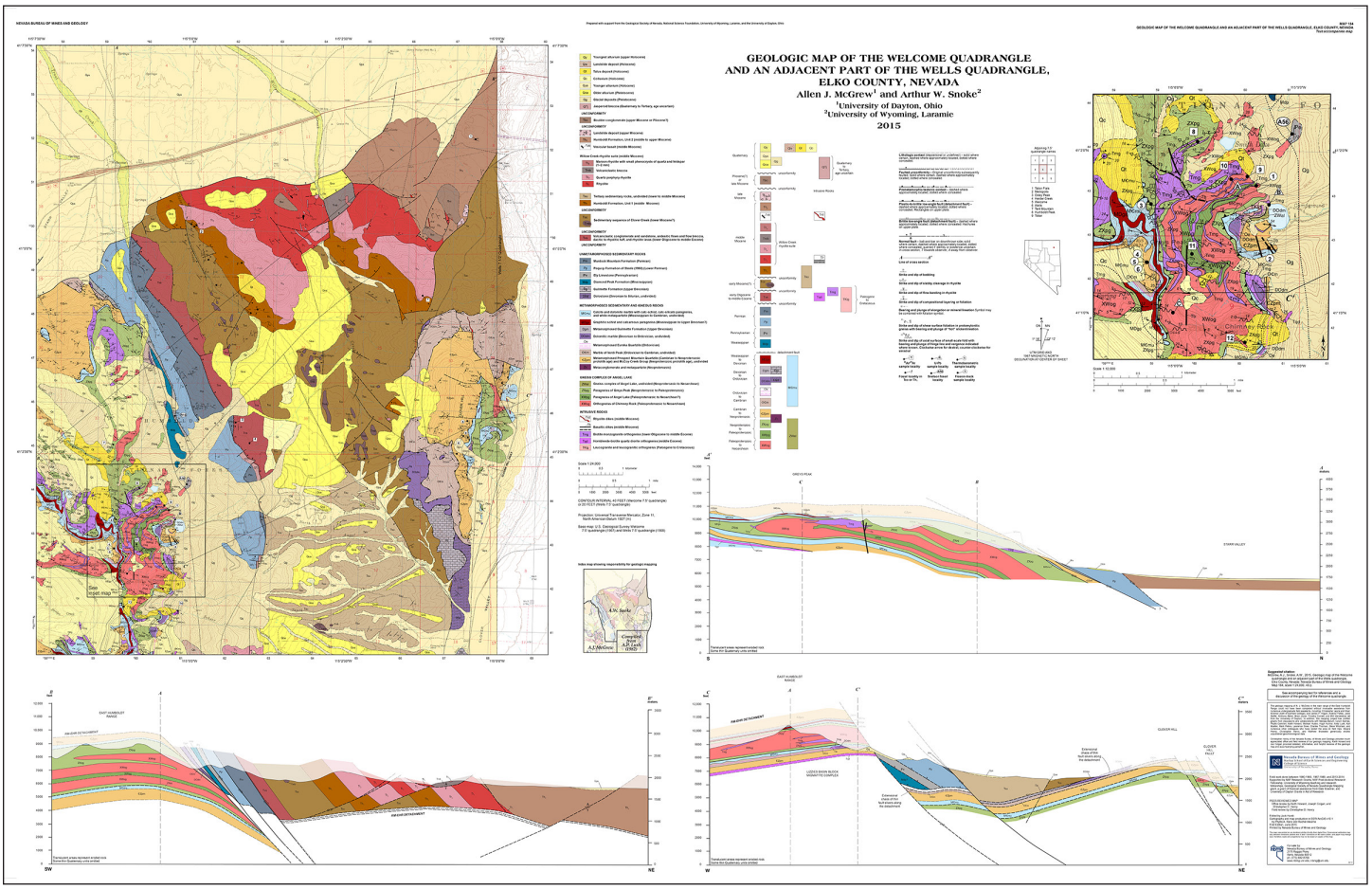
Map showing potential for Carlin-type gold deposits in the DNWR above and map showing lithium deposits in the DNWR below.



Find additional information on NBMG OFR 14-3 at the
Nevada Bureau of Mines and Geology website
http://pubs.nbmg.unr.edu/product-p/of2014-03.htm

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. Geologic mapping has enormous benefits for documenting, analyzing, and planning for natural hazards such as earthquakes and landslides, for urban, industrial, and land-use planning, and for the exploration and extraction of natural resources. In Nevada, a state with rapidly-expanding urban areas, zones of high earthquake activity, and an active mining industry that is fundamental to the state's economy, geologic mapping is of exceptional importance.



NBMG Map 184

Geologic map of the Welcome quadrangle and an adjacent part of the Wells quadrangle, Elko County, Nevada

Includes one plate and 40 pages of text

by Allen J. McGrew and Arthur W. Snoke

Find additional information on NBMG Map 184 at the Nevada Bureau of Mines and Geology website

http://pubs.nbmg.unr.edu/Geol-Welcome-quad-p/m184.htm

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

Geologic Mapping

NBMG Geologist Spotlight

Chris Henry gathering rock samples. *Photographer: Jack Hursh*

Chris Henry
Research Geologist
Nevada Bureau of Mines and Geology

Chris Henry specializes in geologic mapping supplemented with analysis of structure, igneous rocks, and mineralization to figure out magmatic, tectonic, and mineralization processes to benefit Nevada. Much of his research focuses on the origin of mineral deposits, including their large- and small-scale geologic setting, relationship to structures and igneous activity, and timing, so as to help geologists and mining companies explore for additional deposits that can be mined, employ Nevadans, and pay taxes to support Nevada. Chris also maps in urban and tectonically active areas such as Reno and the Walker Lane to identify faults that could generate earthquakes and cause significant damage and physical harm.

Publication Citations

Cassel, E.J., Breecker, D.O., **Henry, C.D.**, Larson, T.E., and Stockli, D.F., 2014, Profile of a paleo-orogen—high topography across the present day Basin and Range from 40 to 23 Ma: Geology, v. 42, p. 1007–1010.

Colgan, J.P., **Henry, C.D.**, and John, D.A., 2014, Evidence for large-magnitude, post-Eocene extension in the northern Shoshone Range, Nevada, and its implications for Carlin-type gold deposits in the lower plate of the Roberts Mountains allochthon: Economic Geology, v. 109, p. 1843–1862.

Long, S.P., **Henry, C.D.**, Muntean, J.L., Edmondo, G.P., and Cassel, E.J., 2014, Early Cretaceous construction of a structural culmination, Eureka, Nevada, U.S.A.—implications for out-of-sequence deformation in the Sevier hinterland: Geosphere, v. 10, p. 564–584.

Long, S.P., **Henry, C.D.**, Muntean, J.L., Edmondo, G.P., and Thomas, R.D., 2014, Geologic map of the southern part of the Eureka mining district, and surrounding areas of the Fish Creek Range, Mountain Boy Range, and Diamond Mountains, Eureka and White Pine counties, Nevada: Nevada Bureau of Mines and Geology Map 183, scale 1:24,000, 2 plates, 36 p.

Hursh, J., Vlcan, J., **Henry, C.**, and Hinz, N., 2014 and 2015, Nevada geology calendar 2015 and 2016.

Christensen, O.D., **Henry, C.D.**, and Wood, J., 2015, Origin of gold in placer deposits of the Sierra Nevada foothills, California, *in* Geological Society of Nevada, New Concepts and Discoveries, W.M. Pennell and L.J. Garside, editors, 2015 Symposium Volume, Reno/Sparks, Nevada, p. 833–859.

Dee, S.M., Dering, G.M., and **Henry, C.D.**, 2015, Preliminary geologic map of the Heelfly Creek quadrangle and adjacent parts of the Tent Mountain, Soldier Peak, and Secret Valley quadrangles, Elko County, Nevada: Nevada Bureau of Mines and Geology Open-File Report 15-4, scale 1:24,000, 5 p.

Henry, C.D., and Thorman, C.H., 2015, Preliminary geologic map of the Pequop Summit quadrangle, Elko County, Nevada: Nevada Bureau of Mines and Geology Open-File Report 15-8, scale 1:24,000, 12 p.

Henry, C.D., Jackson, M.R., Mathewson, D.C., Koehler, S.R., and Moore, S.C., 2015, Eocene igneous geology and relation to mineralization—Railroad District, southern Carlin trend, Nevada, *in* Geological Society of Nevada, New Concepts and Discoveries, W.M. Pennell and L.J. Garside, editors, 2015 Symposium Volume, Reno/Sparks, Nevada, p. 939–965.

Award

Award from Association of Mining Engineers, Metallurgists and Geologists of Mexico for commendable work in research and diffusion of geology in the Sierra Madre Occidental.

Find additional information on Chris Henry's research at the
Nevada Bureau of Mines and Geology website
http://www.nbmg.unr.edu/Staff/Henry.html

Geologic Mapping

NBMG Geologist Spotlight

Sean Long investigating a fold in the geology at Secret Creek Gorge between the Ruby Mountains and the East Humboldt Range in Elko County. *Photographer: Sean Long*

Sean P. Long
Research Assistant Professor
Nevada Bureau of Mines and Geology

Sean Long is a structural geologist, whose primary research interest focuses on the evolution and dynamics of contractional deformation in orogenic belts. Sean utilizes a variety of techniques, including geologic mapping, construction of balanced cross sections, geochronology, thermochronology, and thin-section scale structural analysis. In Nevada, Sean's primary research interests focus on understanding the geometry, timing, and magnitude of contractional deformation that occurred during the Sevier orogeny, including the construction and subsequent extensional collapse of the orogenic plateau that may have once existed across much of Nevada. Sean's active, mapping-based projects in eastern Nevada aid exploration efforts for gold and for oil and gas. Sean also served as the director of the UNR Summer Field Camp course; the primary focus of this course is to teach undergraduate students how to make geologic maps.

Publication Citations

Di Fiori, R.V., **Long, S.P.**, Muntean, J.L., and Edmondo, G.P., 2014, Preliminary geologic and alteration maps of Lookout Mountain, Ratto Ridge, and Rocky Canyon, southern Eureka mining district, Eureka County, Nevada: Nevada Bureau of Mines and Geology Open-File Report 14-8, scale 1:10,000, 2 plates.

Di Fiori, R.V., **Long, S.P.**, Muntean, J.L., and Edmondo, G.P., 2014, Structural analysis of gold mineralization in the southern Eureka mining district, Nevada—a predictive structural setting for Carlin-type gold deposits: Geological Society of America Abstracts with Programs, v. 46, no. 6, p. 462.

Long, S.P., 2014, Preliminary geologic map of Heath Canyon, central Grant Range, Nye County, Nevada: Nevada Bureau of Mines and Geology Open-File Report 14-6, scale 1:24,000, 1 plate, 4 p.

Long, S.P., Henry, C.D., Muntean, J.L., Edmondo, G.P., and Thomas, R.D., 2014, Geologic map of the southern part of the Eureka mining district, and surrounding areas of the Fish Creek Range, Mountain Boy Range, and Diamond Mountains, Eureka and White Pine counties, Nevada: Nevada Bureau of Mines and Geology Map 183, scale 1:24,000, 2 plates, 36 p.

Long, S.P., Henry, C.D., Muntean, J.L., Edmondo, G.P., and Cassel, E.J., 2014, Early Cretaceous construction of a structural culmination, Eureka, Nevada, U.S.A.—implications for out-of-sequence deformation in the Sevier hinterland: Geosphere, v. 10, p. 564–584.

Long, S.P., 2014, A fold province in the hinterland of the Sevier orogenic belt in eastern Nevada—a Valley and Ridge in the Basin and Range: Eos Transactions, American Geophysical Union, Fall Meeting, Abstract T23A-4644.

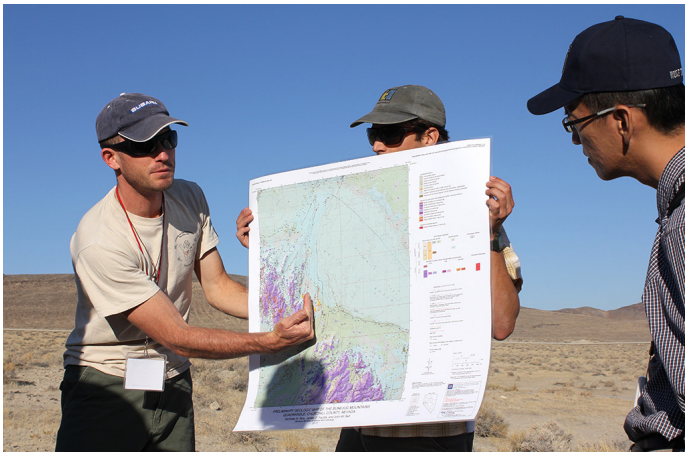
Award

Advisor to M.S. student Russell Di Fiori, awarded 2nd place, student map competition, Geological Society of America annual meeting in Vancouver for his geologic and alteration maps of the Eureka mining district.

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

Geologic Mapping

NBMG Geologist Spotlight



Nick Hinz leads discussion during a Geothermal Resource Council field trip. *Photographer: Terri Garside*

Nicholas H. Hinz
Geologic Mapping Specialist
Nevada Bureau of Mines and Geology

Nick Hinz's research focuses on regional studies of Basin and Range extensional tectonics in both northern and southern Nevada and of dextral shear associated with the Walker Lane in western Nevada using detailed geologic mapping, structural analyses of faults and folds, geochronology, paleomagnetic analyses, and existing drill-hole and geophysical data sets. As a subset to studying Basin and Range tectonics, much of Nick's research also focuses on investigating the structural controls of geothermal systems within the Great Basin region for the purpose of developing successful exploration strategies.

Publication Citations

Hinz, N.H., Faulds, J.E., and Coolbaugh, M.F., 2014, Association of fault terminations with fluid flow in the Salt Wells geothermal field, Nevada, USA: Geothermal Resources Council Transactions, v. 38, p. 3–9.

Hinz, N.H., Ramelli, A.R., and Faulds, J.E., 2014, Preliminary geologic map of the Mount Rose quadrangle, Washoe County, Nevada: Nevada Bureau of Mines and Geology Open-File Report 14-7, scale 1:24,000, 4 p.

Muntean, J., **Hinz, N.**, Cramer, T., Davis, D., Dering, G., and Sladek, C., 2014, An updated mineral and energy resource assessment of the Desert National Wildlife Range, Clark and Lincoln counties, Nevada: Nevada Bureau of Mines and Geology Open-File Report 14-3, 162 p.

Coolbaugh, M., Shevenell, L., Hinz, N., Stelling, P., Melosh, G., Cumming, W., Kremmer, C., and Wilmarth, M., 2015, Preliminary ranking of geothermal potential in the Cascade and Aleutian volcanic arcs, part III—regional data review and modeling: Geothermal Resources Council Transactions, v. 39, p. 677–690.

Hinz, N.H., Coolbaugh, M.F., and Faulds, J.E., 2015, White Pine County renewable energy feasibility study and resource assessment: Nevada Bureau of Mines and Geology Report 55, 21 p.

Hinz, N.H., Coolbaugh, M.F, Faulds, J.E., Siler, D.L., and Dering, G.M., 2015, Building the next generation of regional geothermal potential maps—examples from the Great Basin region, western USA: Proceedings, World Geothermal Congress 2015, Melbourne, Australia, 12 p.

Hinz, N.H., Coolbaugh, M., Shevenell, L., Melosh, G., Cumming, W., and Stelling, P., 2015, Preliminary ranking of geothermal potential in the Cascade and Aleutian volcanic arcs, part II—structural-tectonic settings of the volcanic centers: Geothermal Resources Council Transactions, v. 39, p. 717–725.

Hinz, N.H., and Ramelli, A.R., 2015, Fire and ice—geology of the Mount Rose quadrangle, Lake Tahoe, and the Carson Range: Nevada Bureau of Mines and Geology Educational Series E-57, 19 p.

Hinz, N.H., Ramelli, A.R., and Dee, S., 2015, Preliminary geologic map of the Sloan quadrangle, Clark County, Nevada: Nevada Bureau of Mines and Geology Open-File Report 15-7, scale 1:24,000, 1 sheet, 4 p.

Award

Best poster award (professional, non-student category) at the 2015 Geothermal Resources Council Annual Meeting.

See also Geothermal Energy section of this report for geothermal research and publication collaborations by Nick Hinz.

Find additional information on Nick Hinz's research at the
Nevada Bureau of Mines and Geology website
http://www.nbmg.unr.edu/Staff/Hinz.html

Geologic Mapping

NBMG Geologist Spotlight

Seth M. Dee
Geologic Mapping Specialist
Nevada Bureau of Mines and Geology

Seth Dee's work focuses on geologic mapping to address questions regarding Quaternary geology, earthquake hazards and Basin and Range extensional tectonics in Nevada. In 2015, Seth began serving as the NBMG coordinator for the USGS STATEMAP program, overseeing the preparation of funding proposals and geologic map deliverables. Seth's research on earthquake hazards has included paleoseismic trenching and Quaternary fault mapping using high resolution topographic datasets in the Reno and Las Vegas metropolitan areas. Seth has also worked closely with the USGS and numerous local agencies to secure funding for new lidar topographic data in Nevada.

Publication Citations

Dee, S.M., Dering, G.M., and Henry, C.D., 2015, Preliminary geologic map of the Heelfly Creek quadrangle and adjacent parts of the Tent Mountain, Soldier Peak, and Secret Valley quadrangles, Elko County, Nevada: Nevada Bureau of Mines and Geology Open-File Report 15-4, scale 1:24,000, 5 p.

dePolo, C.M., and **Dee, S.M.**, 2015, Preliminary quaternary fault and seismicity map of Vya, Nevada 1x2 degree quadrangle: Nevada Bureau of Mines and Geology Open-File Report, 15-11A, scale 1:250,000.

dePolo, C.M., and **Dee, S.M.**, 2015, Preliminary quaternary fault and seismicity map of McDermitt, Nevada, 1x2 degree quadrangle: Nevada Bureau of Mines and Geology Open-File Report, 15-11B, scale 1:250,000.

dePolo, C.M., and **Dee, S.M.**, 2015, Preliminary quaternary fault and seismicity map of Wells, Nevada, 1x2 degree quadrangle: Nevada Bureau of Mines and Geology Open-File Report, 15-11C, scale 1:250,000.

dePolo, C.M., and **Dee, S.M.**, 2015, Preliminary quaternary fault and seismicity map of Lovelock, Nevada, 1x2 degree quadrangle: Nevada Bureau of Mines and Geology Open-File Report, 15-11D, scale 1:250,000.

dePolo, C.M., and **Dee, S.M.**, 2015, Preliminary quaternary fault and seismicity map of Winnemucca, Nevada, 1x2 degree quadrangle: Nevada Bureau of Mines and Geology Open-File Report, 15-11E, scale 1:250,000.

dePolo, C.M., and **Dee, S.M.**, 2015, Preliminary quaternary fault and seismicity map of Elko, Nevada, 1x2 degree quadrangle: Nevada Bureau of Mines and Geology Open-File Report, 15-11F, scale 1:250,000.

Hinz, N.H., **Dee, S.**, and Witter, J., 2015, Preliminary geologic map of the Ross River Area, Yukon, Canada: Dena Nezziddi Development Corporation, scale 1:50,000, 1 sheet.

Hinz, N.H., Ramelli, A.R., and **Dee, S.**, 2015, Preliminary geologic map of the Sloan quadrangle, Clark County, Nevada: Nevada Bureau of Mines and Geology Open-File Report 15-7, scale 1:24,000, 4 p.

Find additional information on Seth Dee's research at the
Nevada Bureau of Mines and Geology website
http://www.nbmg.unr.edu/staff/Dee.html

Geologic Mapping

NBMG Publication Spotlight

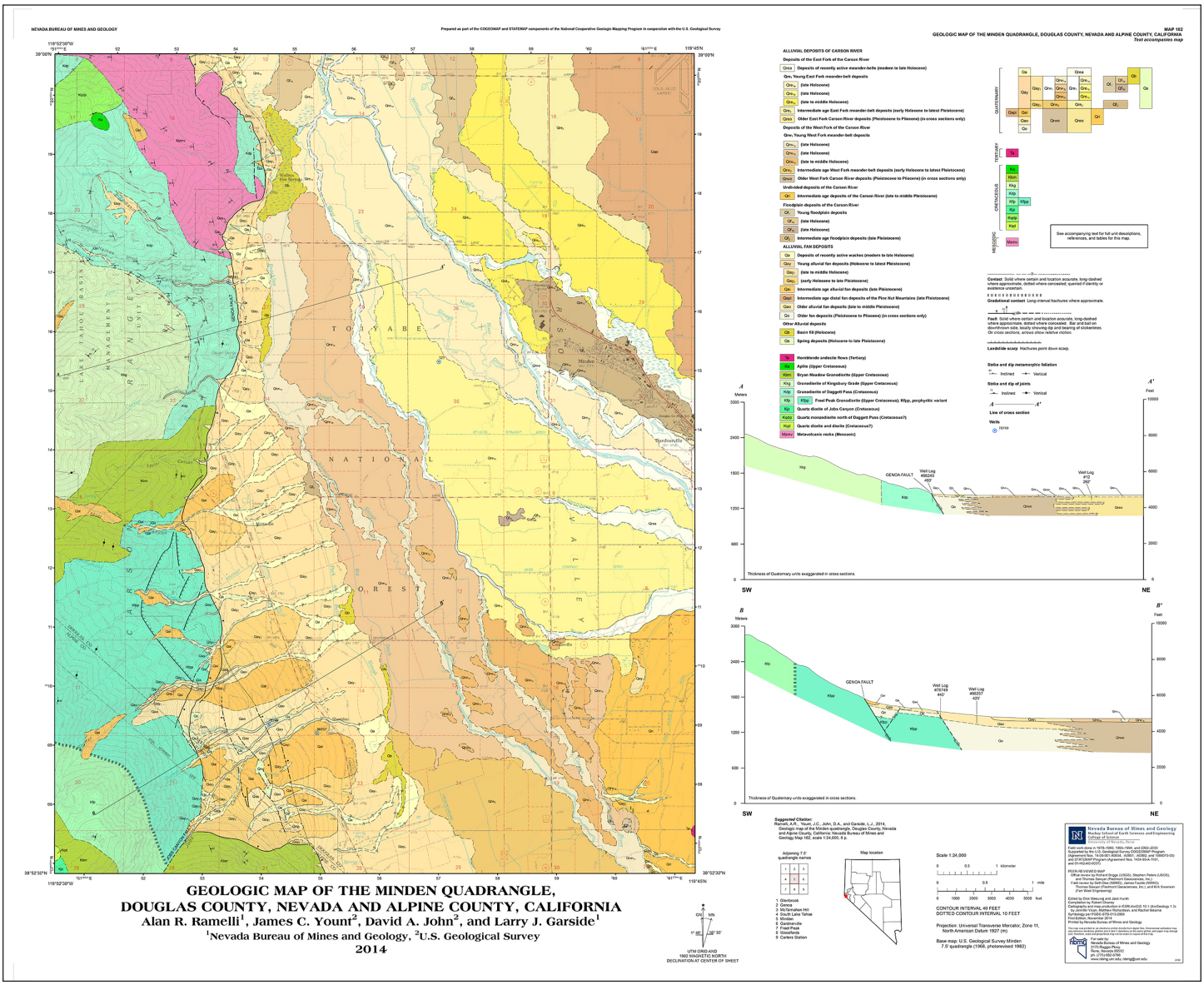
NBMG Map 182

Geologic map of the Minden quadrangle, Douglas County, Nevada and Alpine County, California

Includes one plate and 8 pages of text

by Alan R. Ramelli, James C. Yount, David A. John, and Larry Garside

The Minden quadrangle covers about 40 km^2 of the east side of the southern Carson Range and about 100 km^2 of the west-central part of Carson Valley in Douglas County, Nevada and Alpine County, California, about 30 km south of Carson City. The Carson Range is a 75-km-long, north-trending spur of the Sierra Nevada. Due to its high elevation and alpine climate, the Carson Range commonly is described as being part of the Sierra Nevada, although basin and range faulting actually extends to the Lake Tahoe basin on the west side of the range.



Find additional information on NBMG Map 182 at the
Nevada Bureau of Mines and Geology website
http://pubs.nbmg.unr.edu/Geol-Minden-quad-p/m182.htm

Geologic Mapping

NBMG Publication Spotlight

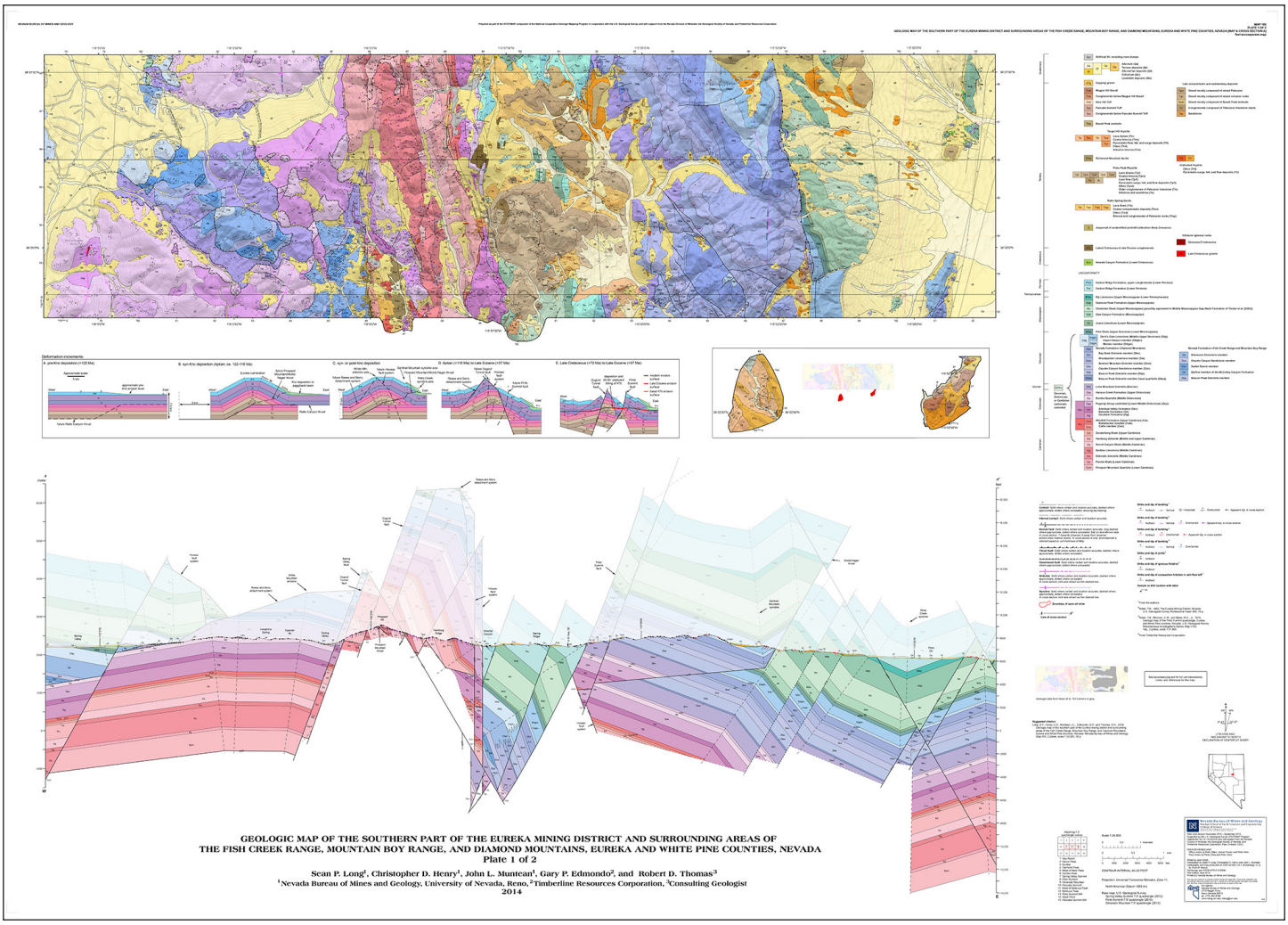
NBMG Map 183

Geologic map of the southern part of the Eureka mining district and surrounding areas of the Fish Creek Range, Mountain Boy Range, and Diamond Mountains, Eureka and White Pine counties, Nevada

Includes 2 plates containing the geologic map, three cross sections, and 36 pages of text

by Sean P. Long, Christopher D. Henry, John L. Muntean, Gary P. Edmondo, and Robert D. Thomas

This map is a 1:24,000-scale, transect-style geologic map through the southern Diamond Mountains, the northern Fish Creek Range, and the southern Mountain Boy Range. The map area also passes through the southern part of the historical, and actively explored, Eureka mining district. The map is accompanied by three cross sections, which illustrate the deformation geometry both above and below the modern erosion surface, a detailed description of map units, a summary of the geologic history of the map area, and a description of mineral deposits in the Eureka mining district. In addition, new data on the distribution, petrographic and chemical characteristics, and timing of the late Eocene Eureka volcanic center is included. This report represents a detailed analysis of the stratigraphy and structure of a classic Great Basin geological locality.



Find additional information on NBMG Map 183 at the
Nevada Bureau of Mines and Geology website
http://pubs.nbmg.unr.edu/Geol-south-Eureka-mining-dist-p/m183.htm

Geologic Mapping

NBMG Publications Spotlight

Open-File Report Geologic Maps:

Carlson, C.W., and Faulds, J.E., 2014, Preliminary geologic map of the Terrill Mountains quadrangle, Churchill and Mineral counties, Nevada: Nevada Bureau of Mines and Geology, Open-File Report 14-4, scale 1:24,000.

Long, S.P., 2014, Preliminary geologic map of Heath Canyon, central Grant Range, Nye County, Nevada: Nevada Bureau of Mines and Geology, Open-File Report 14-6, scale 1:24,000, 4 p.

Hinz, N.H., Ramelli, A.R., and Faulds, J.E., 2014, Preliminary geologic map of the Mount Rose quadrangle, Washoe County, Nevada: Nevada Bureau of Mines and Geology Open-File Report 14-7, scale 1:24,000, 4 p.

Di Fiori, R.V., Long, S.P., Muntean, J.L., and Edmondo, G.P., 2014, Preliminary geologic and alteration maps of Lookout Mountain, Ratto Ridge, and Rocky Canyon, southern Eureka mining district, Eureka County, Nevada: Nevada Bureau of Mines and Geology Open-File Report 14-8, scale 1:10,000, 2 sheets.

Pace, D., 2015, Preliminary geologic map of the RBM pit, Bald Mountain Mine, White Pine County, Nevada: Nevada Bureau of Mines and Geology, Open-File Report 15-1, scale 1:1,000, 2 sheets.

Snee, J.-E., and Miller, E., 2015, Preliminary geologic map of Cenozoic units of the central Robinson Mountain volcanic field and northwestern Huntington Valley, Elko County, Nevada: Nevada Bureau of Mines and Geology, Open-File Report 15-2, scale 1:24,000, 2 sheets, 42 p.

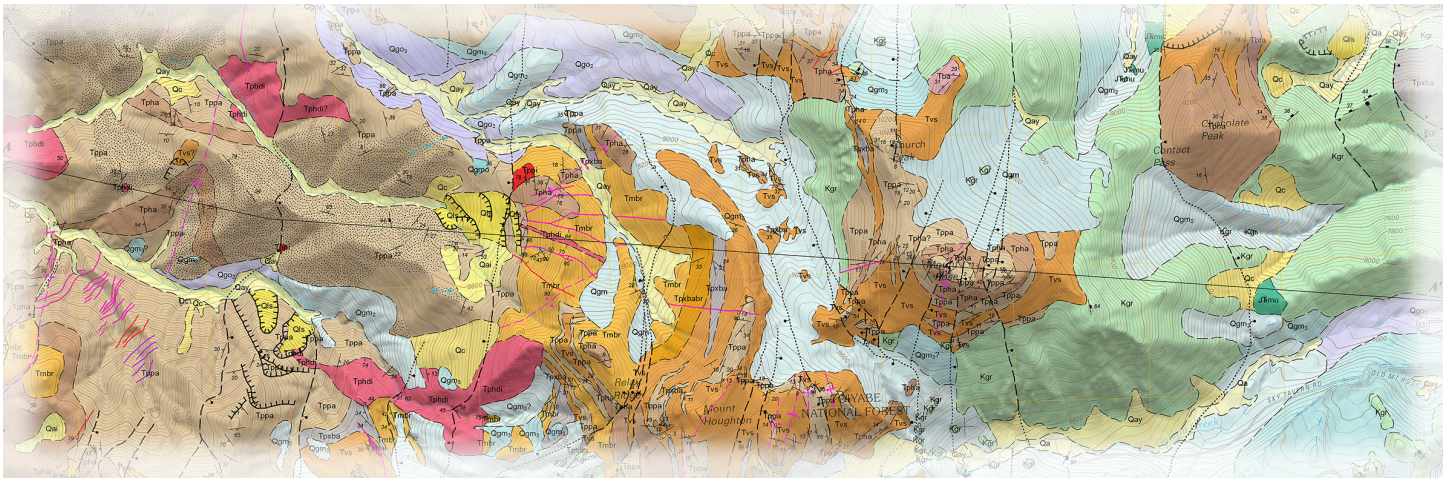
Dee, S.M., Dering, G.M., and Henry, C.D, 2015, Preliminary geologic map of the Heelfly Creek quadrangle and adjacent parts of the Tent Mountain, Soldier Peak, and Secret Valley quadrangles, Elko County, Nevada: Nevada Bureau of Mines and Geology, Open-File Report 15-4, scale 1:24,000, 5 p.

Forson, C., Faulds, J.E., and Allen, M.D, 2015, Preliminary geologic map of the southern and central Seven Troughs Range, potential geothermal area, Pershing County, Nevada: Nevada Bureau of Mines and Geology, Open-File Report 15-6, scale 1:24,000, 5 p.

Hinz, N.H., Ramelli, A.R., and Dee, S.M., 2015, Preliminary geologic map of the Sloan quadrangle, Clark County, Nevada: Nevada Bureau of Mines and Geology, Open-File Report 15-7, scale 1:24,000, 4 p.

Henry, C.D., and Thorman, C.H., 2015, Preliminary geologic map of the Pequop Summit quadrangle, Elko County, Nevada: Nevada Bureau of Mines and Geology, Open-File Report 15-8, scale 1:24,000, 12 p.

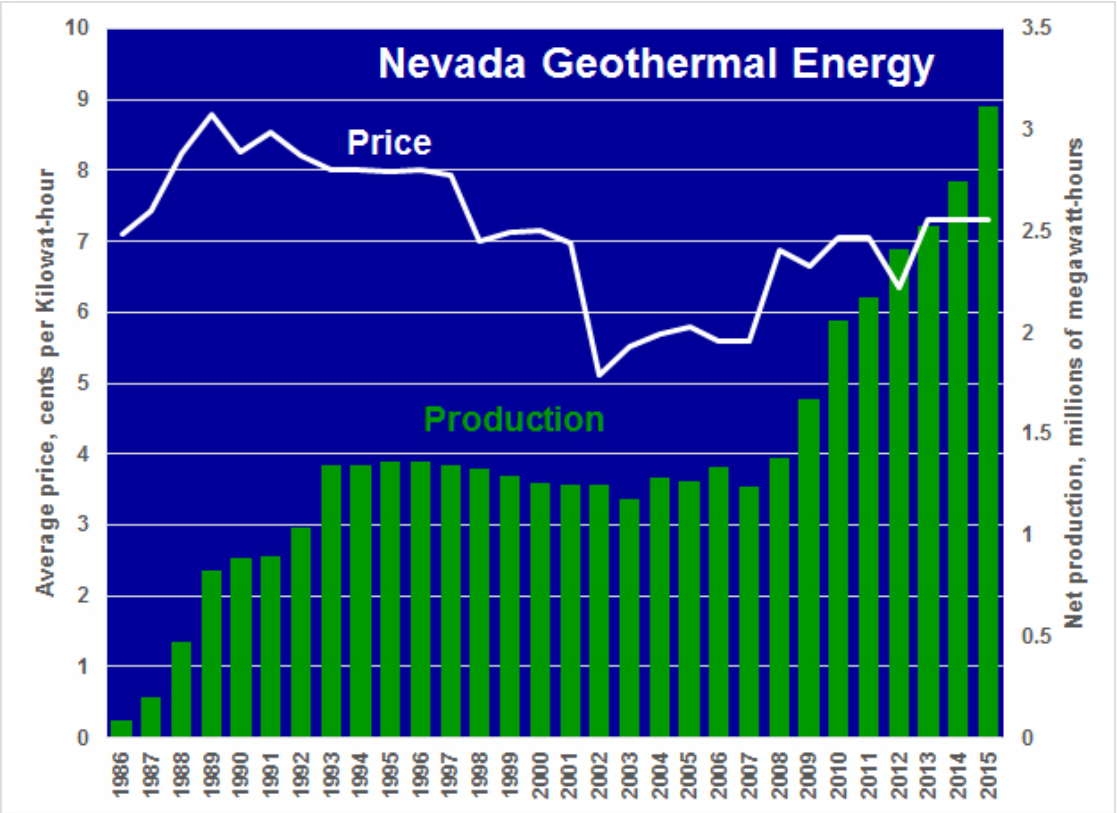
Muntean, J.L., Hill, T.J., Hannink, R.L., Smith, M., Raabe, K., and Shabestari, P., 2015, Preliminary geologic map of the south Kinsley Mountains, Elko and White Pine counties, Nevada: Nevada Bureau of Mines and Geology Open-File Report 15-9, scale 1:12,000, 3 p.



Find additional listings of NBMG Open-File Reports at the
Nevada Bureau of Mines and Geology website
http://pubs.nbmg.unr.edu/Open-File-Reports-s/1861.htm

Geothermal Energy

In 2015, Nevada set another record for geothermal power generation with 3.398 million net MWh, which was a 13.6% increase from 2014. Power was generated from 25 plants at 16 geothermal fields, enough to power about a quarter million Nevada households. The increase in power generation was driven mainly by two major expansion projects operated by Ormat Nevada: (1) the Phase 2 expansion of the McGinness Hills geothermal plant in Lander County, and (2) the Phase 2 expansion of the Don A. Campbell geothermal plant in Mineral County. The McGinness Hills geothermal plant is now the second largest in Nevada in terms of nameplate capacity, after Ormat's Steamboat plant near Reno. Ormat-operated plants were responsible for 57% of the net MWh produced in 2015. Exploration occurred at five projects in 2015. However, no new leases were awarded. Additionally, geothermal energy is used at numerous places in Nevada for space heating, domestic warm water, recreation, dehydrating vegetables, and other agricultural applications. Programs in the U.S. Department of Energy, energy bills passed by the Nevada and California legislatures, and activities of researchers at the University of Nevada, Reno are stimulating geothermal development in Nevada.



Geothermal energy production from Nevada (millions of megawatt-hours) and price of geothermal energy (U.S. cents per kilowatt hour) from 1986 to 2015. *Figure courtesy of NBMG Special Publication MI-2015, The Nevada Mineral Industry 2015, figure 10, page 11.*

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

Geothermal Energy

Jim Faulds discussing the Frontier Observatory for Research in Geothermal Energy (FORGE) site near Fallon. *Photographer: Jack Hursh*

Publication Citations

Hinz, N.H., **Faulds, J.E.**, and **Coolbaugh, M.F.**, 2014, Association of fault terminations with fluid flow in the Salt Wells geothermal field, Nevada, USA: Geothermal Resources Council Transactions, v. 38, p. 3–9.

Faulds, J.E., and **Hinz, N.H.**, 2015, Favorable tectonic and structural settings of geothermal systems in the Great Basin region, western USA—proxies for discovering blind geothermal systems: Proceedings World Geothermal Congress, Melbourne, Australia, 6 p.

Faulds, J.E., Blankenship, D., **Hinz, N.H.**, Sabin, A., Nordquist, J., Hickman, S., Glen, J., Kennedy, M., Robertson-Tait, A., Williams, C., and Calvin, W., 2015, Geologic setting of the proposed Fallon FORGE site, Nevada—suitability for EGS research and development: Geothermal Resources Council Transactions, v. 39, p. 293–301.

Faulds, J.E., **Hinz, N.H.**, **Coolbaugh, M.F.**, **Shevenell, L.A.**, **Siler, D.L.**, **dePolo, C.M.**, **Hammond, W.H.**, **Kreemer, C.W.**, Oppliger, G., Wannamaker, P.E., Queen, J., and Visser, C., 2015, Integrated geologic and geophysical approach for establishing geothermal play fairways and discovering blind geothermal systems in the great basin region, western USA—a progress report: Geothermal Resources Council Transactions, v. 39, p. 691–700.

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.**, 2015, Discovering blind geothermal systems in the Great Basin region, an integrated geologic and geophysical approach for establishing geothermal play fairways: final report submitted to the Department of Energy, 245 p.

Faulds, J.E., **Hinz, N.H.**, **Siler, D.L.**, **Coolbaugh, M.F.**, **Dering, G.**, **Edwards, J.**, **Anderson, R.B.**, **Forson, C.**, and **Sadowski, A.J.**, 2015, Detailed conventional and innovative 3D geologic maps of geothermal systems in the Great Basin region, western USA—critical cost-effective tools for geothermal exploration: Geological Society of America Abstracts with Programs, v. 47, no. 7, p. 407.

Forson, C., **Faulds, J.E.**, and Allen, M.D., 2015, Preliminary geologic map of the southern and central Seven Troughs Range, potential geothermal area, Pershing County, Nevada: Nevada Bureau of Mines and Geology Open-File Report 15-6, 6 p.

Forson, C., **Faulds, J.E.**, and Wannamaker, P., 2014, Prospecting for a blind geothermal system utilizing geologic and geophysical data, Seven Troughs Range, northwestern Nevada: Geothermal Resources Council Transactions, v. 38, p. 369–376.

Hinz, N.H., **Coolbaugh, M.F.**, **Faulds, J.E.**, **Siler, D.L.**, and **Dering, G.M.**, 2015, Building the next generation of regional geothermal potential maps—examples from the Great Basin region, western USA: Proceedings, World Geothermal Congress 2015, Melbourne, Australia, 7 p.

Hinz, N.H., **Coolbaugh, M.F.**, and **Faulds, J.E.**, 2015, Geothermal resource potential assessment, White Pine County: Nevada Bureau of Mines and Geology Report 55, 21 p.

Jolie, E., Moeck, I., and **Faulds, J.E.**, 2015, Quantitative structural–geological exploration of fault-controlled geothermal systems—a case study from the Basin-and-Range Province, Nevada, Geothermics, v. 54, p. 54–67.

Lautze, N., Thomas, D., **Hinz, N.**, Frazer, N., Ito, G., Brady, M., and **Faulds, J.**, 2015, Comprehensive analysis of Hawaii's geothermal potential through play fairway integration of geophysical, geochemical, and geological data: Final report submitted to the Department of Energy, 45 p.

Find additional information on geothermal research at the
Nevada Bureau of Mines and Geology website
http://www.nbmg.unr.edu/Staff.html (see James E. Faulds and Nicholas H. Hinz)

Geothermal Energy

Publication Citations (continued)

Hinz, N.H., and **Dee, S.**, 2015, Final report—geological assessment of the geothermal potential of the Ross River Area, Yukon, Canada: Final report submitted to the Dena Nezziddi Development Corporation as part of a grant deliverable, 22 p.

Hinz, N.H., **Coolbaugh, M.**, **Shevenell, L.**, Melosh, G., Cumming, W., and Stelling, P., 2015, Preliminary ranking of geothermal potential in the Cascade and Aleutian volcanic arcs, part II: Structural-tectonic settings of the volcanic centers: Geothermal Resources Council Transactions, v. 39, p. 717–725.

Hinz, N.H., **Faulds, J.E.**, and **Siler, D.L.**, 2015, Exploration of structurally controlled geothermal systems—systematic workflow from field work to 3D modeling and drill targeting—implications for epithermal mineral exploration: Geological Society of Nevada 2015 Symposium Volume.

Jolie, E., Moeck, I., and **Faulds, J.E.**, 2015, Quantitative structural-geological exploration of fault-controlled geothermal systems—a case study from the Basin-and-Range Province, Nevada, Geothermics, v. 54, p. 54–67.

Lautze, N., Ito, G., Thomas, D., **Hinz, N.**, Frazer, L., and Waller, D., 2015, Integrating geologic, geochemical and geophysical data in a statistical analysis of geothermal resource probability across the state of Hawaii: Fall Meeting, American Geophysical Union, Abstract H23A-1561.

Lautze, N., Thomas, D., **Hinz, N.**, Frazer, N., Ito, G., Waller, D., Schuchmann, H., and Brady, M., 2015, Integration of data in a play fairway analysis of geothermal potential across the state of Hawaii: Geothermal Resources Council Transactions, v. 39, p. 733–737.

Sabin, A., Blake, K., Lazaro, M., Blankenship, D., Kennedy, M., McCullough, J., DeOreo, S., Hickman, S., Glen, J., Kaven, O., Williams, C., Phelps, G., **Faulds, J.**, **Hinz, N.**, Calvin, W., **Siler, D.**, and Robinson-Tait, A., 2015, Geologic setting of the proposed west flank FORGE site, California—suitability for EGS research and development: Geothermal Resources Council Transactions, v. 39, p. 345–352.

Sadowski, A.J., and **Faulds, J.E.**, 2015, Structural controls of the Black Warrior blind geothermal system, Washoe–Churchill counties, Truckee Range, northwestern Nevada, USA: Geothermal Resources Council Transactions, v. 39, p. 573–580.

Shevenell, L., **Coolbaugh, M.**, **Hinz, N.**, Stelling, P., Melosh, G., Cumming, W., and **Kreemer, C.**, 2015, Preliminary ranking of geothermal potential in the Cascade and Aleutian volcanic arcs, Part I—data collection: Geothermal Resources Council Transactions, v. 39, p. 771–784.

Siler, D.L., **Faulds, J.E.**, and **Hinz, N.H.**, 2015, Earthquake-related stress concentration in fault zones and permeability generation in geothermal systems: Geothermal Resources Council Transactions, v. 39, p. 437–444.

Stelling, P., **Hinz, N.**, Kolker, A., and Ohren, M., 2015, Exploration of the Hot Springs Bay Valley geothermal resource area, Akutan, Alaska: Geothermics, v. 57, p. 127–144.

Beowawe Power LLC, Lander County. *Photographer: Jack Hursh*

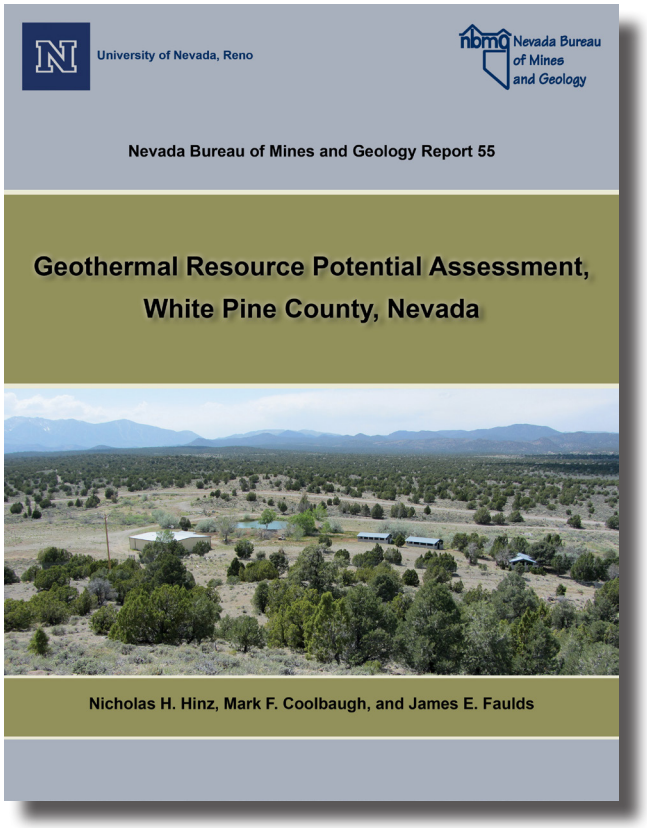
Find additional information on geothermal research at the
Nevada Bureau of Mines and Geology website
http://www.nbmg.unr.edu/Staff.html (see James E. Faulds and Nicholas H. Hinz)

Geothermal Energy

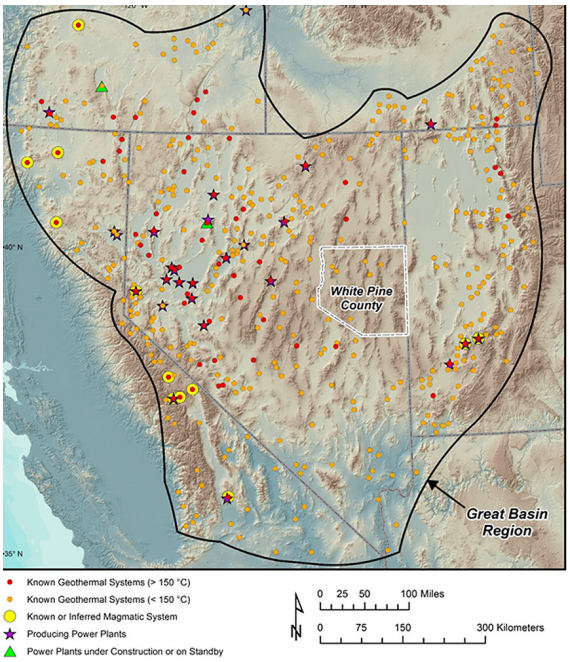
NBMG Publication Spotlight

Geothermal Resource Potential Assessment, White Pine County, Nevada

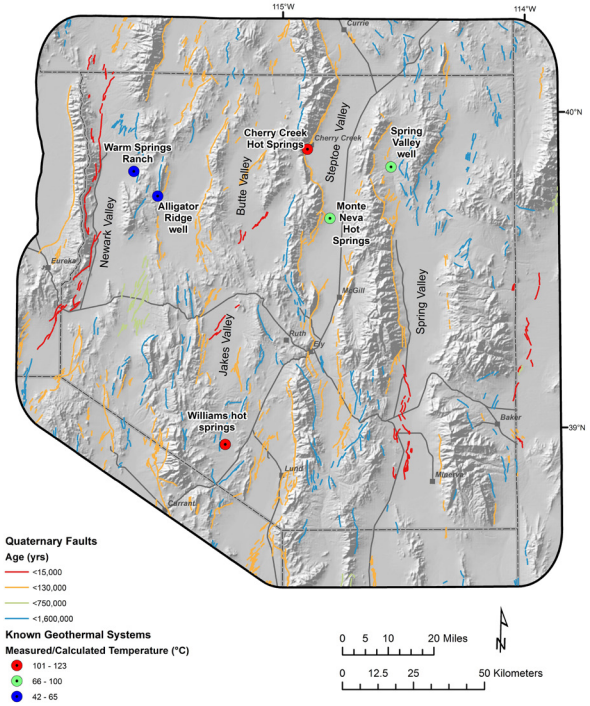
Geothermal resources can potentially contribute toward the renewable energy portfolio of White Pine County in two ways: first through the direct conversion of heat energy into electricity, and the second by way of direct-use applications in which thermal energy is used as a source of heat for buildings, greenhouses, and related structures. Several known geothermal areas within White Pine County lie proximal to the Southwest Intertie power line currently under construction.



Cover of Nevada Bureau of Mines and Geology Report 55 by Nichoas H. Hinz, Mark F. Coolbaugh, and James E. Faulds, 2015, 21 pages.



Geothermal systems and geothermal power plants in the Great Basin region.



Shaded relief map of White Pine County showing known geothermal systems and Quaternary faults.

See geothermal resource potential assessment of White Pine County on the
Nevada Bureau of Mines and Geology website
http://pubs.nbmg.unr.edu/Geothermal-assess-White-Pine-Co-p/r055.htm

Nevada Geodetic Laboratory

The Nevada Geodetic Laboratory (NGL) conducts research in the field of space geodesy to study scientific problems that have both regional and global significance. The NGL uses the Global Positioning System (GPS) and Interferometric Synthetic Aperture Radar (InSAR) to study tectonics, earthquakes, mountain growth, volcanism, geothermal activity, and Earth deformation associated with climate change in Nevada. The NGL also studies global patterns in surface mass loading and global-scale plate tectonic problems.

The NGL is located within the Nevada Bureau of Mines and Geology and interacts closely with the University of Nevada, Reno, Department of Geological Sciences and the Nevada Seismological Laboratory.

Surprise Valley, California looking east towards the Hays Canyon Range, Washoe County, Nevada. Geodesists at the Nevada Bureau of Mines and Geology can precisely measure very slow movement of the Earth's crust with GPS (white antenna disk in photo). When compared with measurements of other GPS stations elsewhere, they can very precisely map deformation that leads to future earthquakes. *Photographer: Corné Kreemer*

Installing a GPS site near the Sierra Nevada crest requires bolting a solar panel to an exposed section of rock near the summit of Ward Peak. Lake Tahoe and Carson range in background. *Photographer: Jean Dixon*

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

Nevada Geodetic Laboratory

NBMG Geodesist Spotlight

Geoff Blewitt next to the continuous GPS station on top of Slide Mountain. *Photographer: Jean Dixon*

Geoffrey Blewitt
Research Professor
Nevada Bureau of Mines and Geology

Geoff Blewitt strives to develop end-to-end techniques to acquire, process and model GPS data in the most accurate way possible, and to apply the results to various geophysical problems. Geoff manages NGL's 200-CPU data computing facility that processes data from just about all 10,000 GPS stations in the world. Using GPS signals for positioning with millimeter accuracy requires that he apply physical models of Earth's changing shape and rotation in space, satellite dynamics, microwave propagation, atmospheric refractivity, atomic clocks, antennas, and even general relativity. In 2004, Geoff started installing NGL's MAGNET GPS network that today has nearly 400 GPS stations spanning Nevada, eastern California, and parts of Arizona and Utah. MAGNET is used to map strain in the Earth's crust in the Nevada region for seismic hazard assessment, to model earthquakes before, during, and after the main shock, and to help target geothermal resources.

Publication Citations

Blewitt, G., 2014, Final report—rapid determination of earthquake displacement field based on GPS for tsunami early warning.

Blewitt, G., and Hammond, W.C., 2014, Annual NASA project report—extending GGOS to high frequencies and low latencies.

Blewitt, G., and Hammond, W.C., 2014, Annual National Science Foundation project report—revealing the nature of contemporary uplift and collapse in the Sierra Nevada–Great Basin system.

Blewitt, G., and Hammond, W.C., 2014, Quarterly NASA project report—plug and play GPS for earth scientists—providing immediate access to low-latency geodetic products for rapid modeling and analysis of natural hazards.

Dixon, T., and **Blewitt, G.**, 2014, AGU Geodesy Section Newsletter: Fall 2014.

Blewitt, G., 2015, Terrestrial reference frame requirements for studies of geodynamics and climate change, International Association of Geodesy Symposia, 146: 8 p.

Blewitt, G., and Hammond, W.C., 2015, Extending GGOS to high frequencies and low latencies, Annual NASA Project Report, 2015: 19 p.

Blewitt, G., and Hammond, W.C., 2015, Plug and play GPS for earth scientists—providing immediate access to low-latency geodetic products for rapid modeling and analysis of natural hazards, 1st Quarterly NASA Project Report.

Blewitt, G., 2015, GPS and space-based geodetic methods, in Treatise in Geophysics, Elsevier, 3: p. 307–338.

Awards

Bowie Lecture, silver award, and Mueller Award ceremony, American Geophysical Union Fall Meeting 2014.

European Geosciences Union "Vening Meinesz Medal" for exceptional international standing in Geodesy, awarded in Vienna in April 2015.

Researcher of the Year 2015, Mackay School of Earth Sciences and Engineering.

Find additional information on Geoffrey Blewitt's research at the
Nevada Bureau of Mines and Geology website
http://www.nbmg.unr.edu/Staff/Blewitt.html

Nevada Geodetic Laboratory

NBMG Geodesist Spotlight

Bill Hammond in the Smoke Creek Desert, near GPS station SMOK. GPS measurements estimate that this valley widens by approximately 1 mm/yr. *Photographer: Bill Hammond*

William C. Hammond
Research Professor
Nevada Bureau of Mines and Geology

Bill Hammond precisely measures active crustal deformation using geodetic techniques such as the Global Positioning System (GPS) and Interferometric Synthetic Aperture Radar (InSAR). From these measurements, he infers the style and distribution of Earth surface deformation that is a direct consequence of continent-scale tectonic processes. Bill's main interest is in relating these motions to the organization of seismogenic faulting, and inferring the source of stresses in the lithosphere. With geodesy, we can better understand the processes that control gradual deformation of the western U.S. continental interior, and hence better understand the physics of Earth deformation and the source of potentially damaging earthquakes.

Publication Citations

Amos, C.B., Audet, P., **Hammond, W.C.**, Bürgmann, R., Johanson, I., and Blewitt, G., 2014, Uplift and seismicity driven by groundwater depletion in central California: Nature, v. 509, p. 483–486.

Hammond, W.C., Blewitt, G., and Kreemer, C.W., 2014, Steady contemporary deformation of the central Basin and Range Province, western United States: Journal of Geophysical Research, v. 119, p. 5235–5253.

Hammond, W.C., Johnson, K., and Burgette, R., 2014, Measuring Ventura area uplift—a four-technique geodetic study of vertical tectonics combining GPS, InSAR, leveling and tide gauges: SCEC Annual Meeting, Southern California Earthquake Center.

Petersen, M.D., Zeng, Y. , Haller, K.M., McCaffrey, R., **Hammond, W.C.**, Bird, P., Moschetti, M., Shen, Z., Bormann, J., and Thatcher, W., 2014, Geodesy- and geology-based slip-rate models for the Western United States (excluding California) national seismic hazard maps: U.S. Geological Survey Open-File Report 2013-1293, 80 p.

Weldon, R.J., Streig, A., and **Hammond, W.C.**, 2014, Colorado River aqueduct San Gorgonio Pass seismic event vulnerability study, San Bernardino County, California: Southern branch San Andreas Fault ruptures Coulomb 3.3 simulations, for the Metropolitan Water District of Southern California.

Aster, R., Simons, M., Bürgmann, R., Gomez, N., **Hammond, W.C.**, Holbrook, S., Chaussard, E., Stearns, L., Egbert, G., Hole, J., Lay, T., McNutt, S., Oskin, M., Schmandt, B., Schmidt, D., Vidale, J., Wagner, L., and Winberry, P., 2015, Future geophysical facilities required to address grand challenges in the Earth sciences, A community report to the National Science Foundation.

Hammond, W.C., Kreemer, C.W., Bormann, J., and Blewitt, G., 2015, Fault slip rates in the Western Great Basin from geodetic and geologic data: Utah Geological Survey Miscellaneous Publication, 15-5.

Melgar, D., Geng, J., Crowell, B.W., Haase, J.S., **Hammond, W.C.**, Bock, Y., and Allen, R.M., 2015, Seismogeodesy of the 2014 Mw6.1 Napa, California, Earthquake: Rapid response and modeling of fast rupture on a dipping strike-slip fault, Journal of Geophysical Research, v. 120, p. 5013–5033.

Awards

Awarded Editors' Citation for Excellence in Refereeing from Journal of Geophysical Research Solid Earth, cited with photograph in American Geophysical Union's weekly publication Eos.

Highlighted in the inaugural edition of Discover Extraordinary People, Programs & Projects from the College of Science from the University of Nevada, Reno, College of Science.

Elected by membership as Secretary for the American Geophysical Union Geodesy Section.

Find additional information on William Hammond's research at the
Nevada Bureau of Mines and Geology website
http://www.nbmg.unr.edu/Staff/Hammond.html

Nevada Geodetic Laboratory

NBMG Geodesist Spotlight

Corné Kreemer next to one of the continuous GPS stations in the Basin and Range that he uses for his deformation modeling.
Photographer: Corné Kreemer

Corné Kreemer
Research Professor
Nevada Bureau of Mines and Geology

Corné Kreemer uses GPS velocity data and other kinematic indicators to precisely map out where and how deformation is occurring in the Earth's crust right now. These models of the deformation field reflect where strain rates are building up and where they are likely to be released in future earthquakes. Corné's research directly contributes to seismic hazard reduction efforts, in the Great Basin and beyond. Corné likes to place his model results in the context of where and how deformation has occurred in the past, how surface deformation relates to the motion and deformation of the underlying mantle, and how lithospheric forces can be thought responsible for the deformation field.

Publication Citations

Kreemer, C.W., 2014, The slow-but-steady deformation of the American West—new insights from GPS geodesy, Northern Arizona University, National Science Foundation EarthScope.

Kreemer, C.W., and Gordon, R.G., 2014, Pacific plate deformation from horizontal thermal contraction, Geology, v. 42, p. 847–850.

Kreemer, C.W., and Hammond, W.C., 2014, Geodetic constraints on fault slip rates and seismic hazard in the greater Las Vegas area, U.S. Geological Survey National Earthquake Hazard Reduction Program, p. 42.

Kreemer, C.W., Blewitt, G., and Klein, E.C., 2014, A geodetic plate motion and global strain rate model: Geochemistry, Geophysics, Geosystems, v. 15, no. 10, p. 3849–3889.

Kreemer, C.W., Klein, E.C., Shen, Z.K., Wang, M., Estey, L., Wier, S., and Boler, F., 2014, Global geodetic strain rate model: Global Earthquake Model Technical Report 2014-07, v.1.0.0, p. 130.

Zheng, L., Gordon, R.G., and **Kreemer, C.W.**, 2014, Absolute plate velocities from seismic anisotropy—importance of correlated errors, Journal of Geophysical Research, v. 119, p. 7336–7352.

Bird, P., and **Kreemer, C.W.**, 2015, Revised tectonic forecast of global shallow seismicity based on version 2.1 of the global strain rate map: Bulletin of the Seismological Society of America, v. 106, p. 152–166.

Bird, P., Jackson, D.D., Kagan, Y.Y., **Kreemer, C.W.**, and Stein, R.S., 2015, GEAR1—a global earthquake activity rate model constructed from geodetic strain rates and smoothed seismicity, Bulletin of the Seismological Society of America, v. 106, p. 2538–2554.

Keiding, M., **Kreemer, C.W.**, Lindholm, C.D., Gradmann, S., Olesen, O., and Kierulf, H.P., 2015, A comparison of strain rates and seismicity for Fennoscandia—depth dependency of deformation from glacial isostatic adjustment: Geophysical Journal International, v. 202, p. 1021–1028.

Gordon, R., and **Kreemer, C.W.**, 2015, Shrinking of the Cocos and Nazca plates due to horizontal thermal contraction and implications for plate non-rigidity and the non-closure of the Pacific-Cocos-Nazca plate motion circuit, American Geophysical Union Fall Meeting.

Find additional information on Corne Kreemer's research at the
Nevada Bureau of Mines and Geology website
http://www.nbmg.unr.edu/Staff/Kreemer.html

Nevada Geodetic Laboratory

NBMG Publication Spotlight

Hammond, W.C., G. Blewitt, C. Kreemer, 2014, *Steady contemporary deformation of the central Basin and Range Province, western United States:* Journal of Geophysical Research, v. 119, p. 5235–5253, doi:10.1002/2014JB011145.

The Nevada Geodetic Laboratory (NGL) uses data from western U.S. GPS networks to estimate the rate, pattern, and style of tectonic deformation of the central Basin and Range Province (BRP). Previous geodetic investigations have found the crust of eastern Nevada and western Utah to act as a rigid microplate, with zero deformation rates to within measurement uncertainty. Observed transients in GPS time series have led others to propose a megadetachment model, predicting that the central BRP behaves as a microplate, but with time-varying translation.

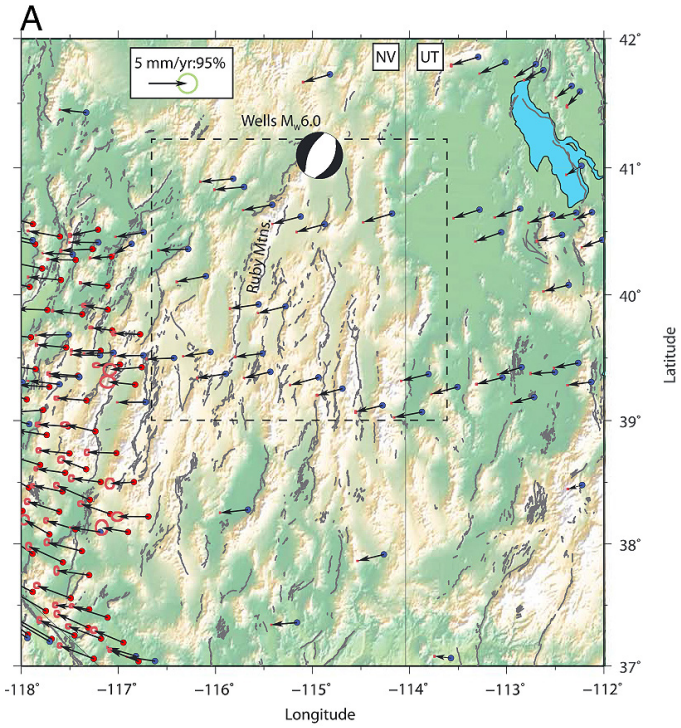


Figure 1A. Horizontal GPS velocity with respect to North America (NA12 reference frame) across the eastern Nevada, western Utah Basin and Range. The moment tensor beach ball marks the location and 21 February 2008 Wells, Nevada, MW 6.0 earthquake epicenter. Red dots indicate MAGNET GPS stations; blue dots are continuous stations. Uncertainty ellipses at tip of vectors indicate 95% confidence in velocity.

NBMG Publication Spotlight

Amos, C.B., Audet, P., Hammond, W.C., Bürgmann, R., Johanson, I., and Blewitt, G., 2014, *Uplift and seismicity driven by groundwater depletion in central California:* Nature, v. 509, p. 483–486.

Groundwater use in California's San Joaquin Valley exceeds replenishment of the aquifer, leading to substantial diminution of this resource and rapid subsidence of the valley floor 5. The volume of groundwater lost over the past century and a half also represents a substantial reduction in mass and a large-scale unburdening of the lithosphere, with significant but unexplored potential impacts on crustal deformation and seismicity. Here NGL uses vertical global positioning system measurements to show that a broad zone of rock uplift of up to 1–3 mm per year surrounds the southern San Joaquin Valley. The observed uplift matches well with predicted flexure from a simple elastic model of current rates of water-storage loss, most of which is caused by groundwater depletion 3.

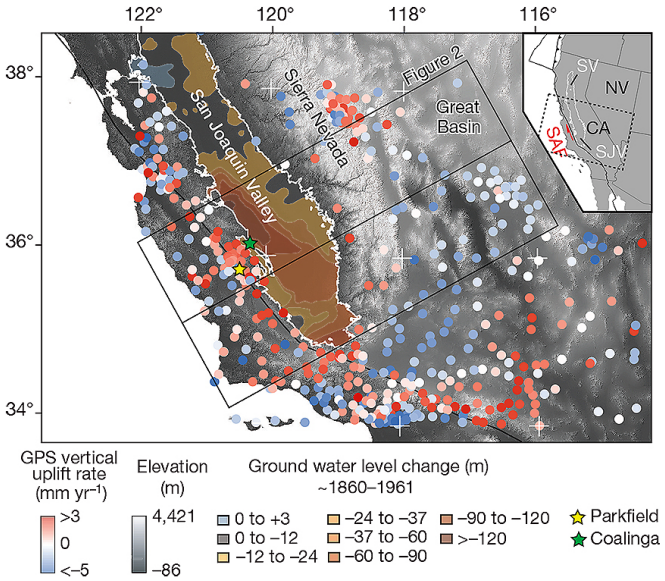
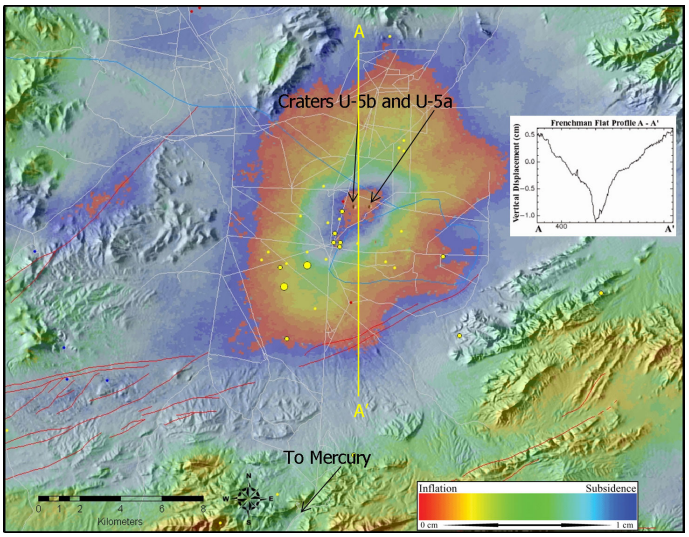


Figure 1. Contemporary GPS vertical rates and groundwater decline. Map of vertical uplift rates from GPS stations (circles) spanning California and the western Great Basin. Stations in the valley showing anomalously larger signals and local irrigation effects are excluded. Contours show historical changes in the deep, confined aquifer 1. The inset depicts the tectonic configuration of the Central Valley groundwater basin (SV, Sacramento Valley; SJV, San Joaquin Valley), and the San Andreas Fault (SAF).

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

InSAR Laboratory

Interferometric synthetic aperture radar (InSAR) is a rapidly evolving remote sensing technology that uses satellite radar data collected since 1992 to measure sub-centimeter-scale ground movement, most commonly in surface deformation studies related to earthquakes, volcanoes, and groundwater-related land subsidence. Two radar scenes each covering about 10,000 km^2 and taken at different times are closely compared for small changes in radar phase of the waves reflected from fixed objects that have moved on the ground. The small shifts in radar phase can be measured with a pixel resolution of about 10 m, allowing deformation patterns to be detected over large regions with a high degree of spatial detail.



Interferogram for period Feb 1998 to Feb 1999 showing deformation (subsidence) associated with the 1999 Frenchman Flat earthquake (M 4.8), Nevada Test Site.

InSAR lab research facilities

The lab is equipped with a full range of computing hardware and software dedicated exclusively to InSAR processing, including multiple Linux, Unix, and PC workstation platforms. The lab can routinely process InSAR data using any of three software packages: DIAPASON developed by the French Space Agency (CNES); ROI_PAC developed by the NASA Jet Propulsion Lab (JPL); and GAMMA developed by Gamma Remote Sensing.

Current Projects

- Subsidence and earth fissuring due to heavy pumping in Pahrump Valley.
- Aquifer system response to heavy pumping on municipal wells in the Virgin Valley (Mesquite).
- Reconnaissance InSAR study of eastern Nevada groundwater basins designated for potential groundwater export to Las Vegas Valley.
- Hydrostratigraphy and InSAR study of the Kelly Creek Basin-Pumpernickel Valley area, funded by Newmont Gold Mining Corporation.
- InSAR study of the aquifer system response to mine de-watering in the Boulder Valley area, funded by Barrick Goldstrike Mining Corporation.
- InSAR study of subsidence and earthquakes in the Yucca Mountain-Amargosa Valley-Ash Meadows-Death Valley region.
- Earthquakes and groundwater subsidence detected by InSAR in the Reno-Carson City-Lake Tahoe area, funded by the US Geological Survey Earthquake Hazard Reduction Program.

Publication Citations

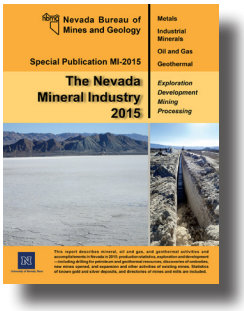
Ali, S.T., Davatzes, N.C., Drakos, P.S., Feigl, K.L., Foxall, W., **Kreemer, C.W.**, Mellors, R.J., Wang, H.F., Zemach, E., 2014, InSAR measurements and numerical models of deformation at Brady Hot Springs geothermal field (Nevada), 1997–2013, Workshop on Geothermal Reservoir Engineering, Stanford University.

Hammond, W.C., **Blewitt, G.**, and **Kreemer, C.W.**, Johnson, K., and Weldon, R., 2014, Vertical crustal motion across southern California fault systems from GPS and InSAR, UNAVCO Science Workshop.

Hammond, W.C., Johnson, K., **Blewitt, G.**, **Kreemer, C.W.**, Weldon, R., and Burgette, R., 2014, GPS and InSAR constraints on vertical tectonic motion improve the estimate of slip rate of the San Andreas Fault in southern California, European Geosciences Union General Assembly.

Find additional information on the **Nevada InSAR Laboratory** at the **Nevada Bureau of Mines and Geology website** **http://www.nbmg.unr.edu/insar_web/insar.htm**

Oil and Gas



The two paragraphs below are excerpts from the Oil and Gas chapter of NBMG Special Publication MI-2015, https://pubs.nbmg.unr.edu/The-NV-mineral-industry-2015-p/mi2015.htm

According to the Nevada Division of Minerals, Nevada's net oil production in 2015 was 281,875 barrels, which accounted for 0.008% of total domestic production. Production was down 11% from 316,426 barrels in 2014 and the lowest since 143,101 barrels were produced in 1976 (NBMG Bulletin 104). Production came from 63 actively producing wells in ten fields in Railroad Valley, Nye County, which accounted for 88% of the state's production, seven wells in two fields in Pine Valley, Eureka County, and one well in a new field in Elko County. Two other minor fields were shut in throughout 2015 and three other minor fields are plugged and abandoned. Nevada ranked 27 out of the 31 oil-producing states (http://www.eia.gov). According to the Division of Minerals, the monthly average per barrel net wellhead price for Nevada crude oil ranged between $30.32 and $59.82. The average for 2015 was $44.72, a decrease of 52% from $93.17 in 2014. The sales volume (or gross yield) decreased 53% to $12,606,643.87 in 2015 from $26,914,233.10 in 2014 (2015–2016 Net Proceeds of Minerals Bulletin).

Exploration

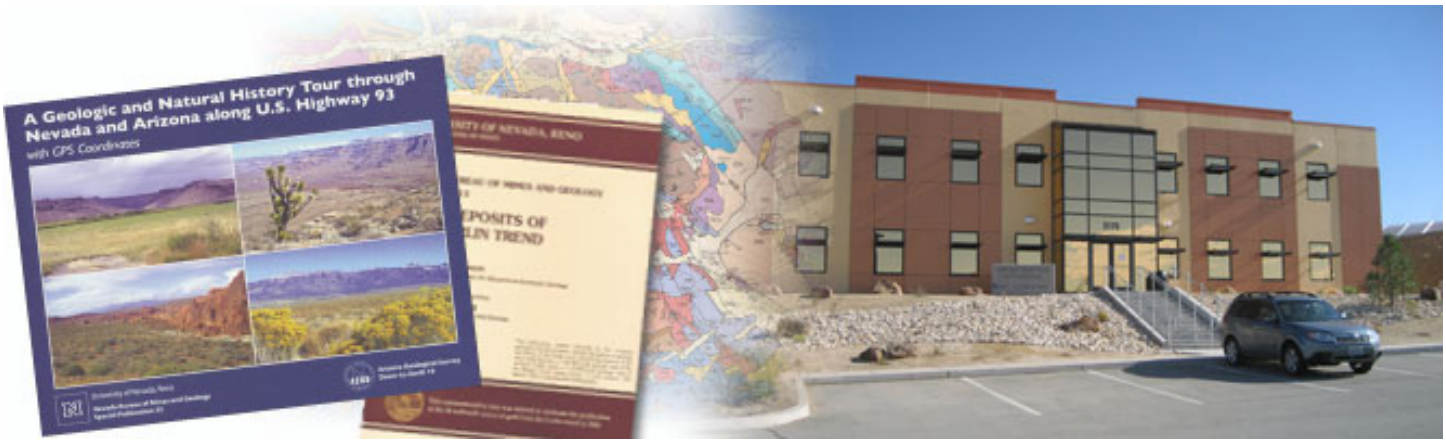
Four wells were permitted for oil and gas in 2015, down from twelve permitted in 2014. Only one well was spudded in 2015, and one well spudded in 2014 was completed in 2015, down from five completed in 2014. Both were plugged and abandoned. The two wells completed totaled 11,214 feet (3,418 m), a decline of 72% from the 39,606 (12,072 m) feet drilled in 2014. Of nine wells completed between 2003 and 2012, six were shut-in, one was temporarily abandoned, one was being tested, and one had been waiting for a plugging and abandoning plan since 2005. One well completed in 2011 was finally plugged and abandoned. One well completed in 1993 has been listed as shut-in or temporarily abandoned over the years. Five permits expired, and one lease (NVN-079238) owned by Roy Barton closed before Petro-Hunt LLC, which held the permit, was able to drill. Based on reports filed with the state for 2015, one drill rig operated in the state during the May-June and July-August periods and none were operated otherwise. No wells were hydraulically fractured in Nevada in 2015, but a table of wells hydraulically fractured in the past is provided.

Nevada Petroleum and Geothermal Society field trip and jar of oil at Gabbs Valley. *Photographer: Jack Hursh*

Find additional reports and data on Nevada's oil and gas industry at the
Nevada Bureau of Mines and Geology website
http://www.nbmg.unr.edu/Oil&Gas/index.html

Great Basin Science Sample and Records Library

GBSSRL



The Nevada Bureau of Mines and Geology Publication Sales and Information Office and the Geological Society of Nevada office are located at the Great Basin Science Sample and Records Library (GBSSRL) on the Desert Research Institute campus: 2175 Raggio Parkway, Reno, NV 89512.

You can purchase or obtain the following information at the GBSSRL:

- NBMG geologic maps and reports
- U.S. Geological Survey geologic maps and publications
- U.S. Geological Survey topographic maps
- Aerial photographs
- Cuttings, core, and well records for oil, gas, and geothermal
- General geological and mining information

Geologists from Colorado examine well cuttings at the GBSSRL. *Photographer: Charlotte Stock*

Well cuttings and core samples are archived in the GBSSRL warehouse. *Photographer: Charlotte Stock.*

Hours of operation
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Fax: (775) 784-6690
E-mail: nbmg@unr.edu

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/GBSSRL/index.html

Geologic Hazards and Public Safety

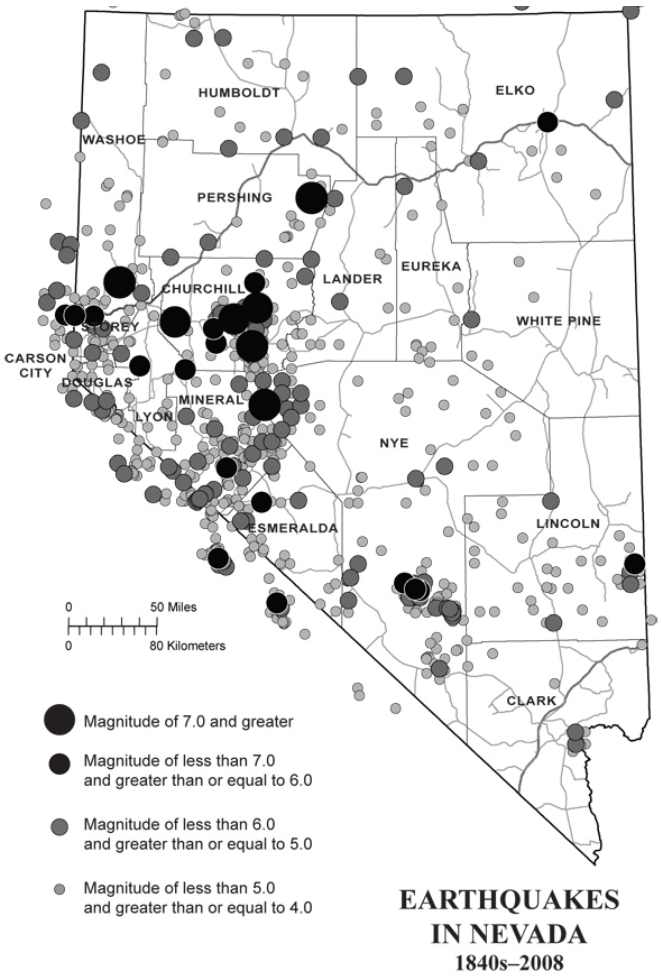
Nevada is at risk from numerous geohazards including earthquakes and flooding. NBMG scientists research these hazards to help us learn how to protect ourselves from danger.

The Great Basin Science Sample and Records Library (GBSSRL) houses information on many of these geohazards. All materials in the collections are open for free public viewing during GBSSRL office hours, and the staff will help locate and pull files for a fee. Many related publications are also available through our Publications Sales Office and for free on our website.

The State of Nevada is located in "earthquake country." It lies within the Basin and Range Province, one of the most seismically active regions in the United States. Along with California and Alaska, Nevada ranks in the top three states subject to the most large earthquakes over the last 150 years.

Given the many "earthquake-generating" faults in Nevada, the geodetic deformation measured between the mountains, and the many historical earthquakes, it is clear that earthquakes will continue to occur in the state.

The Genoa fault plane with vertical grooves was caused by normal-slip movement. Over the last 150 years, Nevada has been the third most active state in the Union in the number of large earthquakes. Since the 1850s, over 63 earthquakes with potentially destructive magnitudes of 5.5 or greater have occurred in the state. *Photographer: Chris Henry*



Earthquakes in the Nevada region recorded from the 1840s to 2008. (Nevada Seismological Laboratory)

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

Geologic Hazards and Public Safety

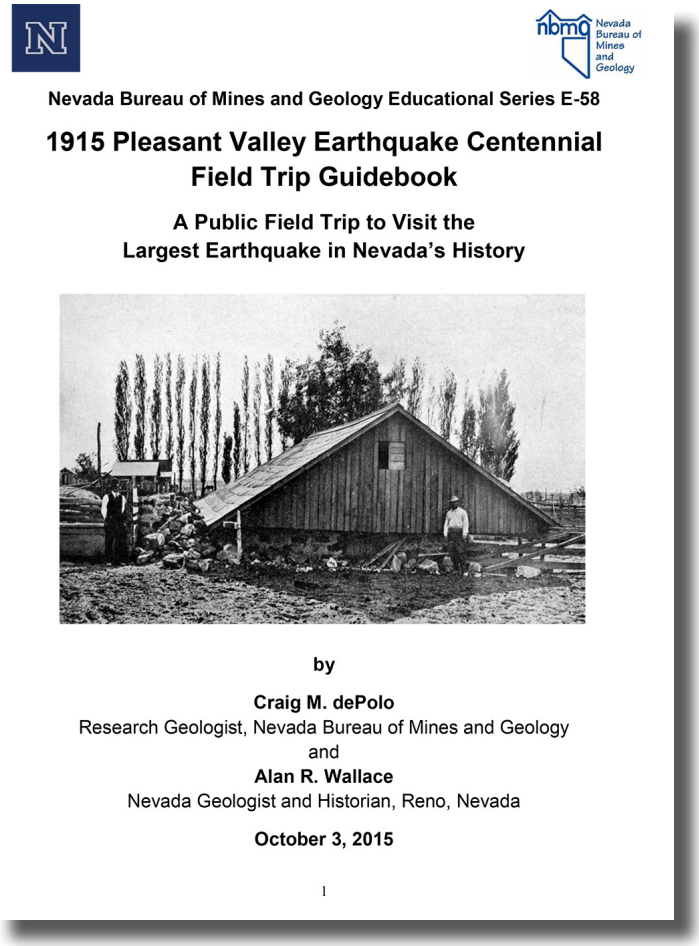
NBMG Publication Spotlight

NBMG Educational Series 58

1915 Pleasant Valley earthquake centennial field trip guidebook: A public field trip to visit the largest earthquake in Nevada's history

Includes 16 pages of text with photos and maps

by Craig M. dePolo and Alan R. Wallace



Nevada Bureau of Mines and Geology Educational Series E-58

1915 Pleasant Valley Earthquake Centennial Field Trip Guidebook

A Public Field Trip to Visit the Largest Earthquake in Nevada's History

by

Craig M. dePolo
Research Geologist, Nevada Bureau of Mines and Geology
and
Alan R. Wallace
Nevada Geologist and Historian, Reno, Nevada

October 3, 2015

1

The centennial anniversary of the 1915 Pleasant Valley earthquake was an opportunity to reflect on this event, what it did, what it means, and how it should influence us. This was the largest earthquake to date in Nevada's written record. It had some of the strongest and widest effects from shaking of all the historical events. And the earthquake offers many lessons and examples on how to live with earthquakes in ways to protect ourselves, our valuables, and our standard of living from earthquakes. In short, the 1915 earthquake reminds us that Nevada is earthquake country.

This guidebook provides a general guide to a half-day trip from Winnemucca to see the fault scarps at Golconda Canyon on the east side of Pleasant Valley. The drive passes by diverse geologic features, including rocks that date back 300 million years, basalts that were erupted 15 million years ago, and hot springs and earthquakes that have been active over just the past few hundred years.

1915 Pleasant Valley surface ruptures. *Photographer: Stanley McCoy*

Group photo of participants in the NBMG sponsored 1915 Pleasant Valley earthquake centennial field trip. *Photographer: Diane dePolo*

Find additional information on the 1915 Pleasant Valley, Nevada Earthquake at the
Nevada Bureau of Mines and Geology website
http://www.nbmg.unr.edu/Geohazards/Earthquakes/1915centennial.html

Geologic Hazards and Public Safety

NBMG Publication Spotlight

NBMG Special Publication 27

Living with Earthquakes in Nevada

Includes 38 color pages

by Craig M. dePolo, Lucy K. Jones, Diane M. dePolo, and Susan Tingley, Third Edition, 2010

This handbook identifies the earthquake threat to Nevada and reviews earthquake safety, how to be prepared for earthquakes, and mitigation of hazards from shaking and fault offset.

Available free on the NBMG website:
http://pubs.nbmg.unr.edu/Living-with-earthquakes-in-NV-p/sp027.htm

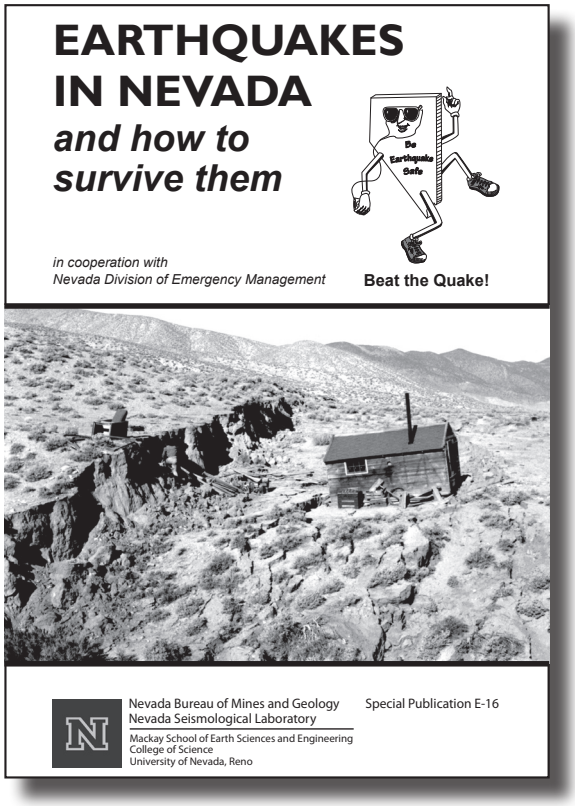
NBMG Publication Spotlight

NBMG E-16

Earthquakes in Nevada and how to survive them

Includes 8 pages

by Craig M. dePolo, Alan Ramelli, and Diane dePolo, Seventh Edition, January 2010



Available free on the NBMG website:
http://pubs.nbmg.unr.edu/Earthquakes-in-Nevada-and-how-t-p/e016.htm

A Spanish version is free on the NBMG website:
http://pubs.nbmg.unr.edu/Terremotos-en-Nevada-y-como-sob-p/e027.htm

For an extensive list of available publications and information on earthquakes, see the
Nevada Bureau of Mines and Geology website
http://www.nbmg.unr.edu/Geohazards/index.html

Geologic Hazards and Public Safety

NBMG Publication Spotlight

Open-File Report 15-11A–F
by Craig M. dePolo and Seth M. Dee

Six 1:250,000-scale preliminary maps showing Quaternary faults and seismicity in northern Nevada:

OF2015-11A
Preliminary Quaternary fault and seismicity map of the **Vya** 1 x 2 degree quadrangle, Nevada

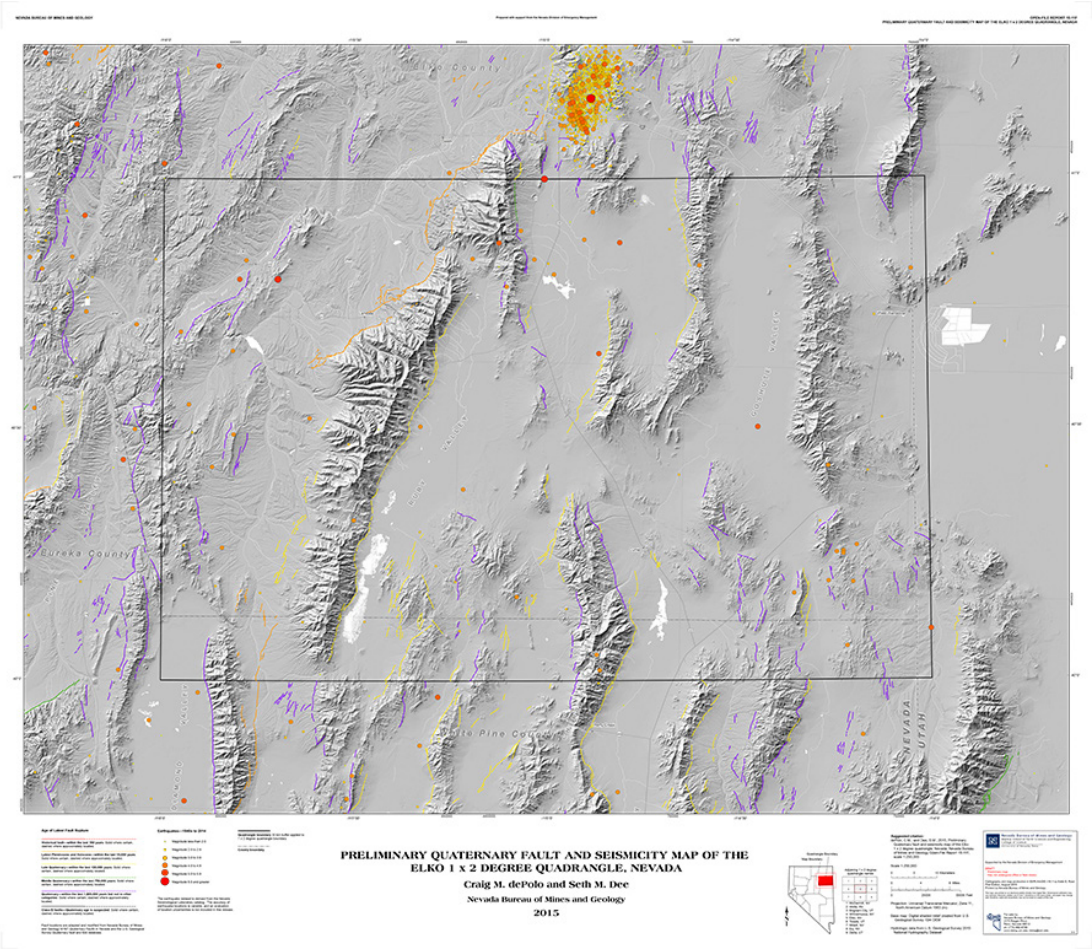
OF2015-11B
Preliminary Quaternary fault and seismicity map of the **McDermitt** 1 x 2 degree quadrangle, Nevada

OF2015-11C
Preliminary Quaternary fault and seismicity map of the **Wells** 1 x 2 degree quadrangle, Nevada

OF2015-11D
Preliminary Quaternary fault and seismicity map of the **Lovelock** 1 x 2 degree quadrangle, Nevada

OF2015-11E
Preliminary Quaternary fault and seismicity map of the **Winnemucca** 1 x 2 degree quadrangle, Nevada

OF2015-11F
Preliminary Quaternary fault and seismicity map of the **Elko** 1 x 2 degree quadrangle, Nevada



Open-File Report 15-11F - Preliminary Quaternary fault and seismicity map of the Elko 1 x 2 degree quadrangle.

Find more fault and seismicity maps in the Open-File Report listing on the **Nevada Bureau of Mines and Geology website**
http://pubs.nbmg.unr.edu/Open-File-Reports-s/1861.htm

Education and Outreach

NBMG plays an important role in educating the public on many geologic topics that directly affect Nevada through educational publications, teacher workshops, field trips and other outreach opportunities.

Teacher Workshops

Staff members regularly participate in the highly effective and popular teacher-education workshops that are sponsored by the Nevada Mining Association and jointly supported by the Nevada Division of Minerals.

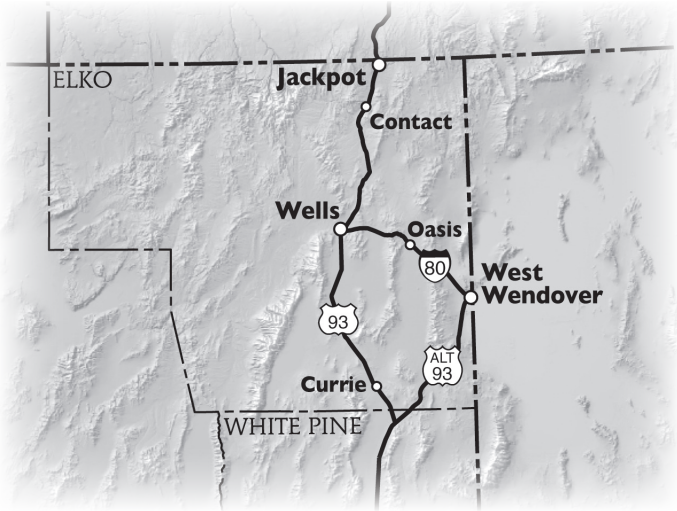
D.D. LaPointe demonstrates the magnet test on a rock to participants on the 2015 Earth Science Week field trip. *Photographer: Jennifer Vlcan*

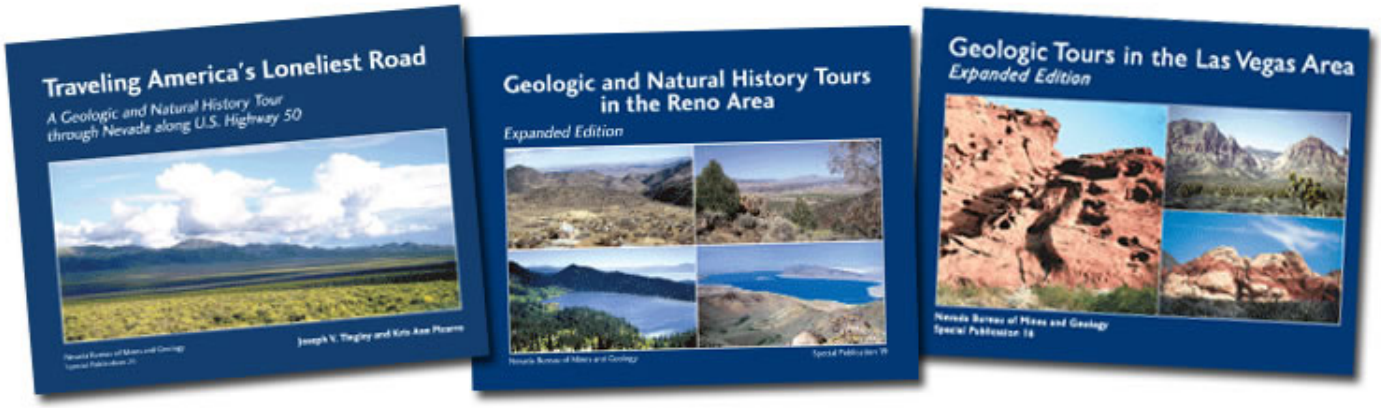
Field Trips

NBMG helps coordinate field trips and other activities for the public and for K-12 teachers and students during Earth Science Week (second full week of October) and Earthquake Awareness and Preparedness Week (late February or early March).

Geologic Tourbooks

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





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 Field Trips

The Nevada Bureau of Mines and Geology annually hosts a geology field trip free and open to the public. This field trip is in conjunction with National Earth Science Week (second full week of October) which encourages people everywhere 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 earthquake hazards from evidence of recent faulting, and evaluate the potential for mineral resources. Participants are given the opportunity to collect mineral specimens.

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://www.nbmg.unr.edu/ScienceEducation/Geotripping.html**

Nick Hinz, NBMG Geologic Mapping Specialist, leads a discussion on geology atop a glacial moraine during an Earth Science Week field trip. *Photographer: Jennifer Vlcan.*

Jon Price discussing rocks during the 2014 Earth Science Week field trip in the Carson City area. *Photographer: Janel Tietje*

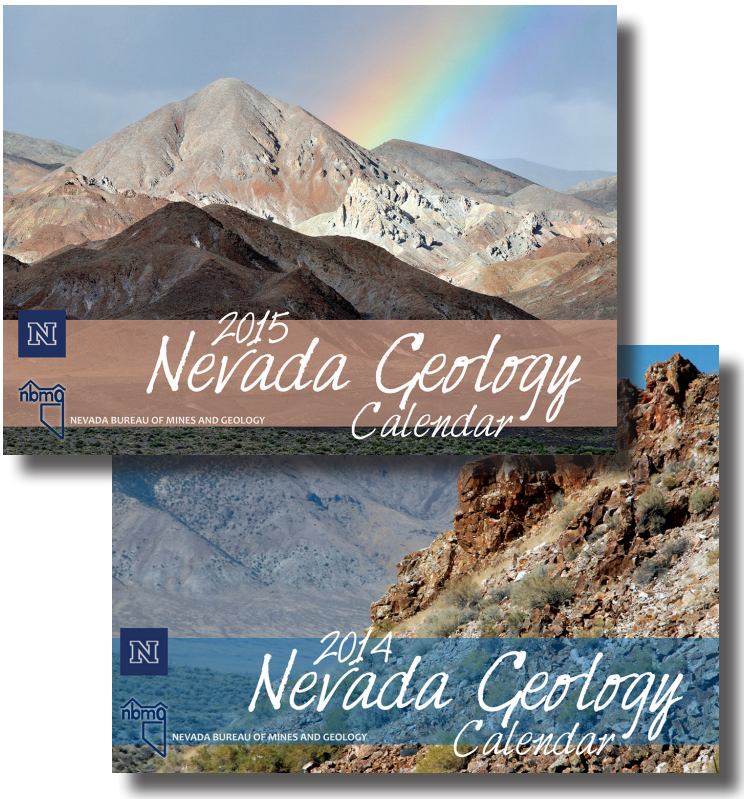
Participants explore interesting geological features during the 2014 Earth Science Week field trip in the Carson City area. *Photographer: Jennifer Vlcan*

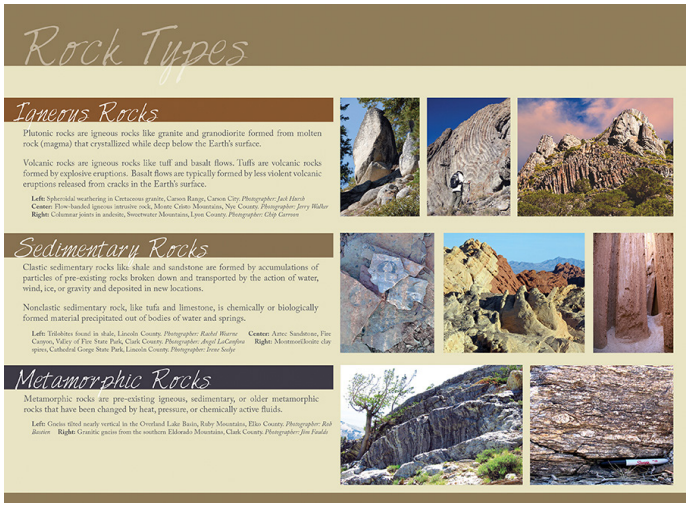
Find additional information on Earth Science Week field trips at the **Nevada Bureau of Mines and Geology website**
http://www.nbmg.unr.edu/ScienceEducation/Geotripping.html

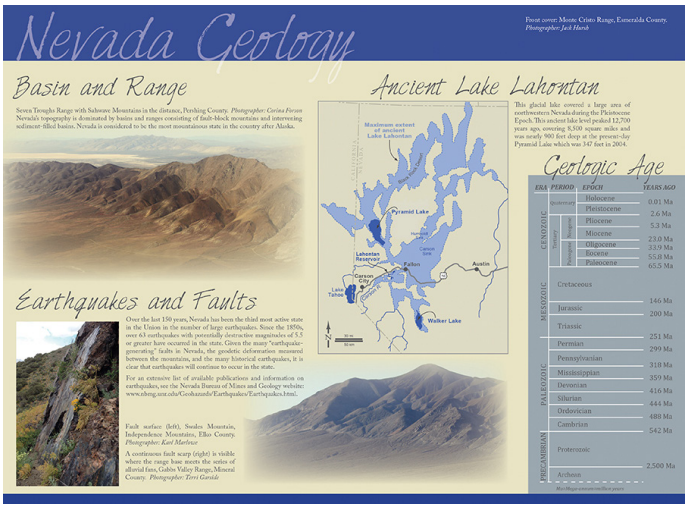
Education and Outreach

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.





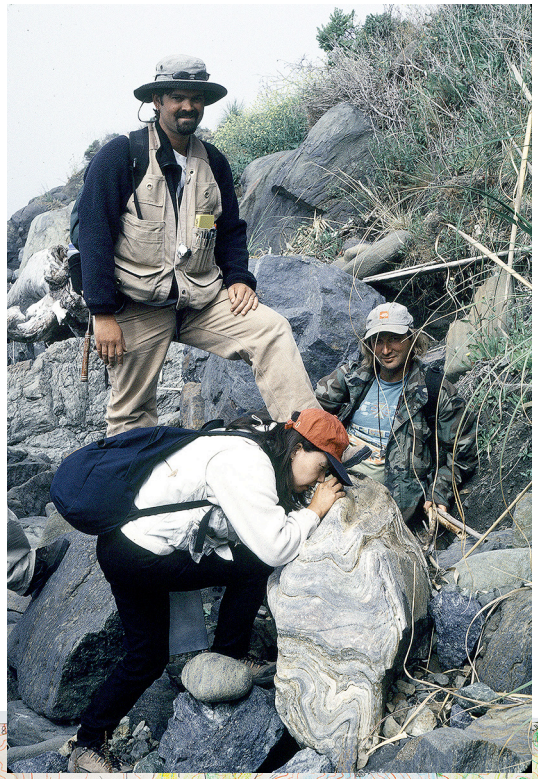


Find additional information on the Nevada geology calendars at the
Nevada Bureau of Mines and Geology website
https://pubs.nbmg.unr.edu/Calendars-s/1853.htm

Education and Outreach

Graduate Students and Summer Field Camp

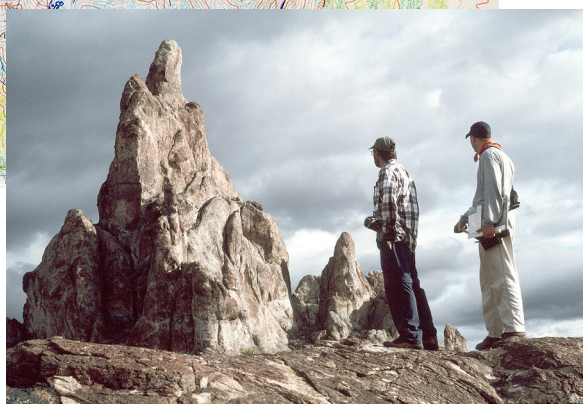
Sean Long served as the director of the UNR Summer Field Camp course in 2014. The primary focus of this course is to teach undergraduate students how to make geologic maps.



Student map awards:

NBMG graduate student Chad Carlson placed first and Joel Edwards placed third in the geologic mapping competition, Geological Society of America Annual Meeting in Vancouver, BC, Canada. Advised by Jim Faulds.

NBMG graduate student Russell Di Fiori placed 2nd place in student geologic mapping competition, Geological Society of America annual meeting in Vancouver for his geologic and alteration maps of the Eureka mining district. Advised by Sean Long.



Cartography and Publication Support

Nevada Bureau of Mines and Geology's Cartography and GIS Lab group receives national recognition with a Special Achievement in GIS award from the Environmental Systems Research Institute (ESRI).

You can read about this honor in the article by Annie Conway (Nevada Today, 9/9/2014) on the web at http://www.unr.edu/nevada-today/news/2014/cartography-and-gis-lab or below:

The staff at the Nevada Bureau of Mines and Geology's Cartography and Geographic Information Systems Laboratory on the University of Nevada, Reno campus received a Special Achievement in GIS award from the Environmental Systems Research Institute. The group received the award at the ESRI International User Conference in San Diego, Calif.

The Cartography and GIS lab is a specialty group within the Nevada Bureau of Mines and Geology, a public service department in the College of Science. The Cartography and GIS Lab is a campus and community resource that specializes in data management, publications and mapping.

"Receiving the Special Achievement in GIS award was an honor," Jennifer Vlcan, manager of the Cartography and GIS lab, said. "We have gone through many changes as technology has improved, and we had to evolve our work flows and how we disseminate our data. It is nice to see these efforts recognized."

Special Achievement in GIS awards are given based on overall GIS work. Nominations are submitted by ESRI staff and the final awards are chosen by founder and president of ESRI, Jack Dangermond. ESRI is a leader in geological information systems.

NBMG has been on campus since 1929 and has had a publications-cartography group since the 1950s. The Cartography and GIS group acts as an intermediary between scientists and the public by taking the research and findings of the scientists and creating publishable maps and reports.

"The Cartography and GIS Lab is a central component to the core mission of NBMG," James Faulds, director of the Nevada Bureau of Mines and Geology, state geologist and professor of geology at the University, said. "Their work is essential to the production and publication of geologic maps and reports."

They also provide support to other groups on campus such as the Department of Geological Sciences and Engineering, University of Nevada Cooperative Extension and other University departments and state agencies. They have even created reports and maps for Nevada public officials and the U.S. Geological Survey.

"The award demonstrates the excellence and versatility of the group," Faulds said.

The team first learned about their nomination at the state GIS conference in Las Vegas in May. The award speaks to the dedication and skills of the staff, which is comprised of three full-time members and two part-time staff. According to Vlcan, former employee Gary Johnson was an important factor in the department receiving the award.

"Johnson, who recently retired from the lab, was a big part of why we received this award." Vlcan said. "His efforts and expertise were instrumental to our management of GIS data and creation of web applications that contributed to our receiving this award."

Find additional information on Cartography, GIS, and Publication Support staff at the
Nevada Bureau of Mines and Geology website
http://www.nbmg.unr.edu/Staff.html

Website Support to Partner Organizations

Extensive resources produced by NBMG can be accessed at the Nevada Bureau of Mines and Geology's website:

www.nbmg.unr.edu

In addition, NBMG provides website hosting and website editing services to several state organizations including the following:

Nevada Earthquake Safety Council

www.nbmg.unr.edu/nesc/index.html

The mission of the Nevada Earthquake Safety Council is to advise the Nevada Earthquake Risk Reduction Program. The Council facilitates public input, develops consensus about seismic issues within the public and private sectors, and is the public advisory body for the State seismic safety policy.

NBMG faculty and staff that served in 2014 and 2015 on the NESC council: **Craig dePolo**.

Nevada Hazard Mitigation Planning Committee

www.nbmg.unr.edu/nhmpc/index.html

The purpose of the Nevada Hazard Mitigation Planning Committee is to advise the Nevada Department of Emergency Management concerning hazard mitigation assistance, which includes planning, projects, and policies.

NBMG faculty and staff that served in 2014 and 2015 on the NHMPC: **Craig dePolo** (Chair).

Nevada Petroleum and Geothermal Society

www.nbmg.unr.edu/nps/index.html

The purpose of the Nevada Petroleum and Geothermal Society is to foster the development and growth of the petroleum and geothermal industries in Nevada in the following ways:

- Promote a high level of professionalism and ethics among the membership through programs of continuing education.
- Foster cooperation and understanding between the petroleum and geothermal industries in Nevada and officials in federal, state, and local government.
- Encourage and sponsor the dissemination of information through meetings, field trips, and publications, and by the support of academic endeavors.

NBMG faculty that served in 2014 and 2015 as committe member of the NPS: **Jim Faulds** (Scholarship).

Nevada State Mapping Advisory Committee

www.nbmg.unr.edu/smac/smac.htm

The Governor of Nevada established the State Mapping Advisory Committee (SMAC) in 1983 to advise the U.S. Geological Survey (USGS) on state priorities for map products and to inform maps users about the status of mapping programs and the availability of map products. The Governor named the Director of the Nevada Bureau of Mines and Geology as the chair of SMAC.

NBMG faculty and staff that served in 2014 and 2015 on the SMAC: **Jim Faulds** (Chair, 2012–present) and **Jennifer Vlcan** (Executive Secretary, 2011–present).

Nevada State Board on Geographic Names

http://www.nbmg.unr.edu/geonames/index.html

The mission of the Nevada State Board on Geographic Names is to coordinate and approve proposed geographic names within the state for official recommendation to the United States Board on Geographic Names.

NBMG faculty and staff that served in 2014 and 2015 on the NSBGN: **Jack Hursh** and **David Davis**.

Find additional resources and links at the
Nevada Bureau of Mines and Geology website
http://www.nbmg.unr.edu/Links.html

Awards

Awards received by NBMG faculty and staff:

Blewitt, G.

Bowie Lecture, silver award, and Mueller Award ceremony, American Geophysical Union Fall Meeting 2014.

European Geosciences Union "Vening Meinesz Medal" for exceptional international standing in Geodesy, awarded in Vienna in April 2015.

Researcher of the Year 2015, Mackay School of Earth Sciences and Engineering.

dePolo, C.M.

Awarded the Dedication (to C.M. dePolo) of a Conference Proceedings Volume from Basin and Range Province Committee of the Western States Seismic Policy Council.

Faulds, J.E.

Inducted as a Fellow of the Geological Society of America for work on tectonics and structural geology.

Geologic Mapping Competition: Major advisor for two graduate students that placed first (Chad Carlson) and third (Joel Edwards) in the geologic mapping competition, Geological Society of America Annual Meeting in Vancouver, BC, Canada.

Nevada Play Fairways grant (for which Faulds is PI) was the top rated project in the DOE Play Fairway Program and received the top award for Phase II research (one of six projects funded for Phase II nationwide).

Hammond, W.C.

Awarded Editors' Citation for Excellence in Refereeing from Journal of Geophysical Research Solid Earth, cited with photograph in American Geophysical Union's weekly publication Eos.

Highlighted in the inaugural edition of Discover Extraordinary People, Programs & Projects from the College of Science from the University of Nevada, Reno, College of Science.

Elected by membership as Secretary for the American Geophysical Union Geodesy Section.

Henry, C.D.

Award from Association of Mining Engineers, Metallurgists and Geologists of Mexico for commendable work in research and diffusion of geology in the Sierra Madre Occidental.

Hinz, N.H.

Best poster award (professional, non-student category) at the 2015 Geothermal Resources Council Annual Meeting.

Long, S.

Advisor, M.S. student Russell Di Fiori, awarded 2nd place, student map competition, Geological Society of America annual meeting in Vancouver for his geologic and alteration maps of the Eureka mining district.

Micander, R.E.

3rd Place "Cartographic" category for cartographic work on Minden quadrangle, Nevada Geographic Information Society, 2015.

Muntean, J.L.

Awarded Arthur Brant Chair in Exploration Geology from Mackay.

Center for Research in Economic Geology student, Tyler Hill won the second place for best student talk, Geological Society of Nevada Symposium.

Seelye, I.M.

1st place, "Cartographic" category for cartographic work on Geologic map of the southern part of the Eureka mining district and surrounding areas of the Fish Creek Range, Mountain Boy Range, and Diamond Mountains, Eureka and White Pine counties, Nevada, 2015.

Shevenell, L.A.

Selected General Chairman of the 2015 Annual meeting of the Geothermal Resources Council.

Vlcan, J.M.

3rd Place "Cartographic" category for cartographic work on Minden quadrangle, Nevada Geographic Information Society, 2015.

NBMG Contact Information

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

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 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. Walk-in customers, please note: **The cash register closes at 3:00 p.m.** (Tuesday–Friday).

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

Please contact the Information Office for information on aerial photographs; cuttings, core, and well records for oil, gas, and geothermal; and general geological information.

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

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