

# Annual Report of the Idaho Geological Survey

Fiscal Year 2015

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# INTRODUCTION

Idaho Geological Survey (IGS) is the lead state agency for the collection, interpretation, and dissemination of geologic and mineral resource data for Idaho. The agency has served the state since 1919 and prior to 1984 was named the Idaho Bureau of Mines and Geology. The IGS is a non-regulatory state agency that is administered as a Special Program of the University of Idaho. In addition to the main office on University of Idaho's Moscow campus, the Survey has branch offices in Pocatello at Idaho State University and in Boise at the University of Idaho Water Center and Boise State University. The agency is staffed by approximately 10 state-funded FTEs and 17 externally-funded temporary and part-time employees.

The Idaho Geological Survey's goal is to provide the state with the best geologic information possible through strong and competitive applied research, effective program accomplishments, and transparent access. IGS is committed to the advancement of the science and emphasizes the practical application of geology to benefit society. The Survey accomplishes their mission through applied geologic research, strong collaborations with academic and private sector partnerships, community service, and educational outreach activities.

Members of the Idaho Geological Survey staff acquire geologic information through field and laboratory investigations of sponsored and cooperative programs with other governmental agencies and the private sector. The Idaho Geological Survey's geologic mapping program is the primary applied research function of the agency. Geologic maps constitute a fundamental and objective scientific foundation on which land-use, water-use, and resource-use decisions are based. The Survey is a leader in the National Cooperative Geological Mapping Program and released a new geologic map of Idaho in FY2013. Over 200 geologic maps have been published from this program and are available for download from the agency website.

The IGS Digital Mapping Laboratory is central to compiling, producing, and delivering new digital geologic map products. Geographic information system (GIS) technology has changed geologic maps by providing software tools that permit geology and other geologic features to be electronically stored, displayed, queried, and analyzed in conjunction with a variety of other data types.

Other major programs at the Idaho Geological Survey include geologic hazards, hydrogeology, geothermal research, oil and gas assessments, mineral and aggregate research, mining record compilations, and earth science educational outreach. As Idaho grows, demand is increasing for geologic information related to population growth; energy-, mineral-, and water-resource development; geologic hazards; and earthquake monitoring.

Over time, the staff has developed wide-ranging interdisciplinary networks in support of its mission. For a one-year snapshot of a very productive synergy, please refer to the Partnerships section for the many organizations currently involved in Survey projects. This is a tribute to the staff's interest, initiative, and ingenuity in building these relationships. Details of the staff's professional engagement in the agency's agenda are in the *Publications and Professional Activities* section at the end of this report.

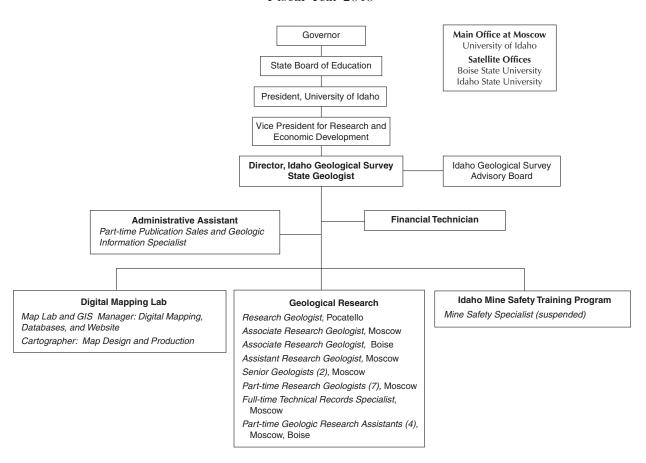


# ORGANIZATION AND PERSONNEL

Reed Lewis served as Interim Director until September, 2014, when Michael "Ed" Ratchford joined the IGS as State Geologist and Director after a national search. State appropriations for FY15 included funding for a new part-time Administrative Specialist and Glenda Bull was hired to fill that position. In addition, two existing Research Geologist positions (Boise and Pocatello staff) were returned to full state funding levels. Those positions had been reduced to academic year positions as a result of funding cuts in FY2010.

# **Organization Chart**

#### Idaho Geological Survey Fiscal Year 2015



# **Directory**

#### Main Office at Moscow

Morrill Hall, Third Floor University of Idaho 875 Perimeter Drive MS 3014 Moscow, ID 83844-3014 208-885-7991

### **Branch Office at Boise**

Idaho Water Center, Suite 201 322 E. Front Street Boise, ID 83702-7359 208-332-4420 Fax 208-332-4400

#### **Branch Office at Pocatello**

Physical Science, Room 201B
Idaho State University
MS 8071
Pocatello, ID 83209-8071
208-282-4254 Fax 208-282-4414

Administrative and Support Staff	
Michael E. Ratchford	Director, Moscow
Tracy Kanikkeberg	Financial Technician, Moscow
Research, Full-Time	
Dennis M. Feeney	Sonian Cooleaist Massayy
*	0 ,
Jane S. Freed.	O 1 .
Dean L. Garwood	0 /
Virginia S. Gillerman.	
Reed S. Lewis.	ę .
William M. Phillips.	0 ,
Loudon R. Stanford.	
Christopher A. Tate	
John A. Welhan	Full Research Geologist, Pocatello
Research and Support, Part-Time	
Glenda K. Bull	Administrative Specialist
Russell F. Burmester	1
Skye W. Cooley	9
Collette K. Gantenbein	e e e e e e e e e e e e e e e e e e e
Jesse A. Hinshaw.	
Susan J. Jones	
Alyson R. Kral	
Mark D. McFaddan	I
Daniel K. Moore	8
Kurt L. Othberg	0
Matthew A. Peterson	9
Duncan B. Rightler	,
Keegan L. Schmidt	*
Darin M. Schwartz	e e
David E. Stewart	1.1
Eric D Stewart	

# Idaho Geological Survey Advisory Board

Ex Officio: Reed Lewis

Interim Director,

Idaho Geological Survey

Ex Officio: Michael "Ed" Ratchford

Director and State Geologist, Idaho Geological Survey

Mickey Gunter

Chair, Department of Geological Sciences,

University of Idaho

David Hawk

Representing Office of the Governor

Jack Lyman Executive Director, Idaho Mining Association Rich Reed President,

Idaho Association of Professional Geologists

Tom Schultz

Director, Idaho Department of Lands

Mark Stephensen

Idaho Bureau of Homeland Security

Leif Tapanila

Chair, Department of Geological Sciences,

Idaho State University

David Wilkins

Chair, Department of Geosciences,

Boise State University

# Idaho Geological Mapping Advisory Committee

William Capaul – Chairman

District Geologist

Idaho Transportation Department

James R. Bartolino

District Ground Water Specialist

U.S. Geological Survey

Stephen Box

Research Geologist

U.S. Geological Survey Minerals Program

Paul Gessler

Professor of Remote Sensing & Geospatial Ecology College of Natural Resources, University of Idaho

Nancy F. Glenn, Ph.D., P.E.

Professor, Boise Center Aerospace Laboratory Department of Geosciences, Idaho State University

Janet Hohle

Project Manager - Clearwater Focus Program Idaho Governor's Office of Species Conservation Clint Hughes

Geologist

Nez Perce-Clearwater National Forests

Jim Myers

Senior Exploration Geologist

Hecla Silver Valley, Inc.

Paul F. Pedone

NRCS State Geologist (OR/ID)

Natural Resources Conservation Service - USDA

Kenneth C. Reid

State Archaeologist and Deputy SHPO

Idaho State Historic Preservation Office

Mark L. Stephensen Mitigation Section Chief

State Hazard Mitigation Officer

Idaho Bureau of Homeland Security

Sean Vincent

Hydrology Section Manager

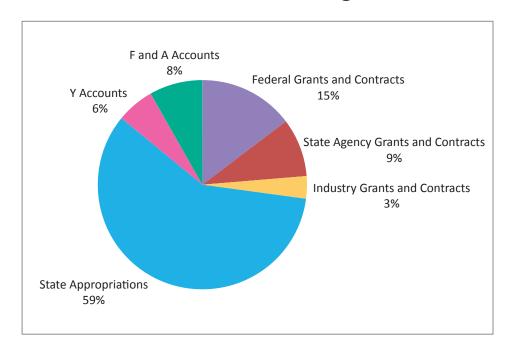
Idaho Department of Water Resources

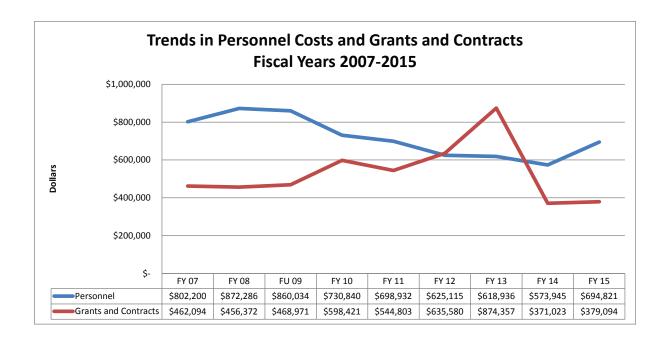
# FISCAL OVERVIEW

The Idaho Geological Survey's state appropriated budget for FY 2015 was \$821,100, an increase from \$706,900 in FY 2014, but still below FY 2007-FY 2009 funding levels. The mandated reductions in the state budget base have affected the agency's mission in research, public service, outreach, and education. Grants and contracts increased to \$379,093 in FY 2015 from \$371,023 in FY 2014.

Budget Fiscal Year 2015							
	Beginning	Income or				Ending	
Category	Balance	Appropriation	n	Actual	Expense	Balance	
Personnel		\$ 777,700.	00	\$ 694,820.95	\$ 694,820.95	\$ 0.00	
Operating Expense		\$ 22,000.	00	\$ 52,550.04	\$ 52,550.04	\$ 0.00	
Capital Outlay		\$ 21,400.	00	\$ 73,729.01	\$ 73,729.01	\$ 0.00	
Total		\$ 821,100.0	00	\$ 821,100.00	\$ 821,100.00	\$ 0.00	
U/I Personnel Funds							
Y Accounts	\$ 82,573.99	\$ 41,650.	32		\$ 42,931.03	\$ 81,293.28	
F and A Accounts	\$ 111,151.58	\$ 16,017.	70		\$ 18,000.00	\$ 115,048.83	
Grants and Contracts				\$ 379,093.72	\$ 379,093.72	(\$379,093.72)	
TOTAL	\$ 193,725.57	\$ 878,768.	)2	\$ 1,200,193.72	\$1,255,245.20	(\$182,751.61)	

## **Sources of Funding**





# **PARTNERSHIPS**

The Idaho Geological Survey's (IGS) statewide mission encourages interdisciplinary partnerships and collaboration with many other agencies, organizations, and universities. This broad cooperation ranges from grant funded research projects to the collegial sharing of expertise and information. On the national level, the IGS is also directly involved in the initiatives of the Association of American State Geologists. These alliances offer many opportunities to engage in projects that enhance the agency's applied research and outreach.

# Association of American State Geologists

The Idaho Geological Survey is an active participant in the Association of American State Geologists (AASG). The Director of the Idaho Geological Survey represented Idaho at the AASG Spring Liaison Meeting in Washington, D.C. and the Annual Meeting in Flagstaff, Arizona. The AASG is a strong advocate for the funding and reauthorization of the U.S. Geological Survey's National Cooperative Geologic Mapping Program (NCGMP) as well as research programs for data preservation, minerals, energy resources, and geologic hazards. AASG is an important partner with state geological surveys, the U.S. Geological Survey, the National Geologic Map Database and the annual Digital Mapping Techniques Workshops.

# **Funding Partners**

Department of Energy-INL (Cooling in Geothermal Idaho Transportation Department (Smiths Ferry Reservoirs and Heat Transfer modeling) Project) Idaho Bureau of Homeland Security and Boise Midas Gold Corporation (Stibnite Project) State University (Seismic Studies in Valley and Texas Christian University NSF-RCN Kootenai Counties) (Sedimentary Brines) Idaho Department of Lands (Abandoned Mine U.S. Geological Survey (Reservoir Lands Project) Characterization & Petroleum Assessments; Idaho EPSCoR (Aquifer and Stream Recharge, STATEMAP Cooperative Project; Data MILES/I-SEED Program Preservation) Idaho State University (Indigenous Nations Geosciences Education)

## **Collaborators**

American Geological Institute

Association of American State Geologists

Bannock County Groundwater Overlay Advisory

Committee

Bannock County Planning and Zoning

Department

Belt Association

Boise Section, Society of Mining Engineers

Boise State University

Brigham Young University-Idaho

Center for Advanced Energy Studies

City of Pocatello Water Department, Planning

Department, and Environmental Department

Energy and Geoscience Institute, Utah

ETH Zurich

Franklin and Marshall Department of Earth and

**Environment Sciences** 

Hecla Mining Company

Ice Age Floods Institute

Idaho Bureau of Homeland Security

Idaho Concrete and Aggregate

Producers Association

Idaho Department of Environmental Quality

Idaho Department of Lands

Idaho Department of Water Resources

Idaho Environmental Forum

Idaho Geospatial Council

Idaho Ground Water Monitoring Technical

Committee

Idaho Historical Society

Idaho Mining Association

Idaho Museum of Mining and Geology

Idaho National Laboratory

Idaho Public Television

Idaho Science Teachers Association

Idaho State Tax Commission

Idaho State University

Idaho Transportation Department

**IHS Energy** 

Inside Idaho

Intermountain Forest Tree Nutrition Cooperative

Midas Gold Corporation

Montana Bureau of Mines and Geology

National Association of Geoscience Teachers

National Science Foundation,

Geoscience Directorate

North Idaho College

Northwest Knowledge Network

Northwest Mining Association/AEMA

Oregon Department of Geology and

Mineral Industries

Oregon State University

Portneuf Watershed Partnership

Shoshone-Bannock Tribal Water Resources

Department

Schlumberger Petroleum Services

Spokane Community College

Tobacco Root Geological Society

U.S. Army Corps of Engineers

U.S. Bureau of Land Management

U.S. Forest Service

U.S. Geological Survey—Advanced National

Seismic System

U.S. Geological Survey—Data Preservation

U.S. Geological Survey—Idaho National Lab

U.S. Geological Survey—Minerals Program

U.S. Geological Survey—STATEMAP

U.S. Geological Survey—US Topo

U.S. Geological Survey—Water Resources

Division

U.S. Silver and Gold Inc.

University of Alaska-Fairbanks

University of Idaho

University of Montana

University of Utah

University of Wisconsin-Madison

Utah Geological Survey

Utah State University

Valley County Local Emergency Planning Group

Wallace District Mining Museum

Washington Division Geology and Earth

Resources

Washington State University

Western States Seismic Policy Council

Wyoming Geological Survey

Yellowstone National Park

Yellowstone Volcano Observatory

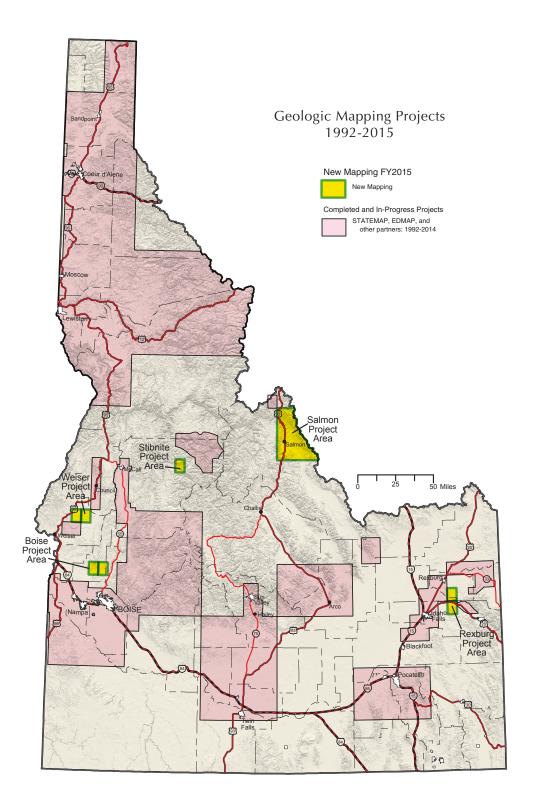
# RESEARCH

Applied geologic research is the primary function of the Idaho Geological Survey. Projects include those related to geologic mapping, hydrogeology, geologic hazards, mineral resources, geothermal energy, and oil and gas.

## Geological Mapping and Related Studies

Many IGS research projects consist of geologic mapping of 7.5′ and 30′x 60′ quadrangles. Before 1990, geologic mapping in Idaho was primarily conducted in localized rural areas to facilitate extraction of geologic resources. In the last two decades, the Survey has been mapping in areas selectively to address development impacts in urban settings, for recognition and assessment of new mineral, aggregate and oil and gas resources, and identification and monitoring of geologic hazards such as earthquake seismicity and landslides. The Idaho Geologic Mapping Advisory Committee (IGMAC) assists the Survey by assessing Idaho's mapping necessities and addressing long-term plans for geologic mapping. Idaho's geologic map products have been used to designate landslide hazards; to define mineralization potential; to delineate rock units that form boundaries of aquifers; to show geologic materials for engineering needs; to define groundwater resources; to aid in highway design and construction; and to define geologic resources on public lands, including federal lands, parks, recreation areas, and state endowment lands.

Funding of Idaho's geologic mapping program is shared by the STATEMAP component of the USGS National Cooperative Geologic Mapping Program and the Survey. Since 1993, Idaho has received over \$3.7 million in federal funds and matched an equal amount of "in kind" salaried employee's participation to complete geologic mapping in Idaho. In FY 2015, the Idaho Survey was again in the top seven geologic surveys in the nation among all STATEMAP proposals. New mapping was conducted in the Boise, Weiser, Rexburg, and Salmon project areas. During the year, Survey geologists mapped six 7.5' quadrangles (Heise, Poplar, Hog Creek Butte, Midvale, Montour, and Northeast Emmett), and mapped and compiled part of a 30' x 60' quadrangle (West Part of Salmon) under the STATEMAP Program. Mapping also continued in the Stibnite 7.5' quadrangle with funding provided by Midas Gold Corporation. Detailed geologic mapping results were provided to Midas with an emphasis toward delineation of district-wide structural and stratigraphic controls associated with gold, tungsten, and antimony mineralization.



# Hydrogeology

Hydrogeologic work by the Idaho Geological Survey (IGS) during FY 2015 focused on applied research in flow dynamics and geochemical/isotopic tracing and modeling, with elements of outreach, service, and education. Research activities covered a wide range of topics but focused on geochemical indicators of ground water flow paths and impacts of contaminant sources. Outreach and education activities involved ongoing communication with tribes, including efforts to create a university-level education-development program for STEM students, collaboration with technical aspects of IDEQ's ground water monitoring effort, interaction with planners and private well owners around the state, and active participation in graduate student research and mentoring at ISU and UI.

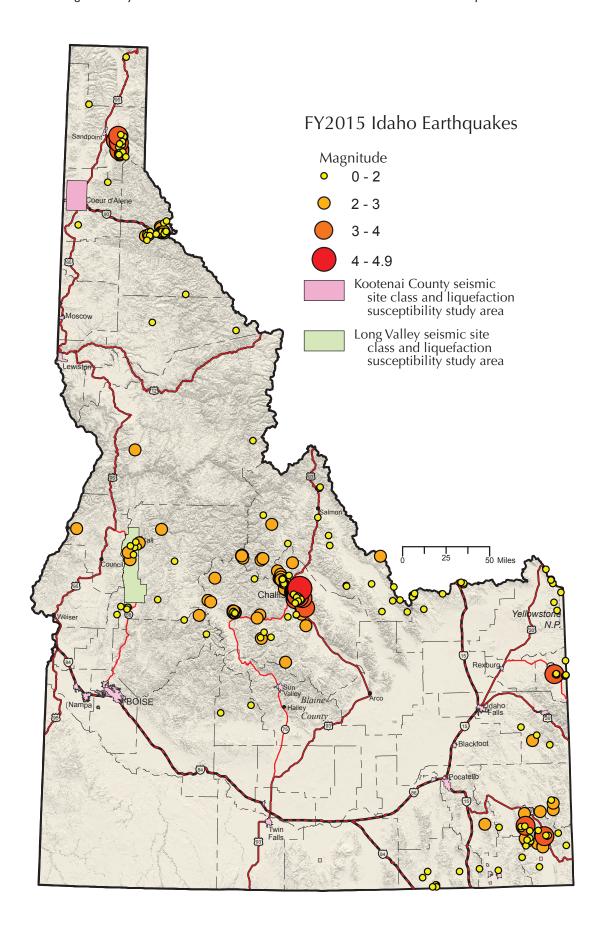
Research activity in FY 2015 included ground water studies in the lower Portneuf River Valley (LPRV), as part of the Idaho EPSCoR MILES project (Managing Idaho's Landscapes for Ecosystem Services). This work represents an outgrowth of the IGS's MILES-funded research last year, which collected data on carbon-14 and tritium in ground water of the LPRV aquifer's principal recharge corridor, an area that has been a focus of hydrogeologic research by IGS in the past. That work identified a previously unrecognized source of recharge to the LPRV aquifer from thermal ground water that originates as upflow along the valley's Basin and Range faults. Work this year focused on developing a new carbon-14 correction procedure for a mixed-source water to age-date the non-thermal component of this flow system.

The IGS also collaborated with ISU on a comprehensive ground water sampling program in the LPRV to quantify spatial and temporal trends of the impacts of septic effluent on the LPRV's municipal and rural-residential drinking water, including the occurrence and prevalence of pharmaceutical and personal-care products in septic impacted ground water, whose widespread presence in ground water and surface waters across the continent has created a new class of contaminants of emerging concern in the hydrosciences. In addition, data collected by IGS-supervised graduate students at ISU over the past 20 years is being compiled as part of a statewide MILES database to enhance and promote current and future basic research in ecosystem services. Such information will be essential to geochemical tracing of ground water flow systematics, both locally and across the state.

## Geologic Hazards

Idaho is prone to earthquakes, volcanic eruptions, landslides, and flooding. The Survey works to support mitigation of these hazards in several ways:

- Public awareness and status of on-going hazard events are addressed through the Idaho Geological Survey website and direct contact with the public and news media by personal interviews, e-mail, telephone, and occasional public lectures or field trips. A Survey staff member has been identified by the University of Idaho as a designated point of contact for natural hazard issues. Requests to the University for hazard information are directed to the Survey in this way. For example, in April 2015, magnitude 3.9 and 3.7 earthquakes in the Sandpoint area were widely felt and generated considerable public interest. Interviews of Survey staff concerning the earthquakes were presented on regional media outlets.
- Survey staff are informed about Idaho earthquakes through seismic monitoring performed by the U.S. Geological Survey (USGS), Montana Bureau of Mines and Geology, the University of Utah, the Idaho National Laboratory, and the Pacific Northwest Seismic Network. When an earthquake occurs, location and magnitude data are automatically posted by the USGS to the internet. A survey staff member receives automated emails and cell phone texts for Idaho-area earthquakes exceeding magnitude 3, and also checks the USGS website for regional activity on a daily basis.
- The Survey is a member of the Western States Seismic Policy Council (WSSPC). The Council's mission is to develop seismic policies and share information to promote programs that reduce earthquake-related losses. In FY 2015, a Survey staff member served as the chair of the Basin and Range Province Committee of WSSPC. This committee focuses on earthquake hazards of Idaho, Wyoming, Montana, Utah, Nevada, Arizona, and New Mexico.
- The Survey collaborates with monitoring of volcanic activity at Yellowstone as a member of the Yellowstone Volcano Observatory Consortium (YVO). YVO members consist of USGS, the University of Utah, Yellowstone National Park, and the geological surveys of Idaho, Wyoming, and Montana. A Survey staff member participates in bimonthly YVO teleconference briefings. In the event of volcanic ash



eruptions from Cascade volcanoes, the Survey will collaborate with the U.S. Geological Survey's Cascade Volcano Observatory.

The Survey provides expert opinion and advice to state and federal agencies involved with Idaho hazard mitigation. In FY 2015, the Survey performed the following hazard mitigation activities at the request of the Idaho Bureau of Homeland Security (IBHS):

- Participated in meetings of the Idaho Seismic Hazard Advisory Committee. This committee provides expert advice on issues related to earthquake hazards and risk-reduction strategies.
- Participated in review and revision of the Idaho State Hazard Mitigation Plan. Updating the State Hazard Mitigation Plan qualifies Idaho for all available federal assistance in the event of disasters. It provides a framework to save lives and reduce vulnerability to natural and human-made hazards. The Survey focuses on the earthquake, volcanic eruption, landslide, and flooding (debris flow) portions of the plan.
- Partnered with the IBHS to produce an annual report for WSSPC on Idaho earthquake hazard mitigation activities. This report also documents earthquake activity occurring within Idaho.
- In collaboration with Boise State University, conducted mapping of seismic site classes and liquefaction susceptibility in the Long Valley area of Valley County, and in portions of Kootenai County.

Geological mapping conducted through the STATEMAP program provides baseline information on the location, magnitude, and frequency of hazards. This information is incorporated into planning documents and also serves as the basis for more detailed studies, such as mapping of landslides. In FY2015, the Survey began updating and correcting the landslide inventory database for Idaho using IGS geological mapping produced since 1992.

## Mineral Resources and Mining

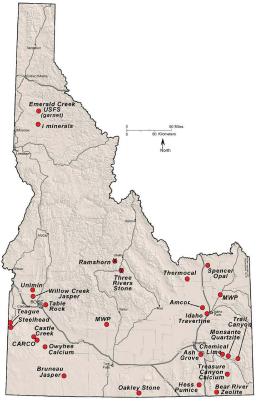
## **Active Mining and Exploration**

The Idaho Geological Survey (IGS) continued its long-time role of providing factual information and documentation of the mineral industry of Idaho. The IGS collaborates with the U.S. Geological Survey (USGS) in production of the Idaho chapter of the Minerals Yearbook, a global compilation of developments in

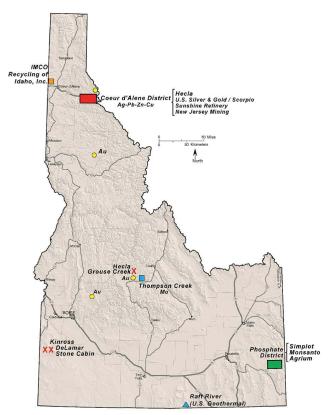
and statistics on mining and minerals information. This year, a preview of the annual summary of Idaho's active mineral and energy industries was presented to the North Idaho Legislative Tour in November. The full summary of calendar year 2014 mineral activity in Idaho was presented at the American Exploration and Mining Association (formerly the Northwest Mining Association) annual convention in December. Overall mining and exploration were affected by declining commodity prices. The preliminary USGS estimate of Idaho's non-fuel mineral production for calendar year 2014 is \$ 1.2 billion, which will include molybdenum production at the giant Thompson Creek mine in Custer County. However, at year's end, the mine was converted to care and maintenance status. In northern Idaho, Hecla Mining is sinking a new internal shaft at their Lucky Friday mine, one of two underground mines in production in the Silver Valley. Three large open pit mines and three large manufacturing plants were active in the Phosphate District of southeast Idaho. Over 5,100 Idahoans were employed in the mining and chemical processing sectors in July 2014. Oil and gas and geothermal exploration and development continued in southern Idaho, as discussed in subsequent sections.

#### Minerals-related Research

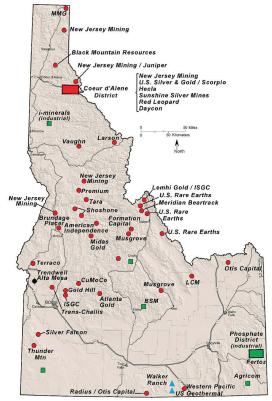
The principal minerals-related research project during FY 2015 was at the Stibnite Mine District in Valley County. It was funded by and done in collaboration with Midas Gold Corporation. The project was extended to Phase II for two years with \$ 70,000 of additional funds provided by Midas, who has been very satisfied with the Phase I work. The effort involved two subprojects: geologic mapping at 1:24,000 scale of the Stibnite 7.5' quadrangle and a more laboratorybased study of the alteration, geochronology, and mineral paragenesis of the goldantimony-tungsten deposits. During FY 2015, a draft geologic map and a report summarizing results of the geochronology and petrographic work to date were delivered to Midas for review. Results of the project were also presented at the National Geological Society of America meeting and the 2015 Geological Society of Nevada Symposium. As noted in the IGS report, ages on alteration minerals associated with vein emplacement indicates Eocene mineralization within Cretaceous granitoid host rocks and stratigraphic units that include Paleozoic shelf carbonates and clastics. Complex hydrothermal alteration assemblages include strong potassic alteration overprinting earlier sericite alteration, and quartz-carbonatesulfide veins that cross-cut earlier skarn and metamorphic minerals. New research during the year included using the electron microprobe to map pyrite growth and the zoning of gold and arsenic within the pyrite grains. Other minerals-related activity included improvements to the minerals databases and web applications, as described in a separate section.



INDUSTRIALS



ACTIVE MINES AND PLANTS



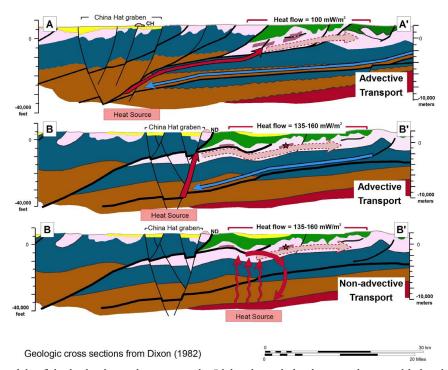
**EXPLORATION** 

Maps showing mining and exploration activity in Idaho for calendar year 2014.

# Energy

#### Geothermal

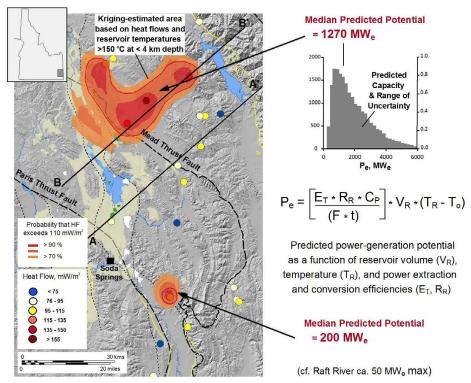
The Idaho Geological Survey (IGS) continued its work in geothermal energy research on two fronts during 2015: (1) a synthesis of data compiled during the DOE-funded National Geothermal Data System (NGDS) project (2010-2014) in which IGS identified and characterized a new high-temperature geothermal resource in the Idaho thrust belt (ITB); and (2) contributions to a geohydrologic conceptual model of the deep geothermal resource beneath the eastern Snake River Plain (ESRP), as part of a collaboration with the Idaho National Laboratory's INL-FORGE initiative to develop electric power from an engineered geothermal system (EGS) in the hot rhyolitic basement of the ESRP.



Conceptual models of the hydrothermal system in the Idaho thrust belt, showing the most likely advective heat transport modes (thrust fault and normal fault-controlled) beneath two areas (orientations of cross sections A-A' and B-B' are shown in Figure 2). The depth to the top of the magmatic heat source, as constrained by thermobarometry, is 12-14 km, but its position relative to the China Hat graben is not known. In addition to advective heat transport, mechanisms beneath the primary heat flow anomaly (cross-section B) may also involve vertical conductive and/or thermohaline heat transport.

#### Idaho Thrust Belt

Work was completed on a comprehensive technical report of the ITB's high-temperature geothermal system, which focused on integration and synthesis of all data compiled during the NGDS project and the development of internally consistent conceptual models of the hydrothermal system based on what is known of its volcanic heat source, subsurface structure, reservoir architecture, and geohydrologic characteristics. Different heat transport pathways and mechanisms likely characterize different parts of this system, depending on their structural context and the possibility that thermohaline circulation has developed in dense brines created by dissolution of Jurassic salt beds. The economic potential of the resource, both from a geothermal and brine-mineral perspective, was also evaluated. The report, to be published under the IGS's Technical Report Series, is currently in peer review and will be made available as a stand-alone report, as well as a hyperlinked document to an on-line compendium of appendices and data files designed to facilitate the dissemination and utilization of these findings for future research and economic assessment of this system.



A summary of electric power generation potential predicted from a Monte Carlo analysis of the thermal resource's volume and power-recovery parameters within the commercially economic window of  $> 150^{\circ}$  C and < 4 km depth (Allis et al., 2013, 2015). The resource is defined on the basis of historic oil exploration well drilling, including the most recent, highest-temperature well drilled in 2009. The late-Quaternary basalt lava flows and rhyolite domes of the Blackfoot volcanic field are shown in yellow and green, respectively. The area of the primary reservoir (solid red line) is defined by having a greater than 80% probability of exceeding 110 W/m2.

As part of the analysis, an estimate was made of the electric power-generating potential of the geothermal resource, based on available subsurface data. The best-characterized portion of the system has a median power-generation potential of over a GigaWatt of electricity over a 30-year power plant life cycle, whether via conventional flashed-steam or binary-cycle power-conversion technology. Results of the power analysis will be presented at the 2016 Stanford Geothermal Workshop and published in those Proceedings, as well as submitted to a peer-reviewed journal in order to promote wider awareness of the area's immense power potential and stimulate interest in its development.

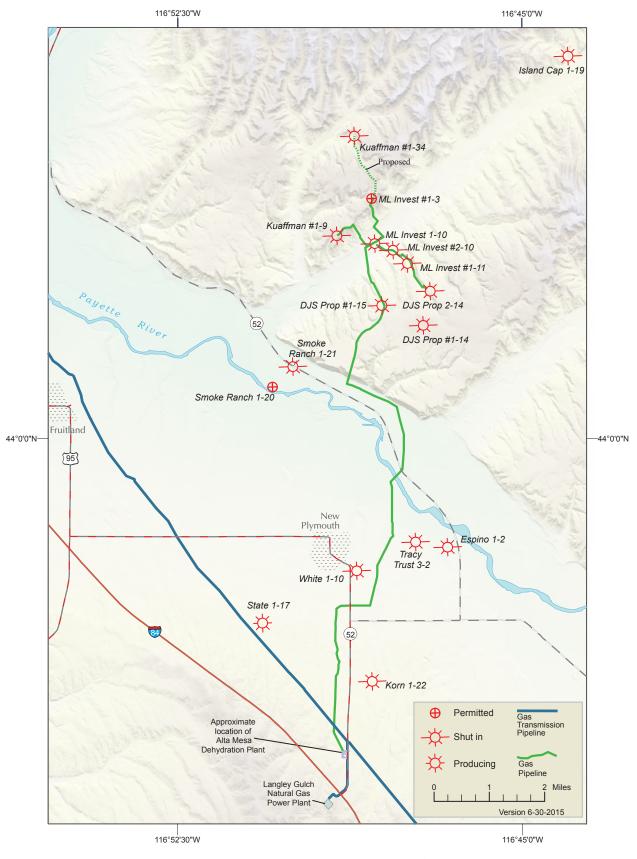
#### **INL-FORGE**

The Survey was funded during 2015 by the INL's LDRD (lab-directed R&D) contract through the Center for Advanced Energy Studies (CAES) as part of an INL-CAES project to refine the geohydrologic conceptual model of the hot rhyolitic basement underlying the ESRP. The goal of the work was to investigate the mode(s) of heat transfer between these basement rocks and the overlying ESRP aquifer and constrain our conceptual understanding of how these rocks could be developed as an EGS power resource.

Results of the Survey's work were presented at the 2015 SRP-FORGE technical workshop and the Geothermal Resources Council (GRC) annual meeting and published in the 2015 GRC Transactions. Project results were submitted as an LDRD Final Report, which emphasized that heat transfer from the ESRP's basement occurs via both conductive heat transport and advective transport of thermal fluids through the base of the aquifer. The existence of significant advective heat transfer within the rhyolites corroborates previous observations of open fractures associated with thermal water flow in a deep core hole beneath the INL. The fact that the EGS resource may have significant localized porosity/permeability has implications for how the EGS resource can be hydraulically stimulated to create engineered flow paths between injection and production wells.

#### Oil and Gas

For the first time in history, Idaho is now a hydrocarbon producing state owing to the recent drilling and production of major gas wells in the Payette County region. These efforts have been focused on the western Snake River Plain and areas to the north toward Midvale, Idaho and to the west toward Vale, Oregon. Drilling from 2010 to the present has resulted in over 14 new exploration wells and production of Idaho's first commercial gas from a well near New Plymouth (State 1-17). Approximately \$130 million dollars in expenditures has been reported by Alta Mesa Energy for pipeline and gas plant infrastructure for the ex-



Southwestern Idaho Natural Gas Play (well status as of June, 2015)

traction and separation of natural gas and liquid condensates, for 3-D seismic surveys, and mineral lease acquisition. Collaboration and research agreements between public and private entities (Idaho Department of Lands and Alta Mesa Resources) have permitted the Survey to acquire subsurface data and begin the process of petroleum system assessment for the region. The Idaho Geological Survey (IGS) was awarded a \$75,000 grant from the US Geological Survey to conduct reservoir characterization and petroleum assessment of this newly discovered resource in the southwestern part of the state. Furthermore, over \$12 million in petroleum modeling software has been donated to the Survey and the University of Idaho from industry partnerships. A digital map covering this area, *Southwestern Idaho Natural Gas Play*, is available for download on the Survey's website.

Drill core and well cuttings analysis, 3-D subsurface mapping, well log correlations, microfossil designations, source rock evaluation, and petroleum system modeling are included within the scope of research for the petroleum resources in southwestern Idaho. In conjunction with this scope of work, new geologic surface mapping projects are underway in the Weiser-Payette area with the objective of tying the surface geological units to reservoir and source rocks in the producing basin at depth.

The IGS has also identified the areas of southcentral and southeastern Idaho as perspective for oil and gas exploration and have near-term and long-term plans to conduct petroleum assessments in these regions of the state. As new drilling and completion technologies have advanced in recent years, these areas should be reevaluated for oil and gas resources, particularly from unconventional reservoirs.

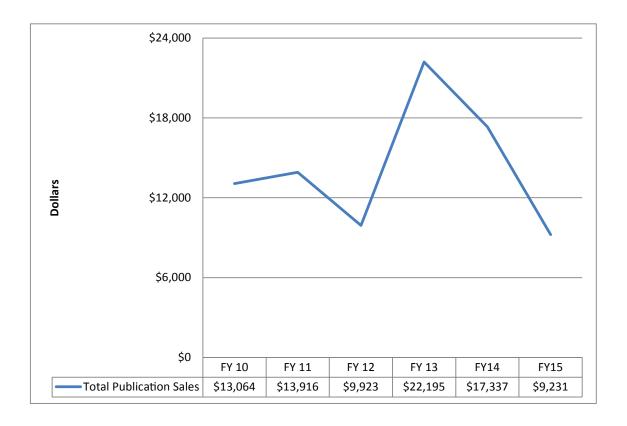
The IGS maintains files on over two hundred historic oil and gas exploration wells in the state. These files include well reports and downhole logs provided by companies to the Idaho Oil and Gas Commission from 1903-1988. The files were transferred to the IGS in 2009 from the Idaho Department of Lands and consist of drilling correspondences, permits and applications, industry reports, maps, and geophysical logs. Many are unique historic documents and in fragile condition. Recent geothermal and oil and gas exploration in Idaho has greatly increased the number of requests for these data. The Survey has now scanned all of the reports and logs and made them available for download from the IGS website. As other historic and contemporary reports become available, IGS will continue to enhance and expand the oil and gas archive geodatabase.

# **OUTREACH**

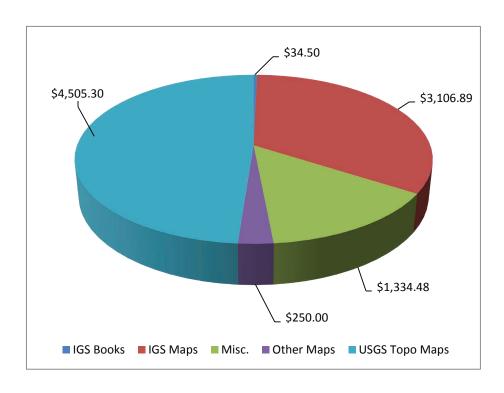
The Survey disseminates geologic data on Idaho primarily through IGS publications, the agency website, in-house collections, and efforts by the staff to educate the public in the earth sciences.

## **Publications**

Total publication sales were down from FY 2014, largely the result of lower demand for the *Geologic Map of Idaho* that was released in October, 2012. In FY 2015, our topographic maps outsold other types of publications, accounting for 49 percent of total sales. Since its release, the *Geologic Map of Idaho* has continued to be the top seller of IGS-produced publications. Because of staffing enhancements, starting in the fall of 2014 the Publication Sales Office hours increased to thirty hours per week, up from sixteen hours. With the purchase last year of a large-format printer, prices on most Survey print-on-demand products were reduced by more than thirty percent.



## **Publication Sales in Dollars**

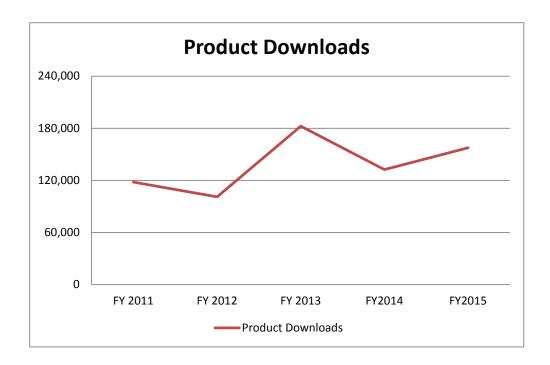


# Overview: All Sales Categories FY 11-15



# Website www.idahogeology.org

The Idaho Geological Survey (IGS) website provides customers easy access to agency publications and data. Nearly all of Survey publications (over 970) are available free for download in PDF format. Finding information on the website has been simplified through search engines, including web map applications. This year, a whole-rock geochemistry web map application was added to the IGS web map. Searching for mine or mineral prospect information became easier with recent improvements to the search engine. Mine documents were also added to the download capabilities of the service. In FY 2015, 439,000 visits were logged on the website and users downloaded 157,000 products. Twenty-seven new Survey publications were posted on the website this year.



# The Digital Mapping and GIS Laboratory

The Survey's digital mapping and GIS laboratory provides services that include digital cartography, spatial data management, database management and design, network system administration, graphic design, desk-top publishing, and website support. The lab continues to compile geology from around the state in geologic map databases, in addition to producing geologic map products. Nine 7.5′ geologic maps were digitized (as stand-alone or compilation efforts) and fifteen geologic maps were published this year. All are available as printed products or can be viewed free on the web.

## **Databases and Archives**

Databases continue to be an important way of managing and distributing information to Idaho Geological Survey (IGS) customers via our website. Database updates of active faults, mines and prospects, oil and gas wells, and survey publications are an ongoing effort.

- New gas wells in the western Snake River Plain, Payette County, were added to an updated design of the IGS Oil and Gas database.
- The Mines and Prospects database was revisited and improvements made to data accuracy and content. These data are easily accessed through the IGS Mines and Prospects web map application which now includes expanded search capabilities. Over 3,000 mine maps and other support documents related to mine properties are now available via the mines web map application.
- A database of aggregate material sources for Idaho was developed this year with data from the six Idaho Transportation Department (ITD) regional offices. It's expected that eventually other stakeholders will contribute to this effort. This database has a GIS component and will be added to the IGS Web Map application for easy access.
- The Survey continued this year to release GIS geologic map compilation data in NCGMP09, a new national voluntary standard for geologic map data in ESRI geodatabase format. The Arco and Twin Falls 30 x 60 minute geologic map data sets are now available for download in this standard.

# Mine Safety Training

The U.S. Department of Labor's Mine Safety and Health Administration (MSHA) distributes federal grants to 49 states and the Navajo Nation. Grant funds are used to support health and safety training courses and programs designed to reduce mining accidents, injuries, and illnesses.

The Idaho Geological Survey suspended MSHA training in FY 2012 due to retirement of qualified personnel and in May, 2015 transferred the program to the Workforce and Training division of North Idaho College in Coeur d' Alene. MSHA training is also available in neighboring states and interested individuals are directed to those facilities as well.

## Earth Science Education

Every October the American Geosciences Institute sponsors Earth Science Education Week in cooperation with its member societies on behalf of the geoscience community. The Idaho Geological Survey (IGS) set up a booth in October at the annual Idaho Science Teachers Association meeting in Boise, Idaho and distributed Earth Science Education Week teaching packets to teachers. The Survey also participated in the "Geologic Map Day" event during Earth Science week by highlighting the recently published map of the central and eastern parts of the Big Creek drainage on the IGS website, through a University of Idaho press release, and via Twitter.

# PUBLICATIONS AND ACTIVITIES

## **Publications**

- Bridging Basalts and Rhyolites in the Yellowstone-Snake River Plain Volcanic Province; the Elusive Intermediate Step, by Dawid Szymanowski, Ben S. Ellis, Olivier Bachmann, Marcel Guillong, and William M. Phillips: Earth and Planetary Science Letters, v. 415, p. 80-89, 2015.
- Database of the Mines and Prospects of Idaho (version 1.2015.1), by Victoria E. Mitchell, Ruth E. Vance, Earl H. Bennett, B. Benjamin E. Studer, Christopher A. Tate, and Loudon R. Stanford: Idaho Geological Survey Digital Database DD-1 (version 1.2015.1), 2015.
- David Blackwell's Forty Years in the Idaho Desert, The Foundation for 21st Century Geothermal Research, by Travis McLing, Mike McCurry, Cody Cannon, Ghanashyam Neupane, Thomas Wood, Robert Podgorney, John Welhan, Greg Mines, Earl Mattson, Rachel Wood, Carl Palmer, and Robert Smith: Geothermal Resources Council Transactions, v. 38, p. 143-153, 2014.
- Determination of Geothermal Anomalies Through Multivariate Regression of Background Variables at Yellowstone National Park Using Landsat 5 TM Thermal Band Data, by Sita Karki, Shannon Kobs Nawotniak, H. Carrie Bottenberg, Michael McCurry, and John Welhan: Geothermal Resources Council Transactions, v. 38, p. 503-509, 2014.
- Geologic Map of the Bellevue Quadrangle, Blaine County, Idaho, by Reed S. Lewis, Kurt L. Othberg, and Keegan L. Schmidt: Idaho Geological Survey Digital Web Map 163, scale 1:24,000, 2014.
- Geologic Map of the Drummond Quadrangle, Fremont and Teton Counties, Idaho, by Dennis M. Feeney, Dean L. Garwood, and William M. Phillips: Idaho Geological Survey Digital Web Map 167, scale 1:24,000, 2014.
- Geologic Map of the East Half of the Bonners Ferry 30 x 60 Minute Quadrangle, Idaho and Montana, mapped and compiled by Roy M. Breckenridge, Russell F. Burmester, Reed S. Lewis, and Mark D. McFaddan: Idaho Geological Survey Digital Web Map 173, scale 1:75,000, 2014.

- Geologic Map of the Fairfield 30 x 60 Minute Quadrangle, Idaho, mapped and compiled by Dean L. Garwood, John D. Kauffman, Kurt L. Othberg, and Reed S. Lewis: Idaho Geological Survey Digital Web Map 171, scale 1:100,000, 2014.
- Geologic Map of the Idaho Part of the Grangeville 30 x 60 Minute Quadrangle and Adjoining Areas of Oregon and Washington, by John D. Kauffman, Keegan L. Schmidt, Reed S. Lewis, David E. Stewart, Kurt L. Othberg, and Dean L. Garwood: Idaho Geological Survey Geologic Map 50, scale 1:100,000, 2014.
- Geologic Map of the Lamont Quadrangle, Fremont and Teton Counties, Idaho, by William M. Phillips, Dean L. Garwood, and Dennis M. Feeney: Idaho Geological Survey Digital Web Map 166, scale 1:24,000, 2014.
- Geologic Map of the Mann Creek SE Quadrangle, Washington County, Idaho, by Dennis M. Feeney, Dean L. Garwood, William M. Phillips, and Skye W. Cooley: Idaho Geological Survey Digital Web Map 169, scale 1:24,000, 2014.
- Geologic Map of the Nutmeg Flat Quadrangle, Washington County, Idaho, by Dean L. Garwood, Dennis M. Feeney, William M. Phillips, and Skye W. Cooley: Idaho Geological Survey Digital Web Map 168, scale 1:24,000, 2014.
- Geologic Map of the Ririe Quadrangle, Madison, Jefferson, and Bonneville Counties, Idaho, by William M. Phillips, Glenn Embree, John A. Welhan, and Dean L. Garwood: Idaho Geological Survey Digital Web Map 165, scale 1:24,000, 2014.
- Geologic Map of the Sal Mountain Quadrangle, Lemhi County, Idaho, by Reed S. Lewis, Kurt L. Othberg, Loudon R. Stanford, Russell F. Burmester, Jeffrey D. Lonn, David E. Stewart, and Eric D. Stewart: Idaho Geological Survey Digital Web Map 170, scale 1:24,000, 2014.
- Geologic Map of the Seamans Creek Quadrangle, Blaine County, Idaho, by Keegan L. Schmidt, Reed S. Lewis, Kurt L. Othberg, Jessica L. Meyers, and David E. Stewart: Idaho Geological Survey Digital Web Map 164, scale 1:24,000, 2014.
- High Heat Flow in the Idaho Thrust Belt: A Hot Sedimentary Geothermal Prospect, by John A. Welhan and Mark Gwynn: Geothermal Resources Council Transactions, v. 38, p. 1055-1066, 2014.

- *Idaho Geology Postcard*, compiled by staff: Idaho Geological Survey Miscellaneous Maps and Poster 6, 2014.
- *Idaho Mining and Exploration,* by Virginia S. Gillerman and Earl H. Bennett: Idaho Geological Survey Staff Report 15-1, 24 p., 2015.
- The Mineral Industry of Idaho, 2009, by Virginia S. Gillerman and USGS: USGS 2009 Minerals Yearbook Idaho [Advance Release], p. 14.0-14.6, 2014.
- The Mineral Industry of Idaho, 2010-2011, by Virginia S. Gillerman, Earl H. Bennett and USGS: USGS 2010-2011 Minerals Yearbook Idaho [Advance Release], p. 14.0-14.11, 2015.
- Reservoir characterization and resource assessment of the Brown Dense Mudstone (Lower Smackover Formation), Gulf Coastal Plain, South Arkansas, by Peng Li, Michael E. Ratchford, Marc C. Charette, Bradley J. Walls, and, Richard P. Philip: Arkansas Geological Survey, Information Circular, Plates 1 and 2 (in press).
- Southwestern Idaho Natural Gas Play, by Michael E. Ratchford and Loudon R. Stanford: Idaho Geological Survey Digital Web Map 172, scale 1:30,000, 2014.

## **Abstracts**

- Geochronology of Intrusive Rocks and Hydrothermal Alteration at the Structurally Controlled Stibnite Au-Sb-W Deposit, Idaho, by Virginia S. Gillerman, Vincent H. Isakson, Mark D. Schmitz, Jeff A. Benowitz, and Paul W. Layer: Geological Society of America Abstracts with Programs, v. 46, no. 6, p. 165, 2014.
- Mapping Yellowstone Hot Spot Track Rhyolites in the Eastern Snake River Plain: A Case Study from the Heise Volcanic Field, Ammon 7.5-minute Quadrangle, Idaho, by William M. Phillips, Loudon R. Stanford, and Dawid Szymanowski, Geological Society of America Abstracts with Programs, v. 46, no. 6, p. 504, 2014.
- Multi-Disciplinary Application of Geology and Engineering to Understanding and Mapping Aggregate Quality in Idaho, by Virginia S. Gillerman, Kerrie N. Weppner, and William M. Phillips, Geological Society of America Abstracts with Programs, v. 46, no. 6, p. 720, 2014.

- The Precambrian Crystalline Basement of Northwest Laurentia: Constraining the Formation and Evolution of North America, by Jeff Vervoort, Christopher M. Fisher, Reed S. Lewis, Da Wang, Andrew C. Jansen, and Richard M. Gaschnig: Geological Society of America Abstracts with Programs, v. 46, no. 6, p. 827, 2014.
- Windermere and Associated Strata in the Stibnite-Edwardsburg Area, Central Idaho, by Reed S. Lewis, David E. Stewart, Darin M. Schwartz, Eric D. Stewart, Vincent H. Isakson, and Jeffrey D. Vervoort: Geological Society of America Abstracts with Programs, v. 46, no. 6, p. 829, 2014.

## Reports

- 2014 Idaho Earthquake Hazard Mitigation Program Report, by William M. Phillips, William R. Hammond, and Mark Stephensen: Joint Report by Idaho Geological Survey, Center for Disease Control/National Institute of Occupational Safety and Health, Spokane Mining Research Division, and the Idaho Bureau of Homeland Security for Western States Seismic Council e-Newsletter, November, 2014.
- The Blackfoot Volcanic Field, Southeast Idaho: A Hidden High-Temperature Geothermal Resource in the Idaho Thrust Belt, Data Compendium, by John A. Welhan: Idaho Geological Survey report for "SedHeat" Proposal Development Workshop, August, 2014.
- Final Report for Task Order No. 002-FY-2013, NEHRP Site Class and Liquefaction Susceptibility Maps for the Long Valley Area, Valley County, Idaho, by William M. Phillips and Lee Liberty: Idaho Geological Survey report to the Idaho Bureau of Homeland Security, December, 2014.
- Index of Geochemical Data, Mine Maps, and Mines and Prospects Database uploaded to ScienceBase, by Christopher A. Tate, Dennis M. Feeney, Reed S. Lewis, and Loudon R. Stanford: Idaho Geological Survey deliverable to U.S. Geological Survey National Geologic and Geophysical Data Preservation Program, March, 2015.
- Geologic Map of the Heise Quadrangle, Bonneville, Jefferson, and Madison Counties, Idaho, by W.M. Phillips, D.K. Moore, D.M. Feeney, and G.F. Embree: Idaho Geological Survey report to the U.S. Geological Survey for STATEMAP, scale 1:24,000, May, 2015.

- Geologic Map of the Hog Creek Butte Quadrangle, Washington and Adams Counties, Idaho, by Dennis M. Feeney, Reed S. Lewis, William M. Phillips, Dean L. Garwood, and Skye W. Cooley: Idaho Geological Survey report to the U.S. Geological Survey for STATEMAP, scale 1:24,000, May, 2015.
- Geologic Map of the Northeast Emmett Quadrangle, Gem County, Idaho, by
  Dennis M. Feeney, Spencer H. Wood, Reed S. Lewis, William M.
  Phillips, and Skye W. Cooley: Idaho Geological Survey report to the U.S.
  Geological Survey for STATEMAP, scale 1:24,000, May, 2015.
- Geologic Map of the Midvale Quadrangle, Washington County, Idaho, by Dennis M. Feeney and William M. Phillips: Idaho Geological Survey report to the U.S. Geological Survey for STATEMAP, scale 1:24,000, May, 2015.
- Geologic Map of the Montour Quadrangle, Gem and Boise Counties, Idaho, by Reed S. Lewis, William M. Phillips, Dennis M. Feeney, Keegan L. Schmidt, and Spencer H. Wood: Idaho Geological Survey report to the U.S. Geological Survey for STATEMAP, scale 1:24,000, May, 2015.
- Geologic Map of the Poplar Quadrangle, Bonneville County, Idaho, by William M. Phillips, Dan K. Moore, and Dennis M. Feeney: Idaho Geological Survey report to the U.S. Geological Survey for STATEMAP, scale 1:24,000, May, 2015
- Geologic Map of the Stibnite Quadrangle, Valley County, Idaho, by David E. Stewart, Eric D. Stewart, Reed S. Lewis, and Kerrie N. Weppner: Idaho Geological Survey Draft Geologic Map and Cross Sections to Midas Gold Corporation, scale 1:24,000, December, 2014.
- Geologic Map of the Western Part of the Salmon 30 x 60 Minute Quadrangle, Idaho and Montana, by Russell F. Burmester, Reed S. Lewis, Loudon R. Stanford, Kurt L. Othberg, Jeffrey D. Lonn, and Mark D. McFaddan: Idaho Geological Survey report to the U.S. Geological Survey for STATEMAP, scale 1:75,000, May, 2015.
- Idaho's Contribution to the National Geothermal Data System Atlas, by John A. Welhan: Idaho Geological Survey for Arizona Geological Survey, November, 2014.
- Pilot Investigation of Hydrothermal Alteration, Mineralization, and Geochronology within Stibnite District, by Virginia S. Gillerman: Idaho Geological Survey report to Midas Gold Corporation, April, 2015.

## **Presentations**

- Aggregate Projects of the Idaho Geological Survey, by Virginia S. Gillerman: Idaho Associated General Contractors 80th Convention, Boise, December, 2014.
- Faults of Concern: Idaho, by William M. Phillips: USGS Evaluation of Hazardous Faults in the Intermountain West Region—2015 Update, Salt Lake City, Utah, January, 2015.
- Geochronology of Intrusive Rocks and Hydrothermal Alteration at the Structurally Controlled Stibnite Au-Sb-W Deposit, Idaho, by Virginia S. Gillerman, Vincent H. Isakson, Mark D. Schmitz, Jeff A. Benowitz, and Paul W. Layer: Geological Society of America Annual Meeting, Vancouver, B.C., October, 2014.
- Geologic and Hydrologic Processes in Volcanic Eruptions, by John A. Welhan (with Mike McCurry and Shannon Kobs), Indian Youth Conference activity day at Idaho State University, Pocatello, March, 2015.
- Geologic Aspects of Oil and Gas in Idaho, by Virginia S. Gillerman: Idaho State Tax Commission Winter School, Boise, January, 2015.
- The Geology of Latah County, by Reed S. Lewis: Latah County Summer Reading Program, Moscow, ID, June, 2015.
- Geology of the Palouse, by Dennis Feeney: Palouse Prairie Expeditionary School, Moscow, February, 2015.
- Geologic Overview of the Southwestern Idaho Basin and Natural Gas Development, by M. "Ed" Ratchford: Bus Tour for the Idaho Legislature and Oil & Gas Conservation Commission, sponsored by the Idaho Petroleum Council, Boise, July, 2015.
- The Great Falls Tectonic Zone: a Perspective from Idaho, by Reed S. Lewis: Washington State University and University of Idaho seminar, Pullman, Washington, January, 2015.
- High Heat Flow in the Idaho Thrust Belt: A Hot Sedimentary Geothermal Prospect, by John A. Welhan: Geothermal Resources Annual Meeting, Portland, Oregon, September, 2014.
- Hydrothermal Alteration, Mineralization and Geochronology of the Stibnite District, Idaho, by Virginia S. Gillerman, Mark Schmitz, Vince

- Isakson, Jeff Benowitz, and Midas Gold Inc.: USGS-Midas-IGS Field Conference, Donnelly, July, 2015.
- Idaho Mining and Exploration, 2014, A Brief Update, by Virginia S. Gillerman: North Idaho Legislative Tour, Coeur d'Alene, November, 2014.
- Idaho Mining and Exploration, 2014, by Virginia S. Gillerman: American Exploration and Mining Association 120th Annual Meeting, Reno, Nevada, December, 2014.
- *Idaho Mining and Exploration, 2014*, by Virginia S. Gillerman: Boise Section of Society of Mining Engineers, Boise, January, 2015.
- Idaho Thrust Belt "SedHeat" Proposal Development Workshop, by John A. Welhan: Center for Advanced Energy Studies, Idaho Falls, August, 2014.
- Long-Term Water-Supply Concerns in the Mink Creek-Gibson Jack Area, by John A. Welhan, Bannock County Planning and Zoning Council, Pocatello, August, 2014.
- A Magmatic-Hydrothermal System in the Basin and Range/Idaho Thrust Belt: A Hot Sedimentary Geothermal Prospect, by John A. Welhan: Idaho State University Geosciences G6601, Seminar class, guest lecture, Pocatello, November, 2014.
- Multi-disciplinary Application of Geology and Engineering to Understanding and Mapping Aggregate Quality in Idaho, by Virginia S. Gillerman, Kerrie N. Weppner, and William M. Phillips: Geological Society of America Annual Meeting, Vancouver, B.C., October, 2014.
- NEHRP Site Class and Liquefaction Susceptibility Maps for the Long Valley Area, Valley County, Idaho, by Lee Liberty and William M. Phillips: Valley County Local Emergency Planning Committee, September, 2014.
- NEHRP Site Class and Liquefaction Susceptibility Maps for the Long Valley Area, Valley County, Idaho, by Lee Liberty and William M. Phillips: Seismic Hazard Technical Advisory Group of the Idaho Bureau of Homeland Security, McCall, October, 2014.
- The Necessity, Design, and Implementation of a Statewide Aggregate Database, by Virginia S. Gillerman and Christopher A. Tate: Idaho Geological Survey, Moscow, May, 2015.
- Recharge Processes in the Lower Portneuf River Valley Watershed, by John A. Welhan: Idaho-EPSCoR Annual Meeting, southern Idaho, October, 2014.

- Research Update: Aquifer and Stream Recharge Processes in the Lower Portneuf Valley Watershed, by John A. Welhan: Idaho-EPSCoR research project overview, Idaho State University, Pocatello, July, 2015.
- Sediment-hosted Mineralization in Neoproterozoic to Paleozoic Platform and Platform Margin Carbonates and Siliciclastics in the Stibnite-Yellow Pine Mining District: A Northern Nevada Analog(?), by Chris Dail, Virginia Gillerman, Reed Lewis, David Stewart, and Eric Stewart: Geological Society of Nevada 2015 Symposium (New Concepts and Discoveries), Reno, Nevada, May, 2015.
- Shoshone-Bannock Tribal High School STEM Geoscience Student Activity, by John A. Welhan: Idaho State University, Pocatello, July, 2015.
- Thermal Waters in the ESRPA and Geochemical Constraints on the Hydrogeologic Conceptual Model, by J.A. Welhan, FORGE Project Workshop, Idaho Falls, July, 2015.
- Windermere And Associated Strata in the Stibnite-Edwardsburg Area, Central Idaho, by Reed S. Lewis, David E. Stewart, Darin M. Schwartz, Eric D. Stewart, Vincent H. Isakson, and Jeffrey D. Vervoort: Geological Society of America Annual Meeting, Vancouver, B.C., October, 2014.

## Web Products

- Idaho Geochemical Database Web Map Application, by Loudon R. Stanford, Dennis Feeney, Dustin Thomas, and Reed S. Lewis: Idaho Geological Survey interactive web map application, March, 2014.
- Idaho Mines and Prospects Web Map Application Improvements, by Christopher A. Tate, Loudon R. Stanford, and Dustin Thomas: Idaho Geological Survey interactive web map application (new version), March, 2015.

# **Operational Improvements**

- *EPSCoR Annual Meeting*, by John A. Welhan: Research coordination and networking across Idaho universities as part of the MILES-EPSCoR research project, October, 2014.
- Geologic Map Digitizing Protocol for IGS Mapping in ArcGIS Using the NCGMP09 Standard, by Loudon R. Stanford: Idaho Geological Survey, July-September, 2014, and June, 2015.

- IGS Aggregate Database Design, by Christopher A. Tate and Virginia Gillerman: Idaho Geological Survey, November-December, 2014.
- Large-Format Print Accounting and Procedure Setup for Canon IPF815 Printer, by Loudon R. Stanford, July-August, 2014.
- New Pricing Schedule for Over 400 IGS Large-Format Printed Publications: Applied to POS and IGS Website, by Alyson R. Kral and Loudon R. Stanford, August, 2014.
- Mines and Prospects Database: Redesign, Improvements, and Document Integration, by Christopher A. Tate and Loudon R. Stanford: Idaho Geological Survey, July, 2014-February, 2015.
- *Updated Grant Track*, by Tracy T. Kanikkeberg: Idaho Geological Survey funding source and salary tracking worksheet improvements, December, 2014 and June, 2015.

## **Media Interviews**

- 100 Years of Drilling, Independent Enterprise/Argus Observer, http://www.argusobserver.com/independent/news/years-of-drilling/article\_5526e35e-a1ab-11e4-8e73-df425cf195f7.html, January 21, 2015 (M.E. Ratchford).
- Idaho Geologic Survey Maps More Than Rocks, University of Idaho Argonaut, http://www.uiargonaut.com/2014/10/16/geologic-map-day-idaho-geologic-survey-maps-more-than-rocks/, October 16, 2014 (R.S. Lewis).
- No Damage After Temblors Rattle Bonner County, Bonner County Daily Bee, http://www.bonnercountydailybee.com/news/local/article\_4ba18e6e-eb17-11e4-bbb5-1f3e74d50480.html, April 25, 2015 (W.M. Phillips).
- Not If We Will Have an Earthquake, But When, KPVI News. http://www.kpvi.com/mostpopular/story/Not-If-We-Will-Have-an-Earthquake-But-When/brVzcaCsvE-iaMKfd49ZBA.cspx, July 29, 2014 (J.A. Welhan).
- Quakes: All Done or More to Come? CDAPress.com, http://www.cdapress.com/news/local\_news/article\_b7589391-df3d-558a-98e4-0eb8bd8af38a. html, April 25, 2015 (W.M. Phillips).
- Quake Rattles Area, Bonner Ferry Herald, http://www.bonnersferryherald.com/news/article\_c21bf3ee-f02c-11e4-8e2b-3751457f4217.html, May 1, 2015 (W.M. Phillips).

- Residents Furious about Being Force-Pooled into Idaho's First Fracking, EnviroNews Idaho, http://environews.tv/080114-residents-furious-about-being-force-pooled-into-idahos-first-fracking/, August 1, 2014, (M.E. Ratchford).
- Science Trek: Earthquakes, Idaho Public Television, http://video.idahoptv.org/video/2365385900/, December 16, 2014 (D.M. Feeney).

## **Professional Activities**

- Adjunct Graduate Faculty, Boise State University (V.S. Gillerman).
- Affiliate Faculty, Idaho State University (J.A. Welhan).
- Affiliate Faculty, University of Idaho (V.S. Gillerman, R.S. Lewis, W.M. Phillips, M.E. Ratchford, J.A. Welhan).
- Affiliate Faculty, Washington State University (R.S. Lewis, W.M. Phillips).
- Arkansas Professional Geologist, (M.E. Ratchford).
- Associate Member, American Association of Petroleum Geologists (M.E. Ratchford).
- Committee Member, Basin and Range Province Committee, Western States Seismic Policy Council (W.M. Phillips).
- Committee Member, Idaho Ground Water Monitoring Technical Committee (J.A. Welhan).
- Committee Member, Idaho State Hazard Mitigation Plan Executive Committee (W.M. Phillips).
- Committee Member, Staff Affair Awards, University of Idaho (T. T. Kanikkeberg).
- Coordinator and Leader, "SedHeat" Proposal Development Workshop, Hot Sedimentary Geothermal Systems, Center for Advanced Energy Studies, August (J.A. Welhan).
- Fellow, Society of Economic Geologists (V.S. Gillerman).
- Field Trip Leader, Idaho Museum of Mining and Geology trip near Riggins, Idaho, June (R.S. Lewis).

- Field Trip Leader, SedHeat Proposal Development Workshop, Center for Advanced Energy Studies, August (J.A. Welhan).
- Field Trip Leader, Tour of Lemhi Pass District and Butte, Montana, Oregon State University Society of Economic Geologists Chapter Field trip, September (V.S. Gillerman).
- Field Trip Leader, Tour of Yellow Pine and Stibnite, Chinese Geological Survey and USGS Tour, August (V.S. Gillerman).
- Field Trip Leader, University of Idaho Structural Geology Class Trip Near Orofino, Idaho, March (R.S. Lewis).
- Field Trip Member, Stibnite District USGS-Midas-IGS Tour, July (V.S. Gillerman, R.S. Lewis).
- Field Trip Member, Mine Tours of Silver Valley, August, November (V.S. Gillerman).
- Field Trip Member, Mine Tour, Thompson Creek Mine, September (V.S. Gillerman).
- Host, Idaho Geological Survey Booth, Annual Idaho Science Teachers Association Meeting, Boise. October (D.M. Feeney).
- Idaho Professional Geologist (R.S. Lewis, W.M. Phillips).
- Instructor, Idaho State Tax Commission Winter School (V.S. Gillerman).
- Judge, Student Poster Competition, Boise Section of Society of Mining Engineers April Meeting (V.S. Gillerman).
- Member, American Exploration and Mining Association, (V.S. Gillerman, R.S. Lewis).
- Member, American Geophysical Union (W.M. Phillips).
- Member, Association of American State Geologists (M.E. Ratchford).
- Member, Department Grant Administrator Round Table, University of Idaho (T.T. Kanikkeberg).
- Member, Earth and Planetary Surface Processes Section, American Geophysical Union (W.M. Phillips).

- Member, Electronic Personnel Action Form User Group, University of Idaho (T.T. Kanikkeberg).
- Member, External Advisory Board for Department of Geosciences, University of Arkansas, Fayetteville (M.E. Ratchford).
- Member, Financial Information Group, University of Idaho (T.T. Kanikkeberg).
- Member, Friends of Landslide Inventory (W.M. Phillips).
- Member Idaho Ground Water Monitoring Technical Committee, Nitrate Priority-Area Subcommittee (J.A. Welhan).
- Member, Idaho Seismic Hazards Technical Working Group, Idaho Bureau of Homeland Security (W.M. Phillips)
- *Member*, Geological Society of America (V.S. Gillerman, R.S. Lewis, W.M. Phillips).
- Member, Geological Society of Nevada, (V.S. Gillerman).
- Member, Geothermal Resources Council (J.A. Welhan).
- Member, Idaho Ground Water Monitoring Technical Committee (J.A. Welhan).
- Member, Human Resource Business Partner and Research Administration meeting, University of Idaho (T.T. Kanikkeberg).
- Member, Morrill Hall Building Safety Committee, University of Idaho (G. K. Bull).
- Member, Geologic Map Database Standard (NCGMP09) Steering Committee (L.R. Stanford).
- Member, Northwest Mining Association (R.S. Lewis).
- Member, Quaternary Geology and Geomorphology Division, Geological Society of America (W.M. Phillips).
- Member, Society for Mining, Metallurgy, and Exploration (V.S. Gillerman).
- Member, Tobacco Root Geological Society (D.M. Feeney, R.S. Lewis, W.M. Phillips).
- Member, Western States Seismic Policy Council (W.M. Phillips).
- Participant, American Exploration and Mining Association Annual Convention, Reno, Nevada, December (V.S. Gillerman).

- Participant, Annual meeting of Western States Seismic Policy Council, Pasadena, California, April (W.M. Phillips).
- Participant, Digital Mapping Techniques 2015 Workshop, Salt Lake City, Utah, June (L.R. Stanford).
- Participant, Geological Society of America Annual Meeting, Vancouver, B.C., October (V.S. Gillerman, R.S. Lewis).
- Participant, Geological Society of Nevada Symposium 2015, Reno, Nevada, May (V.S. Gillerman).
- Participant, Geology and Geohazards Community of Use, US TOPO meeting, December (L.R. Stanford).
- Participant, GIS Day, University of Idaho, November (W.M. Phillips)
- Participant, Groundwater Monitoring Technical Committee Meeting, Idaho Department of Environmental Quality, Boise, December (V.S. Gillerman).
- Participant, Mid-Year Meeting of Association of American State Geologists, Vancouver, B.C., October (R.S. Lewis).
- Participant, MSHA Safety Training Refresher Course, Boise, November (V.S. Gillerman).
- Participant, North Idaho Chamber of Commerce Legislative Tour, November (V.S. Gillerman, M.E. Ratchford).
- Participant, Tobacco Root Geological Society Field Conference, Republic, Washington, July (W.M. Phillips).
- Presenter, GIS Day, University of Idaho, November (L.R. Stanford).
- Representative, Idaho Bureau of Homeland Security ESF Coordinating Group, Boise, September (V.S. Gillerman).
- Reviewer, Geosphere manuscript, May (J.A. Welhan).
- Reviewer, Geological Society of America Books Manuscript, May (J.A. Welhan).
- Reviewer, U.S.G.S. National Geologic and Geophysical Data Program Grant Submissions, Denver, Colorado, April (R.S. Lewis).

- Team Leader, Hot sedimentary Rock (SedHeat) Geothermal Research Coordinator, Texas Christian University Energy Institute (J.A. Welhan).
- Technical Advisor, Bannock County Groundwater Overlay Advisory Committee (J.A. Welhan).
- Technical Advisor, Department of Environmental Quality on Statistical Tools for Ground Water Quality Monitoring (J.A. Welhan).
- *Technical Advisor*, Idaho State University's National Science Foundation "Opportunities for Educational Diversity in the Geosciences" (J.A. Welhan).
- Technical Advisor, Idaho State University Geosciences Ground-Water Study of Pharmaceuticals in Drinking Water (J.A. Welhan).
- Technical Advisor, Shoshone-Bannock Tribes' Water Resources Department (J.A. Welhan).
- Technical Advisor, Statistical Tools for Ground Water Quality Monitoring, Department of Environmental Quality (J.A. Welhan).
- Training Session, PeopleAdmin, University of Idaho, September (T.T. Kanikkeberg).
- Training Session, Rate Development, University of Idaho, March (T.T. Kanikkeberg).

# **Petroleum Modeling Software Donations**

Schlumberger Petroleum Services, Petrel modeling software, \$11,785,977. IHS Energy, Petra modeling software, \$223,400.

## **Graduate Thesis Committees**

Collette Gantenbein, M.S. Geography, University of Idaho (W.M. Phillips).

Rachael Hoover, M.S. Geology, Washington State University (W.M. Phillips).

Sita Karki, M.S. Geological Sciences, Idaho State University (J.A. Welhan).

Jeff Larimer, M.S. Geology, University of Idaho (W.M. Phillips).

Rebecca Ohly, M.S. Geological Sciences, Idaho State University (J.A. Welhan).

Courtney Richards, M.S. Geological Sciences, Idaho State University (J.A. Welhan).

Darin Schwartz, M.S. Geology, University of Idaho (W.M. Phillips).

Tor Stetson-Lee, M.S. Geology, University of Wisconsin, Madison (R.S. Lewis).

Liane Stevens, Ph.D. Geology, University of Montana (R.S. Lewis).

Da Wang, M.S. Geology, Washington State University (R.S. Lewis).

## **Grants and Contracts**

- Additional Geologic Mapping and Study of Hydrothermal Alteration,
  Mineralization and Geochronology in and near Stibnite Mining District,
  Idaho: V.S. Gillerman and R.S. Lewis (Midas Gold, Inc., July 2014-June 2016, \$70,000).
- Aquifer and Stream Recharge Processes in the Lower Portneuf Valley Watershed: G. Thackray, J. Welhan and M. Shapley (Idaho EPSCoR MILES/I-SEED Program; January-December 2014, \$13,002).
- Cooling in Fractured Geothermal Reservoirs: Software Tools: J.A. Welhan, co-PI (DOE-INL LDRD, October 2012-September 2015, \$524,000).
- Idaho Department of Lands Abandoned Mine Lands Project, Task 2: R.S. Lewis (Idaho Department of Lands, May 2012-February 2015, \$89,857).
- Idaho Department of Lands Abandoned Mine Lands Project, Task 3: R.S. Lewis (Idaho Department of Lands, December 2014-February 2017, \$122,560).
- Geologic Mapping in the Rexburg, Weiser, Boise, and Salmon areas: R.S. Lewis, W.M. Phillips, D.L. Garwood, and D.M. Feeney (U.S. Geological Survey STATEMAP Program, June 2014-May 2015, \$175,275).
- Geologic Mapping in the Rexburg, Weiser, and Salmon areas: R.S. Lewis, W.M. Phillips, and D.M. Feeney (U.S. Geological Survey STATEMAP Program, June 2015-May 2016, \$133,584).
- Geologic Mapping of Stibnite 7.5' Quadrangle and Pilot Investigation of Hydrothermal Alteration, Mineralization and Geochronology within Stibnite Mining District, Idaho: V.S. Gillerman and R.S. Lewis (Midas Gold, Inc., May 2012-December 2014, \$75,000).

- Magmatically Influenced, Hot Sedimentary Brines in Southeast Idaho: Implications for Power Production and Economic Mineral Extraction: J.A. Welhan, PI (Texas Christian University NSF-RCN incubator funds for SedHeat workshop and logistical support, February, 2014-2016, \$7,000).
- Recruiting and Retaining Native American Students in the Geosciences: J.A. Welhan (subcontract to ISU, NSF, December 2011-August 2014, \$17,122)
- Seismic Site Class and Liquefaction Susceptibility Study of Portions of Kootenai County, Idaho: W.M. Phillips (Idaho Bureau of Homeland Security, March-August 2015, \$9,349).
- Seismic Site Class and Liquefaction Susceptibility Study of Portions of Valley County, Idaho: W.M. Phillips (Idaho Bureau of Homeland Security, November 2013-August 2014, \$63,000).
- Snake River Plain Heat Flux Estimation via Groundwater Heat Transport Modeling: J.A. Welhan, co-PI (DOE-INL LDRD, June-October 2015, \$24,600).
- US Geological Survey FY2013 Data Preservation Program: R.S. Lewis (United States Geological Survey, September 2013-December 2014, \$23,261).
- US Geological Survey FY2014 Data Preservation Program: R.S. Lewis (United States Geological Survey, September 2014-September 2015, \$15,150).