



Annual Report of the **Idaho Geological Survey**

Fiscal Year 2016

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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 11 state-funded FTEs and 17 externally-funded temporary and part-time employees.

The Idaho Geological Survey's goal is to provide the state with timely and relevant geologic information through strong and competitive applied research, effective program accomplishments, and transparent access. IGS is committed to the advancement of geosciences and emphasizes the practical application of geology to benefit the citizens of the state. The Survey staff 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 fundamental to solving and identifying a wide array of geologic problems and issues throughout the state. 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 research, 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 and geologic hazards such as landslides and earthquakes.

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.

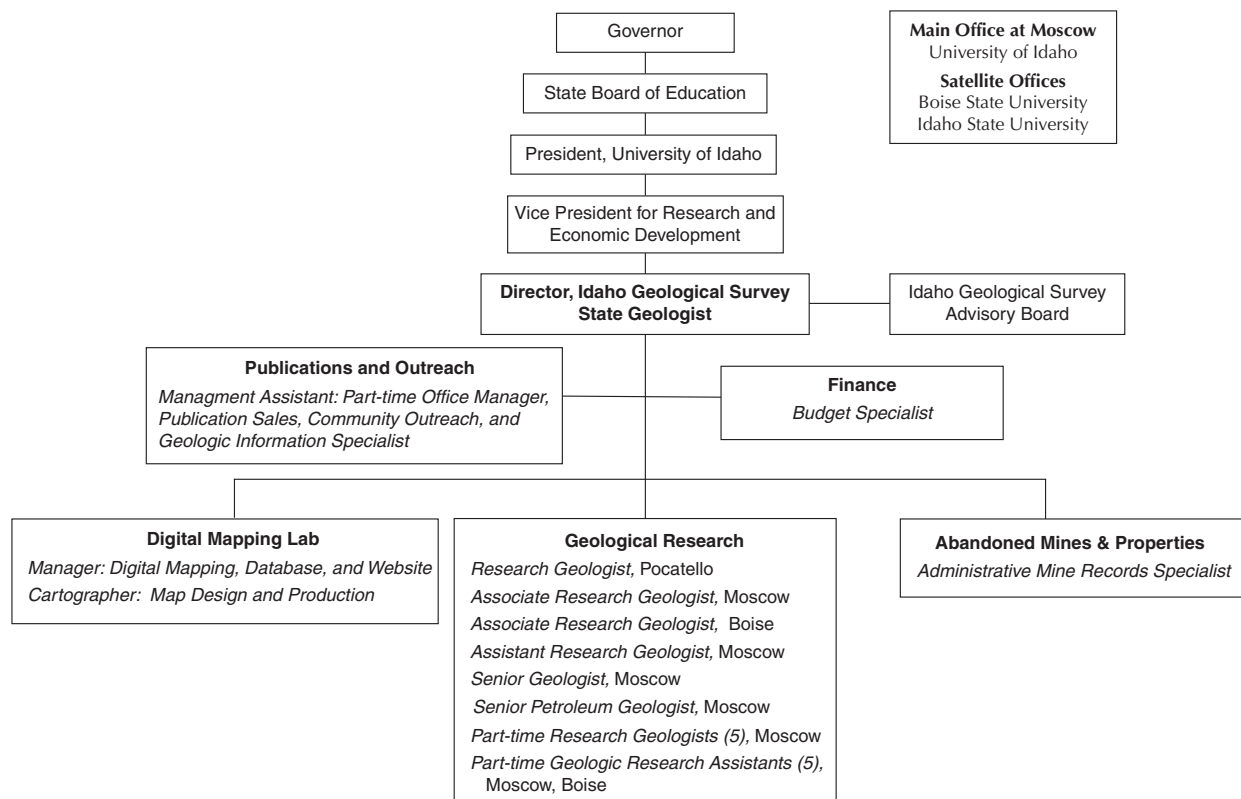


ORGANIZATION AND PERSONNEL

The Idaho Geological Survey provided its geological services during fiscal year 2016 from the main office in Moscow and from the two satellite offices located in Boise and Pocatello. Legislative approval was conveyed during the spring of 2016 to add two new full-time positions beginning in FY 2017, a GIS Analyst and a Geohazards Geologist. Workflow planning, supervision changes and personnel reorganization was initiated during late spring of 2016 to prepare for the two new employees that will be added to the Survey's staff. The organization chart below represents existing personnel and reporting effective during fiscal year 2016.

Organization Chart

Idaho Geological Survey Fiscal Year 2016



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
John R. Brabb Financial Specialist, Moscow
Glenda K. Bull Administrative Specialist

Research, Full-Time

Renee L. Breedlovestrout Senior Petroleum Geologist, Moscow
Dennis M. Feeney Senior Geologist, Moscow
Jane S. Freed Cartographer, Moscow
Virginia S. Gillerman Associate Research Geologist, Boise
Reed S. Lewis Associate Research Geologist, Moscow
William M. Phillips Assistant Research Geologist, Moscow
Loudon R. Stanford Manager, Digital Map and GIS Lab, Moscow
Christopher A. Tate Technical Records Specialist
John A. Welhan Full Research Geologist, Pocatello

Research and Support, Part-Time

Megan M. Aunan Research Support
Russell F. Burmester Geologist
Hailey J. Couture Research Support
Collette K. Gantenbein Research Support
Jesse A. Hinshaw Work Study-Research Support
Susan J. Jones Research Support
Mark D. McFadden Geologist
Daniel K. Moore Geologist
Kurt L. Othberg Geologist
Matthew A. Peterson Work Study
Keegan L. Schmidt Geologist
William Schuster Work Study
David E. Stewart Geologist
Eric D. Stewart Geologist
Ander J. Sundell Research Support

Idaho Geological Survey Advisory Board

Susan Cleverly

Idaho Office of Emergency Management

Chris Dail

Exploration Manager,
Midas Gold Inc.

Mickey Gunter

Chair, Department of Geological Sciences,
University of Idaho

David Hawk

Representing Office of the Governor

Mike McCurry

Chair, Department of Geological Sciences,
Idaho State University

Dr. James “Jim” McNamara

Chair, Department of Geological Sciences,
Boise State University

Keith Nottingham

Geologist,
Idaho Transportation Department

Rich Reed

President,
Idaho Association of Professional Geologists

Tom Schultz

Director, Idaho Department of Lands

Ex Officio: Michael “Ed” Ratchford

Director and State Geologist,
Idaho Geological Survey

Idaho Geological Mapping Advisory Committee

Janet Hohle – Chair

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

James R. Bartolino

District Ground Water Specialist
U.S. Geological Survey

Stephen Box

Research Geologist
U.S. Geological Survey Minerals Program

Dale Kerner

Mining Services Manager
Haley & Aldrich, Inc.

Mark Kimsey

Intermountain Forestry Cooperative
Dept. of Forestry, Rangeland and Wildfire Sciences
College of Natural Resources, University of Idaho

Sean Long

Assistant Professor, Earth Sciences
Washington State University

Ryan McDaniel

Risk MAP Program Manager
Idaho Office of Emergency Management

Jim Myers

Senior Exploration Geologist
Hecla Silver Valley, Inc.

Dennis Owsley

Technical Hydrogeologist
Idaho Department of Water Resources

David Pearson

Assistant Professor, Department of Geosciences
Idaho State University

Karen Porter

Geologist, Program Lead Leasable and
Salable Minerals
BLM Idaho State Office

Kenneth C. Reid

State Archaeologist and Deputy SHPO
Idaho State Historic Preservation Office

Diane Wheeler

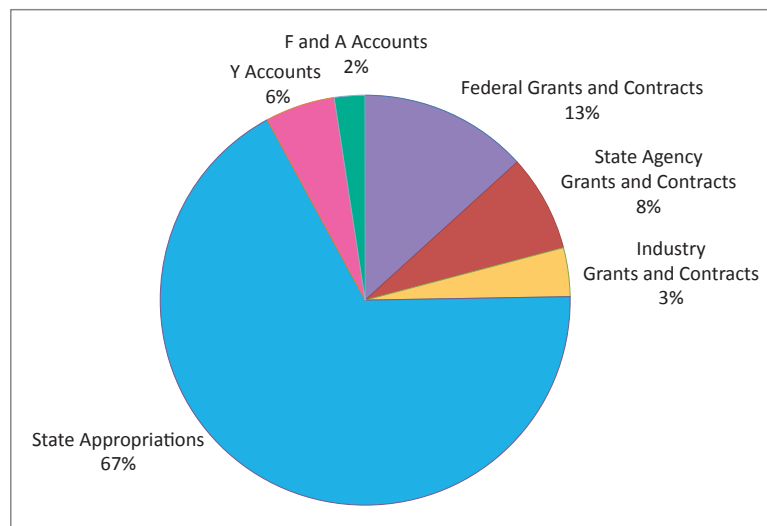
Forest Geologist
Caribou-Targhee National Forests

FISCAL OVERVIEW

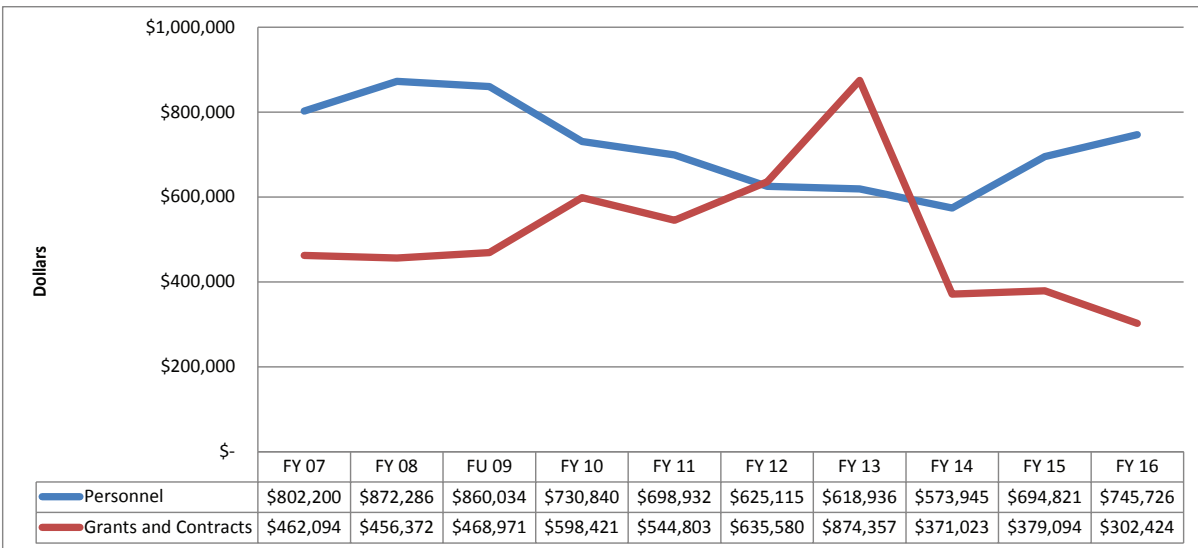
The Idaho Geological Survey's state-appropriated budget for FY 2016 was \$824,200, a nominal increase from \$821,100 in FY 2015, but still below FY 2007- FY 2009 funding levels. The mandated reductions in the state budget base have affected the agency's mission in research, public service, outreach, and education. Grants and contracts decreased to \$302,424 in FY 2016, down from \$379,093 in FY 2015, a 20% reduction. In FY2015, expenditures came from 20 projects and in FY2016, expenditures were spread over 16 projects.

Budget Fiscal Year 2016					
Category	Beginning Balance	Income or Appropriation	Actual	Expense	Ending Balance
Personnel		\$ 799,300.00	\$ 745,726.20	\$ 745,726.20	\$ 0.00
Operating Expense		\$ 22,000.00	\$ 65,898.52	\$ 65,898.52	\$ 0.00
Capital Outlay		\$ 2,900.00	\$ 12,575.48	\$ 12,575.48	\$ 0.00
Total		\$ 824,200.00	\$ 824,200.00	\$ 824,200.00	\$ 0.00
U/I Personnel Funds		-	-	-	-
Y Accounts	\$ 75,374.16	\$ 67,923.42		\$ 67,138.89	\$ 76,158.69
F and A Accounts	\$ 98,826.00	\$ 16,479.02		\$ 29,635.25	\$ 85,669.77
Grants and Contracts			\$ 302,423.56	\$ 302,423.56	(\$302,423.56)
TOTAL	\$ 174,200.16	\$ 908,602.44	\$ 1,126,623.56	\$ 1,223,397.70	(\$140,595.10)

Sources of Funding



Trends in Personnel Costs and Grants and Contracts Fiscal Years 2007-2016



PARTNERSHIPS

The Idaho Geological Survey's 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 (AASG). These alliances offer many opportunities to engage in projects that enhance the agency's applied research and outreach.

Association of American State Geologists

The Director of the Idaho Geological Survey represented Idaho at the AASG Spring Liaison Meeting in Washington, D.C. and the Annual Meeting in Girdwood, Alaska. 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 Reservoirs and Heat Transfer modeling)	Idaho Transportation Department (Smiths Ferry Project)
Idaho Bureau of Homeland Security and Boise State University (Seismic Study in Kootenai County)	Midas Gold Corporation (Stibnite Project)
Idaho Department of Lands (Abandoned Mine Lands Project)	U.S. Geological Survey (Reservoir Characterization & Petroleum Assessments; STATEMAP Cooperative Project; Data Preservation)
Idaho EPSCoR (Aquifer and Stream Recharge, MILES/I-SEED Program)	

Collaborators

Ada County Highway District	Inside Idaho
Alta Mesa Energy	Intermountain Forestry Cooperative
American Exploration and Mining Association	Lewis-Clark State College
American Geological Institute	Midas Gold Corporation
American Water Resources Association, Idaho State Section	Montana Bureau of Mines and Geology
Americas Silver Corporation	National Association of Geoscience Teachers
Association of American State Geologists	National Geographic
Bannock County Groundwater Overlay Advisory Committee	National Science Foundation, Geoscience Directorate
Bannock County Planning and Zoning Department	Nevada Bureau of Mines and Geology
Belt Association	New Jersey Mining Company
Boise Section, Society of Mining Engineers	North Idaho College
Boise State University	Northwest Knowledge Network
Brigham Young University-Idaho	Oil and Gas Conservation Commission
Bryant University	Orma J. Smith Museum of Natural History
Center for Advanced Energy Studies	Portneuf Watershed Partnership
City of Pocatello Water Department, Planning Department, and Environmental Department	Shoshone-Bannock Tribal Water Resources Department
College of Idaho	Spokane Community College
College of Western Idaho	Tobacco Root Geological Society
Energy and Geoscience Institute, Utah	University of Tennessee-Knoxville
Federal Emergency Management Agency	U.S. Bureau of Land Management
Franklin and Marshall Department of Earth and Environment Sciences	U.S. Forest Service
Geological Society of America	U.S. Geological Survey—Data Preservation
Hecla Mining Company	U.S. Geological Survey—Idaho National Lab
Idaho Office of Emergency Management	U.S. Geological Survey—Minerals Program
Idaho Department of Environmental Quality	U.S. Geological Survey—STATEMAP
Idaho Department of Lands	U.S. Geological Survey—US Topo
Idaho Department of Water Resources	U.S. Geological Survey—Water Resources Division
Idaho Environmental Forum	U.S. Geothermal Inc. - Raft River Plant
Idaho Geospatial Council	University of Alaska, Fairbanks
Idaho Ground Water Monitoring Technical Committee	University of Idaho
Idaho Historical Society	University of Montana
Idaho Mining Association	University of Utah
Idaho Museum of Mining and Geology	University of Wisconsin-Madison
Idaho National Laboratory	Utah Geological Survey
Idaho Office of Energy Resources	Utah State University
Idaho Petroleum Council	Wallace District Mining Museum
Idaho Public Television	Washington Division Geology and Earth Resources
Idaho Science Teachers Association	Washington State University
Idaho State University	Western States Seismic Policy Council
Idaho Transportation Department	Western State Colorado University
	Western Washington University
	Yellowstone National Park
	Yellowstone Volcano Observatory

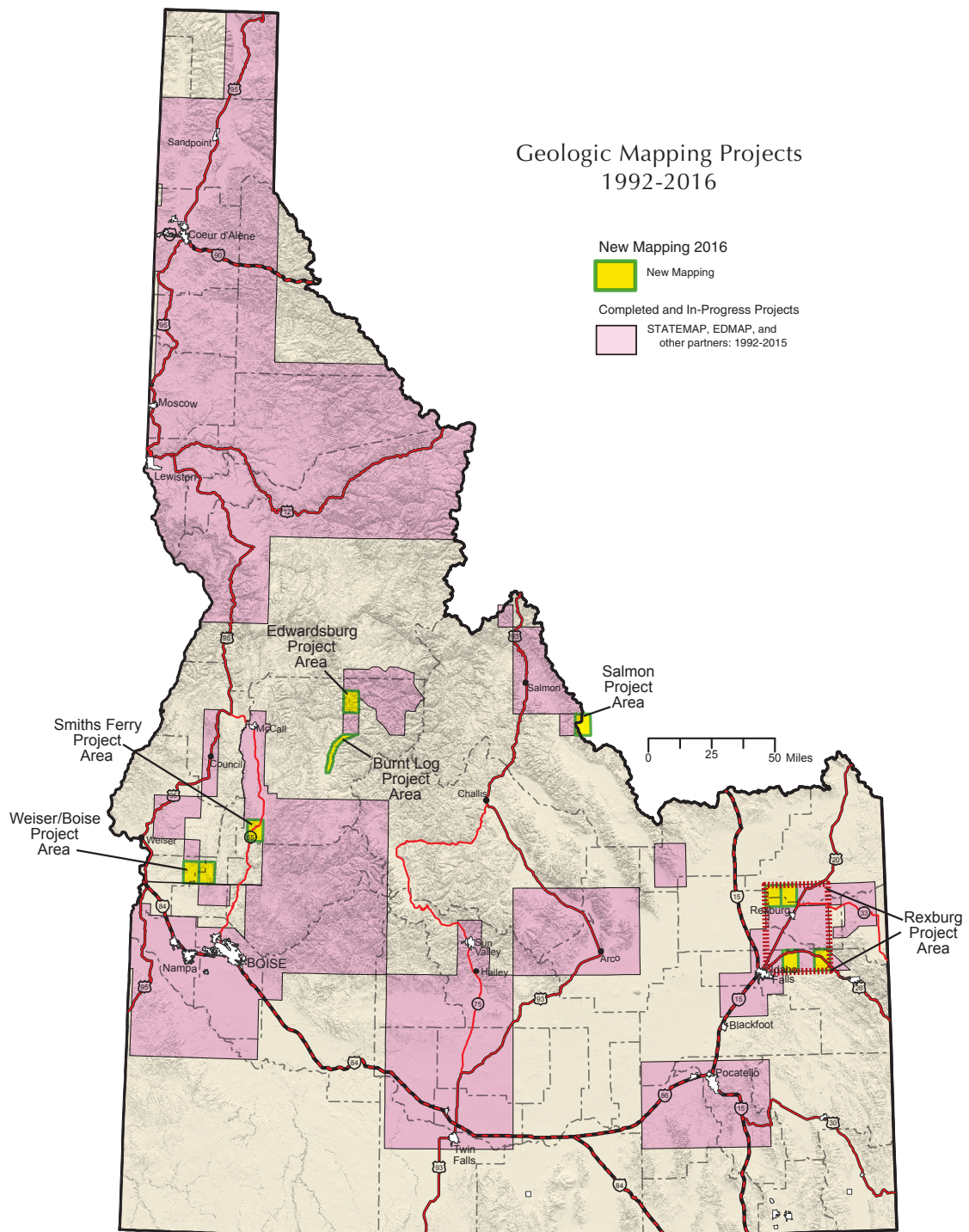
RESEARCH

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 \$3.8 million in federal funds and matched an equal amount of "in kind" salaried employee's participation to complete geologic mapping in Idaho. In FY 2016, new mapping was conducted in the Weiser-Boise, Rexburg, and Salmon project areas. During the year, Survey geologists mapped four 7.5' quadrangles (Hawley Gulch, Midvale Hill, Paddock Valley Reservoir, and Agency Creek) under the STATEMAP Program. Mapping was also conducted in the Smiths Ferry quadrangle for the Idaho Department of Transportation. A new mapping project in the Burnt Log Road area near Stibnite was initiated, and mapping was completed in the Stibnite 7.5' quadrangle; both projects 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. Results from many of our mapping projects were highlighted at the Rocky Mountain Section meeting of the Geological Society of America in Moscow in May.

Hydrogeology

Hydrogeologic work by the Idaho Geological Survey (IGS) during FY 2016 focused on applied research in geochemical/isotopic tracing and flow-system modeling, together with continued efforts in the areas of outreach, public service, and education. Research activities focused on understanding stable isotope indicators of ground water source regions and their application to mapping of both modern and prehistoric flow systems. Outreach and education activities involved ongoing communication with the Shoshone-Bannock Tribes, including collaborative efforts to educate the tribal community about recent aquifer water-supply problems due to overdrafting, and assistance with developing a STEM education program for college-bound Native students; Technical collaboration with IDEQ involving aspects of that agency's ground water monitoring efforts; continued interactions with planners, consultants and private well owners around the state; and active participation in graduate student research and mentoring at ISU and UI.

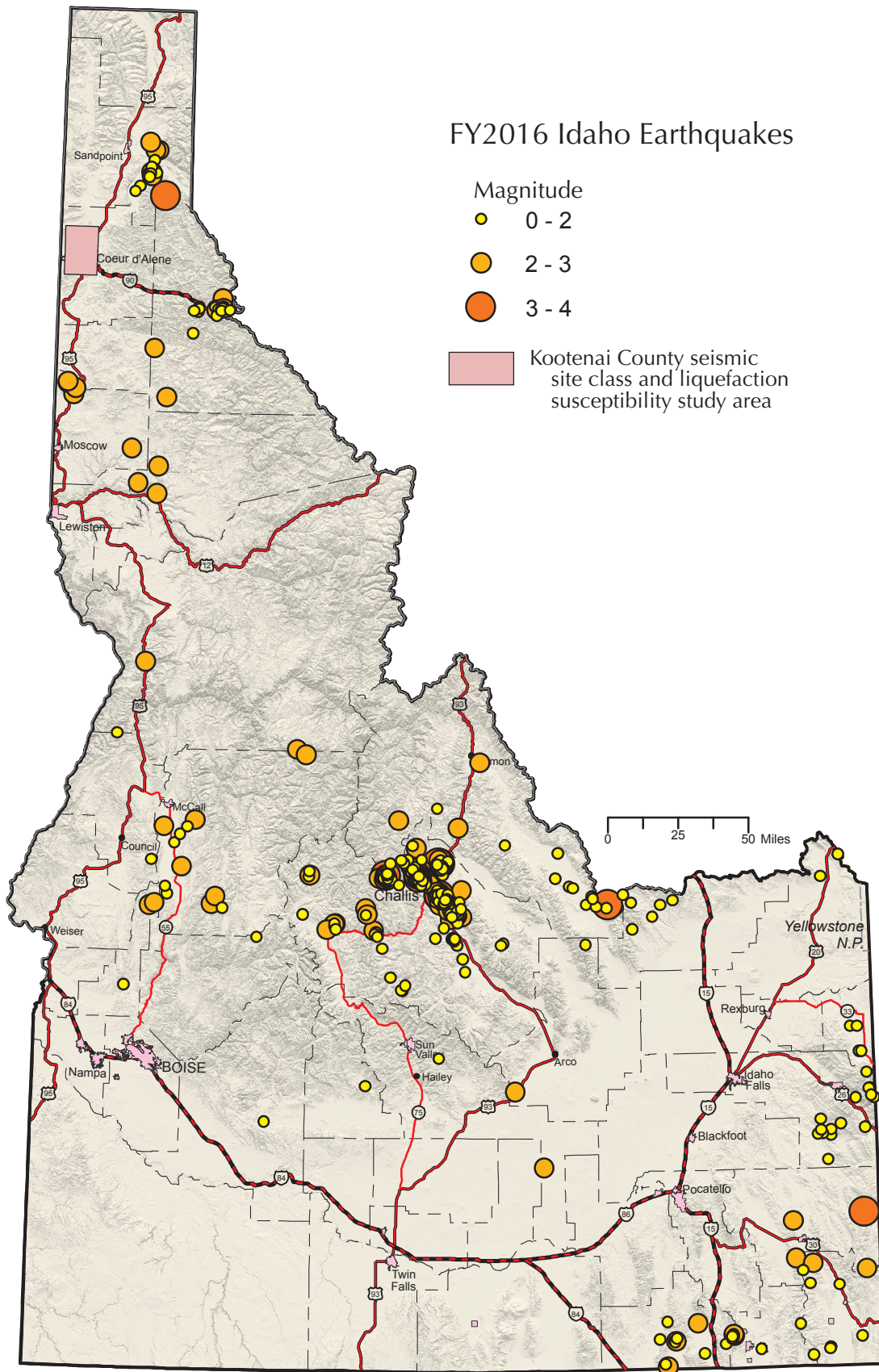
Research activities in FY 2016 included analysis of ground water data that has been collected in the lower Portneuf River Valley (LPRV) over the past three years as part of the Idaho EPSCoR MILES project (Managing Idaho's Landscapes for Ecosystem Services). This work, done in conjunction with a comprehensive sampling campaign by ISU graduate students, has confirmed the presence of deep, fossil ground water (> 10,000 years old) in the Mink Creek flow system, a major source of ground water to Pocatello's municipal aquifer. This finding represents a previously unrecognized source of recharge to the LPRV aquifer, possibly derived from low-temperature thermal ground water upwelling along the lower Portneuf Valley's Basin and Range faults. Work in FY 2017 will focus on estimating the quantity of recharge that this deep, fossil component may contribute to the municipal aquifer's water balance.

These findings were made possible because of the close collaboration that has evolved between IGS and ISU faculty and students. Data collected by a variety of IGS-supervised graduate students at ISU over the past 25 years is being compiled as part of a statewide MILES database to enhance current basic research and to promote future applied research in ecosystem services. Such information will prove to be useful in developing geochemical tracing approaches for ground-water flow system studies 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 FY 2016, a series of earthquakes with magnitudes as large as 3.8 occurred in the Challis area. These earthquakes are part of a continuing swarm that has 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 2016, 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



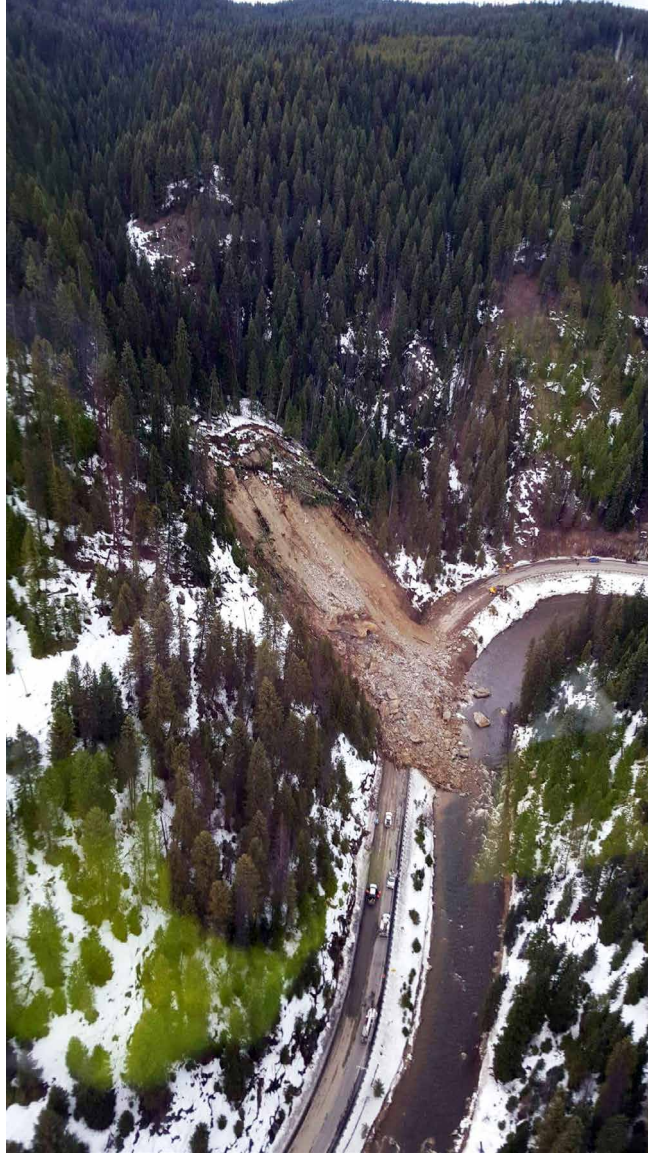
bi-monthly YVO teleconference briefings. In the event of volcanic ash eruptions from Cascade volcanoes, the Survey will collaborate with the U.S. Geological Survey's Cascade Volcano Observatory.

The Survey provides expert opinion and advice to state and federal agencies involved with Idaho hazard mitigation. In FY 2016, 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. This input is used to revise and strengthen 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.
- The Survey conducted mapping of seismic site classes and liquefaction susceptibility in portions of Kootenai County in collaboration with Boise State University.
- During FY2016, the Survey became a Cooperating Technical Partner (CTP) of the Federal Emergency Management Agency (FEMA). The CTP program creates collaborations between FEMA and qualified agencies for the purpose of addressing gaps in multi-hazard data. As a CTP participant, the Survey can seek federal funding for hazard mapping activities in FEMA's Risk MAP program. In FY2016, the Survey participated in Risk MAP community hazard discovery meetings in Kamiah and Lewiston.

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.

On February 18, 2016, a large landslide occurred on State Highway 14 west of Elk City. The landslide blocked the road intermittently for over 4 months. Mitigation of the slide has cost about \$4.8 million to date. The Survey provided geologic framework.



Landslide blocking State Highway 14 (photograph courtesy Idaho Department of Transportation, taken February 19, 2016)

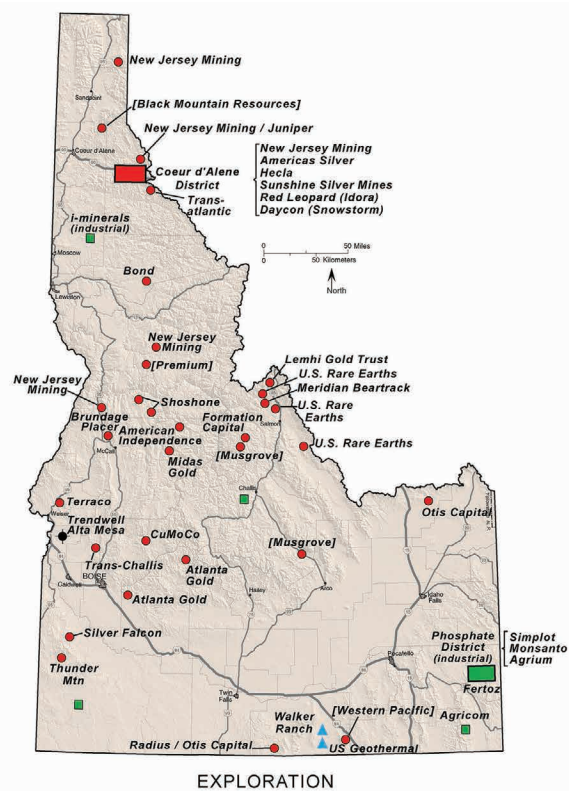
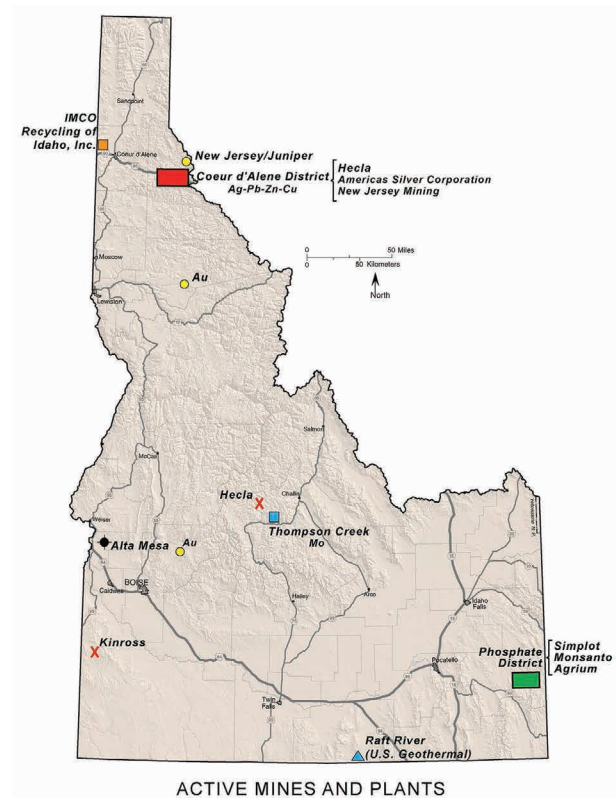
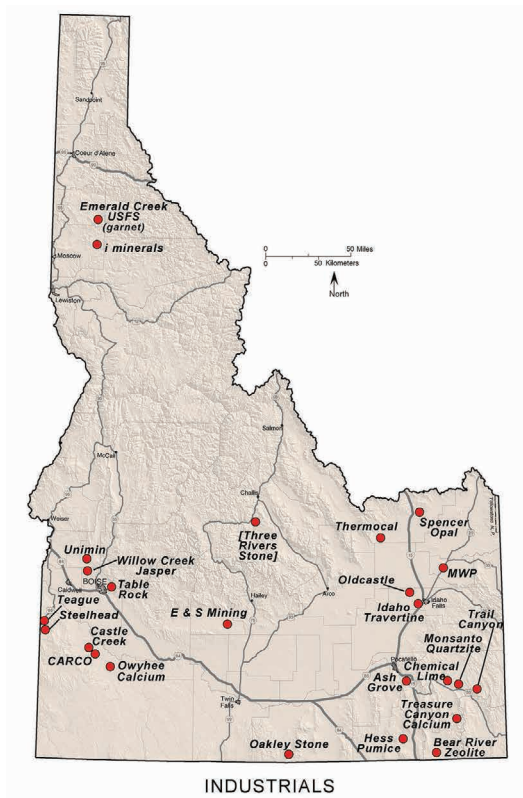
Mineral Resources and Mining

Active Mining and Exploration

The Idaho Geological Survey (IGS) has a long history of and statutory responsibility to provide annual factual updates and reports on the mining industry in Idaho. It is the lead state agency for compiling and disseminating information on the state's mineral resources. 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 and statistics on mining and minerals information. During FY 2016, the annual summary for calendar year 2015 mineral activity was presented at the American Exploration and Mining Association (formerly the Northwest Mining Association) annual convention in December. As in 2014, mining and exploration activity was adversely affected by weak commodity prices and the economic downturn in Asia. The USGS estimate of Idaho's value of nonfuel mineral production in 2015 was \$713 million, a sharp drop from the 2014 estimate of \$1.2 billion. The difference was due largely to the closure and status change of the Thompson Creek molybdenum mine in Custer County. Only limited stripping for Phase 8 and a small amount of toll milling was conducted by the few employees left at the mine. In November, 2015, molybdenum oxide prices were under \$ 5 per pound. Three large phosphate mines in southeastern Idaho and two silver mines in northern Idaho did operate. Hecla continued to sink the new #4 internal shaft at the Lucky Friday mine in Shoshone County. Many exploration companies suffered from lack of financing, as well as new federal regulatory hurdles.

Minerals-related Research

The principal minerals related research project during FY2016 continued to be at the Stibnite Mining District in Valley County. Work there is being funded by and in collaboration with Midas Gold Corporation. The project is in Phase II of work that involves geologic mapping at 1:24,000 scale of the Stibnite 7.5' quadrangle and more laboratory-based study of the alteration, geochronology, and mineral paragenesis of the gold-antimony-tungsten deposits. Cartographic work on the geologic quadrangle map was completed, and the product was ready for final review. Work on the alteration study included additional petrographic work, age dates and electron microprobe data interpretation. Two poster presentations at the Rocky Mountain Geological Society of America meeting held in Moscow in May were based on geologic and geochemical work derived from the Stibnite Project. One poster compared lead isotopic data acquired by Fred Brackebusch



Maps showing mining and exploration activity in Idaho for calendar year 2015.

for the Murray Au-Ag District in northern Idaho with lead isotopic data from Stibnite and the Lemhi Pass District. Results suggest that mantle and crustal architecture in east and central Idaho may differ from that in northern Idaho.

Several major minerals-related service tasks took place during FY 2016. The IGS Economic Geologist was a session co-chair and field trip co-leader to the Coeur d' Alene Mine District as part of the Geological Society of America meeting held in Moscow during May. In September 2015, the U.S. Secretary of Interior proposed a withdrawal of 10 million acres of western federal lands from locatable mineral entry due to perceived threats to sage grouse. This action initiated a mineral assessment of these lands by the U.S. Geological Survey and NEPA action. The announcement prompted an IGS review and compilation of mineral data that was overlain on GIS map layers relative to the 3.8 million acres of Sagebrush Focal Areas (SFAs) proposed for mineral withdrawal in Idaho. IGS provided mineral resource information and assessments on mineral potential in the state that was incorporated into an Idaho alternative to BLM's proposal. A primary objective for the State of Idaho is to have input into the Environmental Impact Statement being prepared by the Bureau of Land Management.

Energy

Geothermal

The IGS's work in geothermal energy research was focused on two fronts during 2016: (1) completion of a comprehensive analysis and synthesis of data that were compiled during the DOE-funded National Geothermal Data System (NGDS) project (2010-2014), on a previously unrecognized high-temperature geothermal resource in the Idaho thrust belt (ITB), which IGS identified in 2012; 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.

Idaho Thrust Belt

Work continued on finalizing a comprehensive data compendium and technical report detailing what is known of the ITB's high-temperature geothermal system and refining conceptual models of the hydrothermal system in order to understand its volcanic heat source, subsurface structural context, reservoir architecture, and geohydrologic characteristics. Analyses of the system's economic potential, both from a geothermal power and brine-mineral perspective, were also

completed and published in the proceedings of the 2016 Stanford Geothermal Workshop and the GSA's 2016 Rocky Mountain Section annual meeting, which highlight the system's Gigawatt-scale power production potential.

The IGS report is currently undergoing final in-house editorial review and is to be published as a stand-alone report with hyperlinked documents and a digital compendium of appendices and data files that are designed to facilitate dissemination of the report's findings and promote future research and economic development. Work is also underway on a manuscript for the journal *Geothermics*, in order to more widely publicize the economic potential of this resource and to build awareness of its existence.

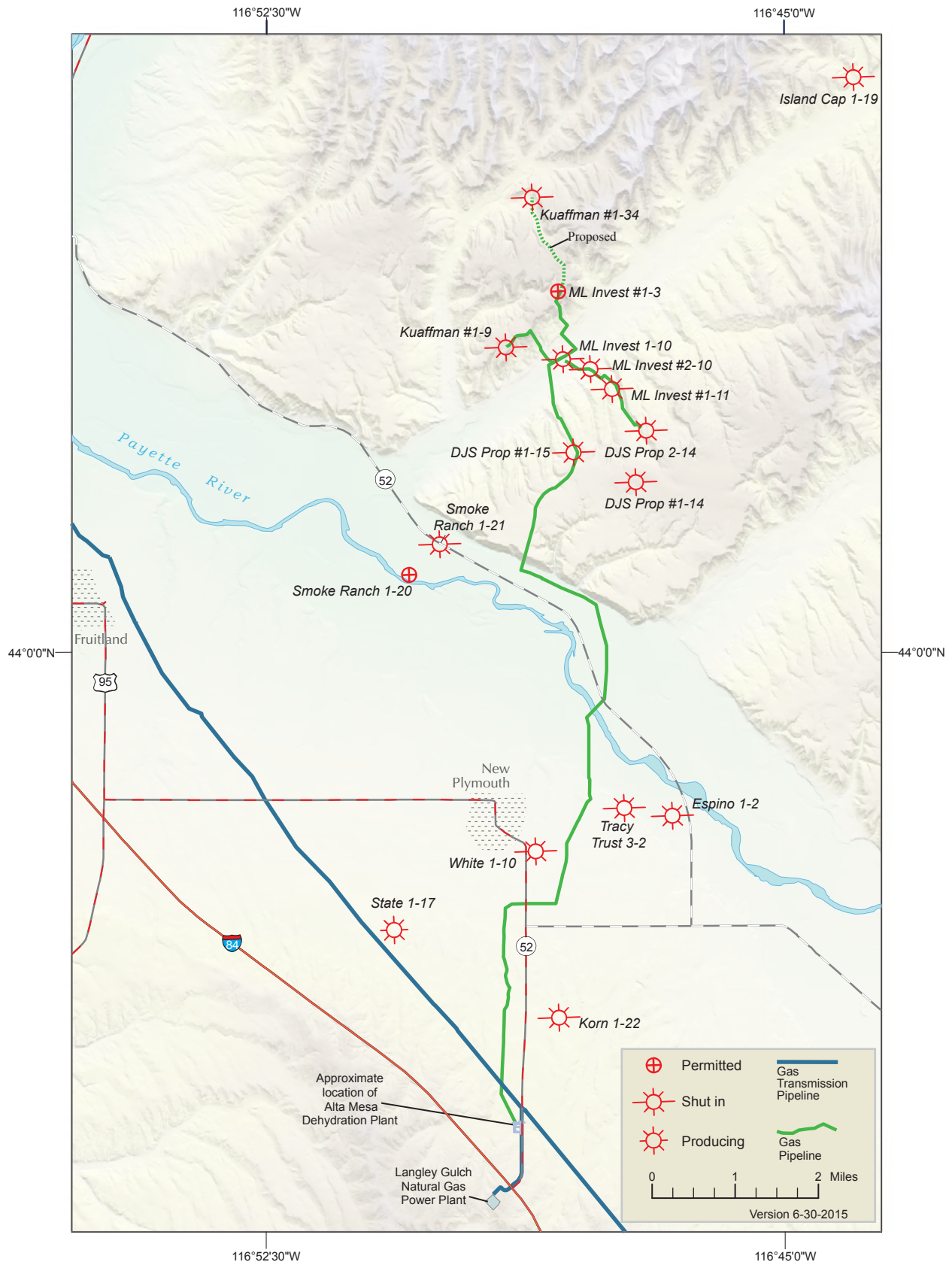
INL-FORGE

The Survey continued its close collaboration during 2016 with Idaho National Laboratory (INL) and the Center for Advanced Energy Studies (CAES) as part of an INL-CAES Snake River Geothermal Consortium (SRGC) to promote research and development efforts to extract geothermal energy from the hot rhyolitic basement rocks of the ESRP. Unfortunately, the SRGC's proposal to the Department of Energy to fund the ESRP FORGE initiative was unsuccessful. However, discussions continue to redirect the focus of the SRGC's technical team to other promising areas of geothermal research and development in Idaho, such as the Idaho thrust belt.

Oil and Gas

For the first time in history, Idaho is now a hydrocarbon producing state owing to the recent drilling success and production of natural gas and liquid condensate from 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 17 new exploration wells, 6 of which are currently in production near New Plymouth. The IGS is monitoring activity in the field including the exploration and drilling of new wells, emplacement of pipeline and gas plant infrastructure, acquisition of 3-D seismic surveys, and mineral lease acquisition. Collaboration between public and private entities (Idaho Department of Lands and Alta Mesa Holdings) has permitted the Survey to acquire subsurface data and begin the process of petroleum system assessment for the region.

In 2015, 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



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

of the state; IGS just fulfilled the first year of that contract. 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, subsurface mapping, well log correlations, microfossil designations, source rock evaluation, and petroleum-system modeling is being conducted by Survey staff to assess 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 rocks in the producing basin at depth.

The IGS has also identified the areas of south-central 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. Collaboration between IGS, Cedar Creek Resources, and Western State Colorado University are now in place to gain further subsurface information to study these potential petroleum systems. As new drilling and completion technologies have advanced in recent years, both of 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. All the reports and logs were then scanned and made available for download from the IGS website and consist of drilling correspondences, permits and applications, industry reports, maps, and geophysical logs. As other historic and contemporary reports become available, IGS will continue to enhance and expand the oil and gas archive geodatabase.

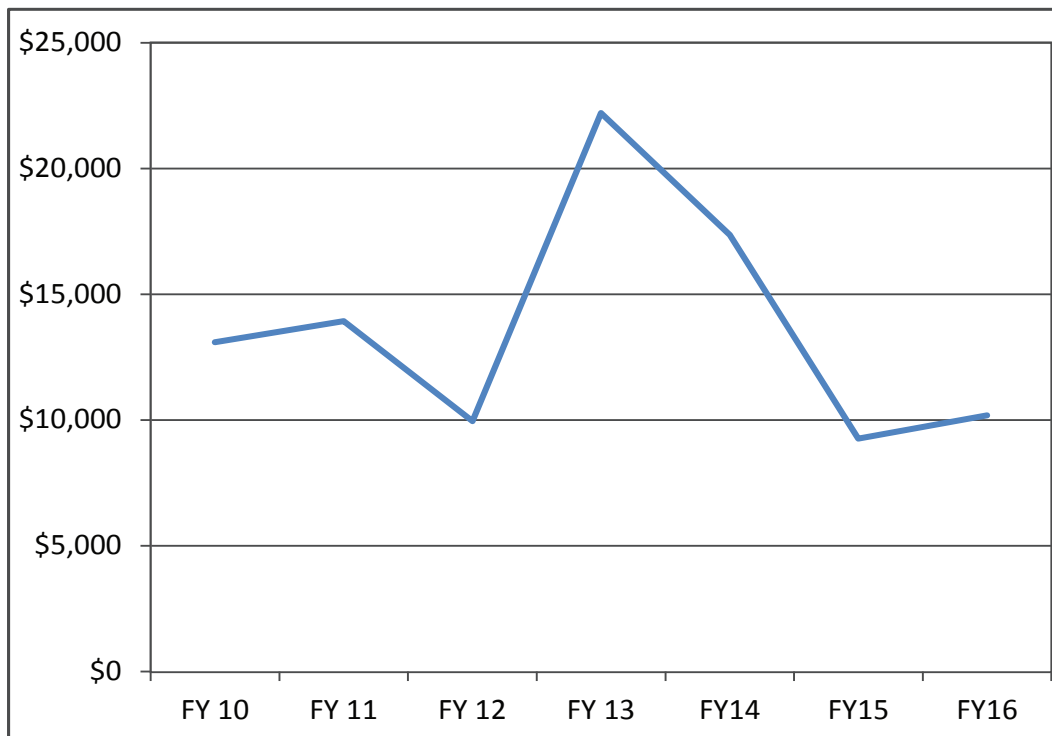
OUTREACH

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

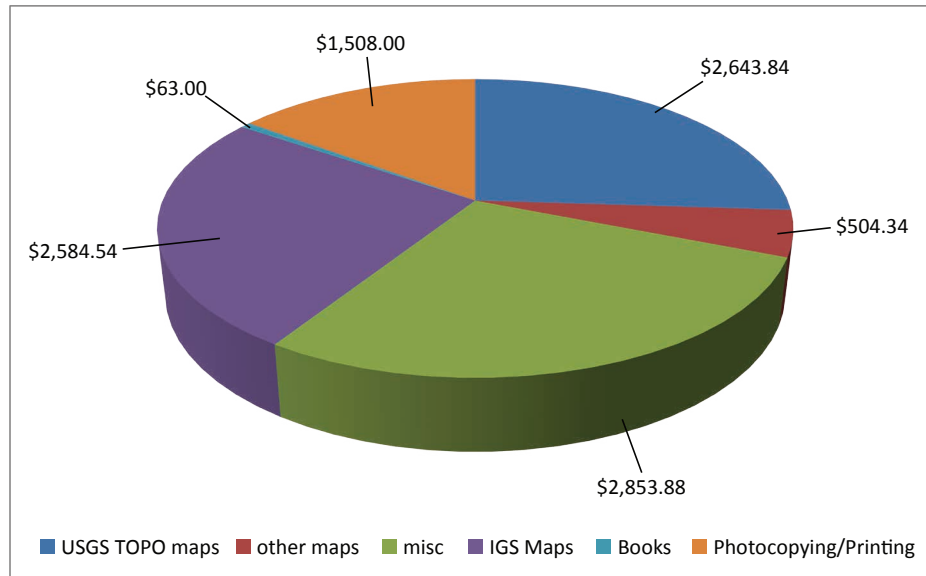
Publications

In FY 2016, our topographic maps outsold other types of publications, accounting for over 30 percent of total sales. Since its release in 2012, the Geologic Map of Idaho has continued to be the single biggest seller of IGS-produced publications. Nearly all publications are available for free download on our website.

Total Publication Sales Comparison Fiscal Years 2010-2016



Publication Sales in Dollars



Overview: All Sales Categories Fiscal Years 2011-2016

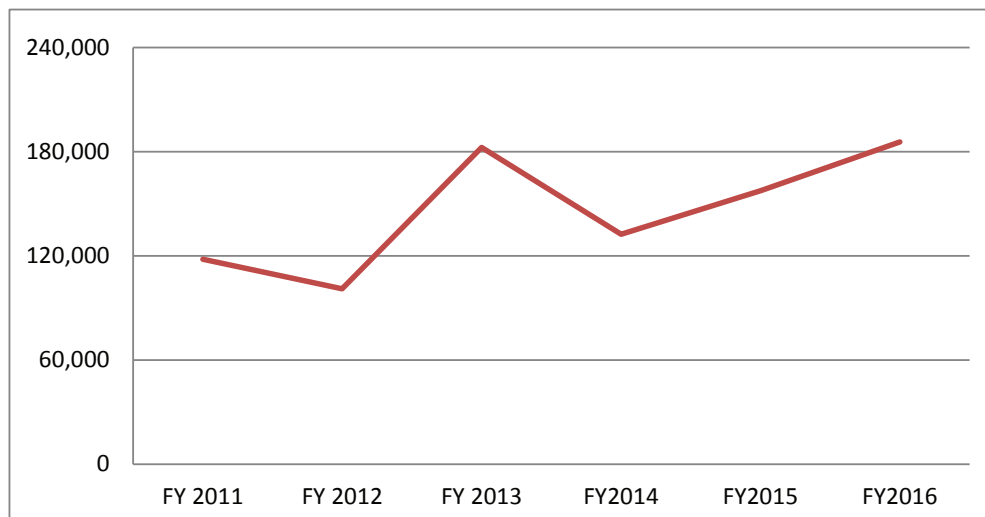


Website

www.idahogeology.org

The Idaho Geological Survey 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. Obtaining geologic information on the IGS website has been simplified through search engines, including web map applications. This year, an aggregate web map application was added to the IGS web map. Thousands of additional mine documents were also added to the download capabilities of the mine and prospect web app service. More than 11,000 visitors used these web map applications to explore Idaho. In FY 2016, 398,400 visits were logged on the website and users downloaded 185,635 products. Ten new Survey publications were posted on the website this year.

Product Downloads



Social Media

The Idaho Geological Survey (IGS) has maintained a social media presence on Facebook and Twitter (@IDGeoSurvey) since December 2013. Social Media gives IGS the ability to reach a broader nontraditional audience. IGS uses social media to announce new IGS publications, give details on statewide geology related activities, post general geoscience information, and post job announcements. Through FY2016 IGS has 471 Twitter followers.

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. Eight 7.5' geologic maps were digitized (as stand-alone or compilation efforts) and seven geologic maps were published this year. All are available as printed products or can be viewed free on the web. As of this year, the lab is capturing new geologic map data in the NCGMP09 format using ArcGIS.

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. These design changes, for both historic and active wells, increase our ability to use oil and gas data to answer questions and solve down-hole issues across the state. Our new digital map titled 'Southwestern Idaho Natural Gas Play' reflects these updates and can be found on our website.
- 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 6,500 mine maps and other support documents related to mine properties are now available via the mines web map application.

- A database of aggregate material was designed, created, and added as an application to the IGS Web Map.
- 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 Deadwood River, Idaho City, and Murphy 30 x 60 minute geologic map data sets are now available for download in this standard. In addition, the lab is now capturing new geologic map data in a NCGMP09-schema geodatabase.

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 distributed Earth Science Teachers Toolkits at the annual Idaho Science Teachers Association meeting in Rexburg, Idaho and delivered fifty additional Earth Science Education Week toolkits to earth science and physical science teachers in northern Idaho. The Survey also participated in the “Geologic Map Day” event during Earth Science week by highlighting the recently published map of Bonner’s Ferry East on the IGS website, through a University of Idaho press release, and via Twitter and Facebook. The IGS has also given presentations and demonstrations to elementary students in the local area per teacher request. We are increasing our outreach with a dedicated email and mailing list to provide the latest geology news and recent map publications in the state to earth science and physical science teachers and geology enthusiasts.

PUBLICATIONS AND ACTIVITIES

Publications

Database of Select Aggregate Material Sources for Idaho (version 1.2015.1), by Christopher A. Tate, Virginia S. Gillerman, and Loudon R. Stanford: Idaho Geological Survey Digital Database DD-9, 2015.

Geologic Map of the Heise Quadrangle, Bonneville, Jefferson, and Madison Counties, Idaho, by William M. Phillips, Daniel K. Moore, Dennis M. Feeney, Glenn F. Embree: Idaho Geological Survey Digital Web Map 176, scale 1:24,000, 2016.

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 Digital Web Map 174, scale 1:24,000, 2016.

Geologic Map of the Midvale Quadrangle, Washington County, Idaho, by Dennis M. Feeney and William M. Phillips: Idaho Geological Survey Digital Web Map 179, scale 1:24,000, 2016.

Geologic Map of the Montour Quadrangle, Boise and Gem Counties, Idaho, by Reed S. Lewis, William M. Phillips, Dennis M. Feeney, Keegan L. Schmidt, and Spencer H. Wood: Idaho Geological Survey Digital Web Map 177, scale 1:24,000, 2016.

Geologic Map of the Poplar Quadrangle, Bonneville County, Idaho, by William M. Phillips, Daniel K. Moore, and Dennis M. Feeney: Idaho Geological Survey Digital Web Map 175, scale 1:24,000, 2016.

Geologic Map of the Rexburg Quadrangle, Madison County, Idaho, by William M. Phillips, Glenn F. Embree, and John A. Welhan: Idaho Geological Survey Digital Web Map 178, scale 1:24,000, 2016.

Geologic Maps of the Moody, White Owl Butte, and Wright Creek Quadrangles, Madison and Teton Counties, Idaho, by Glenn F. Embree, Daniel K. Moore, William M. Phillips, and Harold J. Prostka: Idaho Geological Survey Technical Report 16-2, 4 plates, scale 1:24,000, booklet, 2016.

- Gigawatt-Scale Power Potential of a Magma-Supported Geothermal System in the Fold and Thrust Belt of Southeast Idaho*, by John A. Welhan: Proc., 40th Workshop on Geothermal Reservoir Engineering, Stanford University, Stanford, California, SGP-TR-209, 14 p., 2016.
- Idaho Mining and Exploration, 2013*, by Virginia S. Gillerman and Earl H. Bennett: Idaho Geological Survey Staff Report 15-2, 30 p., 2015.
- Metamorphic History of the Belt Supergroup and Underlying Paleoproterozoic Basement Rocks in the Western Part of the Clearwater Complex, Idaho*, by Julia A. Baldwin, Reed S. Lewis, Jeffrey D. Vervoort, and Clay D. McDonie, in Reed S. Lewis and Keegan L. Schmidt, editors, *Exploring the Geology of the Inland Northwest: Geological Society of America Field Guide 41*, p. 251-264, 2016.
- Neoarchean and Paleoproterozoic Crystalline Basement Rocks of North-central Idaho: Constraints on the Formation of Western Laurentia*, by Jeffrey D. Vervoort, Reed S. Lewis, Chris Fisher, Richard M. Gaschnig, Andrew C. Jansen, and Rachel Brewer: *Geological Society of America Bulletin*, v. 128, p. 94-109, 2016.
- Mesozoic Tectonics West of the Accretionary Boundary in West-central Idaho: A Road Log Along U.S. Highway 95 Between Moscow and New Meadows, Idaho*, by Keegan L. Schmidt, Keith D. Gray, Reed S. Lewis, Cody J. Steven, and Vince Isaacson, in Reed S. Lewis and Keegan L. Schmidt, editors, *Exploring the Geology of the Inland Northwest: Geological Society of America Field Guide 41*, p. 175-210, 2016.
- Origin and Potential Geothermal Significance of China Hat and Other Late Pleistocene Topaz Rhyolite Lava Domes of the Blackfoot Volcanic Field, SE Idaho*, by M. McCurry, D. M. Pearson, J.A. Welhan, S.K. Natwotniak and M. Fisher, *Geothermal Resources Council Transactions*, v. 39, p. 35-47, 2015.
- Thermal and Geochemical Anomalies in the Eastern Snake River Plain Aquifer: Contributions to a Conceptual Model of the Proposed FORGE Test Site*, by John A. Welhan: Proc., 40th Workshop on Geothermal Reservoir Engineering, Stanford University, Stanford, California, SGP-TR-209, 20 p., 2016.
- Thermal and Trace-Element Anomalies in the Eastern Snake River Plain Aquifer: Toward a Conceptual Model of the EGS Resource*, by John A. Welhan: *Geothermal Resources Council Transactions*, v. 39, p. 363-375, 2015.

Abstracts

- Eocene Deformation at Tubbs Hill of Coeur d'Alene, Idaho, Southeast Priest River Complex*, by Niki E. Wintzer and Reed S. Lewis: Geological Society of America Abstracts with Programs, v. 48, no. 6, 2016.
- Geologic Map of the Western Part of the Salmon 30' X 60' Quadrangle and Regional Stratigraphic Implications*, by Russell F. Burmester, Reed S. Lewis, Loudon R. Stanford, Mark D. McFadden, Kurt L. Othberg, and Jeff Lonn: Geological Society of America Abstracts with Programs, v. 48, no. 6, 2016.
- Geothermal Potential of the Fold and Thrust Belt of Southeast Idaho*, by John A. Welhan and Renee L. Breedlovestrout: Geological Society of America Abstracts with Programs, v. 48, no. 6, 2016.
- Island-arc Serpentinite in West-central Idaho, Analog for Modern-day Marianas Serpentinite?*, by Cody J. Steven and Reed S. Lewis: Geological Society of America Abstracts with Programs, v. 48, no. 6, 2016.
- Landscape Response to Late Pleistocene Climate Change in NW Argentina; Sediment Flux Modulated by Basin Geometry and Connectivity*, by T.F. Schildgen, R.A.J. Robinson, Sara Savi, W.M. Phillips, J.Q.G. Spencer, Bodo Bookhagen, Dirk Scherler, Stefanie Tofelde, R.N. Alonso, P.W. Kubik, S.A. Binnie, and M.R. Strecker: Journal of Geophysical Research-Earth Surface, v. 121, no. 2, p. 392-414, 2016.
- Lead Isotope Data for the Murray Au-Ag Subdistrict of the Coeur D'Alene Pb-Zn-Ag Mining District, with Comparison to the Stibnite Mining District and Lemhi Pass Region, Idaho*, by Virginia S. Gillerman, Fred W. Brackebusch, and Mark D. Schmitz: Geological Society of America Abstracts with Programs, v. 48, no. 6, 2016.
- Major- and Trace-Element Characteristics of Archean and Paleoproterozoic Basement Rocks Near Coeur d'Alene, Idaho*, by Andrew M. Buddington and Reed S. Lewis: Geological Society of America Abstracts with Programs, v. 48, no. 6, 2016.
- Mesoproterozoic Lemhi Strata Represent Immense Alluvial Aprons that Prograded Northwest into the Belt Sea, Idaho and Montana*, by Jeffrey D. Lonn, Russell F. Burmester, Reed S. Lewis, and Mark D. McFadden: Geological Society of America Abstracts with Programs, v. 48, no. 6, 2016.

Neoproterozoic and Paleozoic Strata in the Stibnite-Edwardsburg Area, Central Idaho, by Reed S. Lewis, Vincent H. Isakson, David E. Stewart, Mark D. Schmitz, and Darin Schwartz: Geological Society of America Abstracts with Programs, v. 48, no. 6, 2016.

Onion-Like Map Pattern and Basement-Involved Thrusting in the Boehls Butte-Marble Creek Area of Northern Idaho, by Reed S. Lewis, Russell F. Burmester, Julia A. Baldwin, Jeffrey D. Vervoort, and Clay McDonie: Geological Society of America Abstracts with Programs, v. 48, no. 6, 2016.

Preliminary Characterization and Interpretation of a Thick Rhyolite Ignimbrite in Borehole USGS142 on the Idaho National Laboratory, Eastern Snake River Plain, by Michael McCurry, Ryan C. Goldsby, William Lochridge, William R. Hackett, William M. Phillips, Evan Martin: Geological Society of America Abstracts with Programs. Vol. 48, No. 6, 2016

Reconnaissance Mapping of the Eocene Thunder Mountain Caldera Complex, Central Idaho, by David E. Stewart, Reed S. Lewis, and Eric D. Stewart: Geological Society of America Abstracts with Programs, v. 48, no. 6, 2016.

Refined Stratigraphy of the Weiser Embayment, West-central Idaho, by Dennis M. Feeney, Reed S. Lewis, Vincent H. Isakson, Mark D. Schmitz, and Stanley A. Mertzman: Geological Society of America Abstracts with Programs, v. 48, no. 6, 2016.

Reservoir Characterization and Petroleum Assessment of an Active Gas and Liquid Condensate Field in Southwestern Idaho, by Renee L. Breedlovestrout, and Michael E. Ratchford: Geological Society of America Abstracts with Programs, v. 48, no. 6, 2016.

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 Christopher Dail, Virginia S. Gillerman, Reed S. Lewis, David E. Stewart, and Eric D. Stewart: Geological Society of America Abstracts with Programs, v. 48, no. 6, 2016.

Surface Processes Driven by Plume-lithosphere Interaction: Using Cosmogenic ¹⁰Be Radionuclides with a River Incision Model to Study Late Miocene Landscape Evolution in Central Idaho, by Jeffrey E. Larimer, Brian J. Yanites, William M. Phillips, and Eric Mittelstaedt: Geological Society of America Abstracts with Programs. Vol. 48, No. 6, 2016.

The 2015 Sandpoint, Idaho, Earthquake Sequence: A Constraint on Basin-and-Range Style Extension on the Western Portion of the Lewis and Clark Fault Zone, Northern Rockies, U.S.A., by Daisuke Kobayashi, Kenneth Sprenke, Michael Stickney, and William Phillips: American Geophysical Union Fall Meeting, Abstract S11A-2761, 2015.

The April 2015 Sandpoint, Idaho, Earthquake Sequence: A Spatial Constraint on Basin-and-Range Style Extension on the Western Portion of the Lewis and Clark Fault Zone, by Daisuke Kobayashi, Kenneth F. Sprenke, Michael C. Stickney, and, William M. Phillips: Geological Society of America Abstracts with Programs. Vol. 48, No. 6, 2016.

Unravelling the Western Clearwater Complex: New Insights from U-Pb Geochronology, by Clay D. McDonie, Jeff D. Vervoort, Reed S. Lewis, and Julia A. Baldwin: Geological Society of America Abstracts with Programs, v. 48, no. 6, 2016.

Reports

Deer Valley Subdivision Hearing Technical Opinion, by John A. Welhan: Bannock County Planning and Zoning Commission, Pocatello, August.

Final Technical Report, National Geological and Geophysical Data Preservation Program, by Reed S. Lewis: Deliverable to U.S. Geological Survey National Geologic and Geophysical Data Preservation Program, December.

Geologic Map of the Agency Creek Quadrangle, Lemhi County, Idaho, by Russell F. Burmester, Kurt L. Othberg, Loudon R. Stanford, Reed S. Lewis, and Jeff D. Lonn: Idaho Geological Survey report to the U.S. Geological Survey for STATEMAP, scale 1:24,000, May.

Geologic Map of the Hawley Gulch Quadrangle, Bonneville and Madison Counties, Idaho, by William M. Phillips, Renee L. Breedlovestrout, and Dennis M. Feeney: Idaho Geological Survey report to the U.S. Geological Survey for STATEMAP, scale 1:24,000, May.

Geologic Map of the Midvale Hill 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.

Geologic Map of the Paddock Valley Reservoir Quadrangle, Payette and Washington Counties, Idaho, by Dennis M. Feeney, Spencer H. Wood, Ander J. Sundell, Reed S. Lewis, and Renee L. Breedlovestrout: Idaho Geological Survey report to the U.S. Geological Survey for STATEMAP, scale 1:24,000, May.

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: Deliverable to U.S. Geological Survey National Geologic and Geophysical Data Preservation Program, March.

Precious and Base Metal Deposits of the Coeur d'Alene Mining District, by Chris Dail and Virginia Gillerman, with contributions from John Etienne and Grant Brackebusch: Unpublished Field Trip Guidebook for Geological Society of America Rocky Mountain Section Trip #11, 66 p., 2016.

Thermal and Geochemical Anomalies in the Eastern Snake River Plain Aquifer: Contributions to a Conceptual Model of the Proposed FORGE Test Site, by John A. Welhan: Final Project Report, LDRD / CAES project, October.

Presentations

A New Look at the Weiser Embayment Volcanics and Related Tertiary Sedimentation, New Plymouth to Cambridge, Idaho, by Dennis M. Feeney: Columbia Basin Geological Society, Spokane, Washington, December.

An Overview of the Idaho Geological Survey, by Ed Ratchford: Center for Higher Education, Idaho Falls, April.

An Overview of the Idaho Geological Survey, by Ed Ratchford: Idaho Water Center, Boise, April.

An Overview of the Idaho Geological Survey, by Ed Ratchford: North Idaho College, Coeur d'Alene, April.

Bannock County Commission Study Session, Fielding Questions About the County's Proposed Groundwater Protection Ordinance, by John A. Welhan: Bannock County Courthouse, April.

Current Research Activities, by John A. Welhan: Idaho State University Geosciences G6601, Advanced Physical Geology, guest lecture, Pocatello, November.

- Deer Valley Subdivision Hearing Oral Testimony*, by John A. Welhan: Bannock County Planning and Zoning Commission, Pocatello, August.
- Geologic Data and Web Access at the Idaho Geological Survey*, by Loudon R. Stanford: GIS Day, University of Idaho, Moscow, November.
- Geothermal Potential of the Fold and Thrust Belt of Southeast Idaho*, by John A. Welhan and Renee Breedlovestrout: Geological Society of America Rocky Mountain Section Meeting, Moscow, May.
- Gigawatt-Scale Power Potential of a Magma-Supported Geothermal System in the Fold and Thrust Belt of Southeast Idaho*, by John A. Welhan: Stanford Geothermal Workshop, Stanford University, Stanford, California, February.
- Idaho Mining, 2015*, by Virginia S. Gillerman: Lecture to Ore Deposits Class, Boise State University, Boise, February.
- Idaho Mining and Exploration, 2015*, by Virginia S. Gillerman: American Exploration and Mining Association, Spokane, Washington, December.
- Idaho Mining and Geology, 2015*, by Virginia S. Gillerman: Timberline High School Geology Classes, Boise, December.
- Integration of Social Perceptions, Behaviors, and Economic Valuations of Groundwater Quality Following Exurban Development*, by D. Larson, S. Godsey, C. Ohr, J. Welhan, K. Lohse, S. Kobs-Nawtoniak, D. Lybecker, R. Hale and J. Stoutenborough: American Geophysical Union Fall Meeting, San Francisco, California, December.
- Mining in Idaho: Past and Present*, by Virginia S. Gillerman and Jeff Root: AARP New Knowledge Adventures Treasure Valley, Boise, November.
- Lead Isotope Data for the Murray Au-Ag Subdistrict of the Coeur D'Alene Pb-Zn-Ag Mining District, with Comparison to the Stibnite Mining District and Lemhi Pass Region, Idaho*, by Virginia S. Gillerman: Geological Society of America Rocky Mountain Section Meeting, Moscow, May.
- Liquefaction Susceptibility Mapping in Coeur d'Alene Area and Challis Earthquake Swarm Continues*, by William M. Phillips: Seismic Technical Working Group, Idaho Bureau of Homeland Security, Boise, October.
- Neoproterozoic and Paleozoic Strata in the Stibnite-Edwardsburg Area, Central Idaho*, by Reed S. Lewis, Vincent H. Isakson, David E. Stewart, Mark D. Schmitz, and Darin Schwartz: Geological Society of America Rocky Mountain Section Meeting, Moscow, May.

Mining in 21st Century: Idaho, by Virginia S. Gillerman, Moderator and Presenter: Panel Discussion: Idaho Section, American Water Resources Association, Boise, February.

Recommendations Arising from the South Ross Fork Basin Ground Water Report and Implications for Water Users, by John A. Welhan: Fort Hall Water Commission, Fort Hall Reservation, Fort Hall, March.

Redefined Stratigraphy of the Weiser Embayment, West-central Idaho, by Dennis M. Feeney, Reed S. Lewis, Vince H. Isakson, Mark D. Schmitz, and Stanley A. Mertzman: Geological Society of America Rocky Mountain Section, Moscow, May.

Seven Steps to Earthquake Safety for College Students and Great Idaho Shakeout, by William M. Phillips: Introduction to Physical Geology and Introduction to Physical Geology for Science Majors classes, University of Idaho, Moscow, October.

Rare Earth Elements: Modern Uses and Geology, by Virginia S. Gillerman: Idaho Museum of Mining and Geology, Boise, September.

The Water Well Drilling Report: A Source of Information, Insight and Value, by John A. Welhan: Idaho Ground Water Association Well Driller's Certification workshop, Fort Hall, March.

Thermal and Geochemical Anomalies in the Eastern Snake River Plain Aquifer: Contributions to a Conceptual Model of the Proposed FORGE Test Site, by John A. Welhan: Stanford Geothermal Workshop, Stanford University, Stanford, California, February.

Thermal and Trace-Element Anomalies in the Eastern Snake River Plain Aquifer: Toward a Conceptual Model of the EGS Resource, by John A. Welhan: Geothermal Resources Council Annual Meeting, Reno, Nevada, September.

Thermal Waters in the ESRPA and Geochemical Constraints on a Hydrogeologic Conceptual Model, by John A. Welhan: Snake River Geothermal Workshop and FORGE Project Meeting, Idaho Falls, July.

Web Products

IWeb Application for Select Aggregate Material Sources for Idaho, by Christopher Tate, Loudon R. Stanford, and Dustin Thomas: Idaho Geological Survey, September.

Update and Redesign of the Southwestern Idaho Oil and Gas Database to Include Web Delivery of New Wells, by Renee L. Breedlovestrout and Loudon Stanford: IGS Energy Tab: <http://www.idahogeology.org/DrawOnePage.asp?PageID=228>, December.

Operational Improvements

Set-up of Boise Satellite Office in Expanded Quarters (Suite 201, Water Center), by Michael E. Ratchford and Virginia S. Gillerman: Idaho Geological Survey and University of Idaho, Boise, August and December.

New Geologic Map Digitizing Protocol Operational and Documentation Complete for IGS Mapping in ArcGIS Using the NCGMP09 Standard, by Loudon R. Stanford: Idaho Geological Survey, July.

Media Interviews

Another Earthquake Swarm Shake East-central Idaho, Associated Press, <https://www.ksl.com/?sid=37724357>, December 11, 2015 (W.M. Phillips).

Idaho Geological Survey, UI Department of Geological Sciences Host Great Idaho ShakeOut Activities, University of Idaho News, <http://www.uidaho.edu/news/news-articles/news-releases/2015-October/101315-shakeout>, October 13, 2015 (W.M. Phillips).

Map Data for Imagery, National Geographic, submitted GIS data for Yellowstone hot spot traverse, May 2016 (D.M. Feeney).

Recent Northwest Storms Bring Higher Risk For Landslides, NW News Network, <http://nwnewsnetwork.org/post/recent-northwest-storms-bring-higher-risk-landslides>, December 8, 2015 (M.E. Ratchford and W.M. Phillips).

The Great Idaho ShakeOut, Northwest Public Radio, <https://idahopublicradio.wordpress.com/2015/10/15/the-great-idaho-shakeout/> October 15, 2015 (W.M. Phillips).

Professional Activities

Adjunct Graduate Faculty, Boise State University (V.S. Gillerman).

Affiliate Faculty, University of Idaho (R. L. Breedlovestrout, V.S. Gillerman, R.S. Lewis, W.M. Phillips, M.E. Ratchford, J.A. Welhan).

Affiliate Faculty, Washington State University (R.S. Lewis and W.M. Phillips).

Affiliate Faculty, Idaho State University (J.A. Welhan).

Committee Member, Idaho Ground Water Monitoring Technical Committee (J.A. Welhan).

Coordinator and Leader, “SedHeat” Proposal Development Workshop, Hot Sedimentary Geothermal Systems, Center for Advanced Energy Studies (J.A. Welhan).

Exhibit Chair, Geological Society of America Rocky Mountain Section Meeting, May (D.M. Feeney).

Fellow, Society of Economic Geologists (V.S. Gillerman).

Field Logistics Coordinator, Geological Society of America Rocky Mountain Section Meeting, May (R. L. Breedlovestrout).

Field Trip Member, Geology of the Wallowa Terrance in North Hells Canyon, Geological Society of America Rocky Mountain Section Meeting, May (R. L. Breedlovestrout).

Field Trip Member, Accretionary Tectonics of West-Central Idaho, Geological Society of America Rocky Mountain Section Meeting, May (R. L. Breedlovestrout).

Field Trip Member, Monitor Mine, July (R.S. Lewis)

Field Trip Member, Tobacco Root Geological Society, August (R.S. Lewis).

Field Trip Leader, Belt Association, Coeur d’Alene, Idaho, October (R.S. Lewis).

Field Trip Leader, SedHeat Proposal Development Workshop, Center for Advanced Energy Studies, August (J.A. Welhan).

Host, Idaho Geological Survey display, American Exploration and Mining Association Exhibitor Hall, December (C.A. Tate).

Idaho Geologist-in-Training (D.M. Feeney).

Idaho Professional Geologist (R.S. Lewis, M.E. Ratchford, W.M. Phillips).

Idaho Professional Geologist license (V.S. Gillerman and D.M. Feeney).

Manager, Idaho Geological Survey Twitter feed (D.M. Feeney).

Member, American Association of Petroleum Geologists Professional Women in Earth Sciences Committee (PROWESS) (R.L. Breedlovestrout).

Member, American Association of Professional Geologists (R.L. Breedlovestrout).

Member, American Association of Women Geoscientists (R.L. Breedlovestrout).

Member, American Exploration and Mining Association (V.S. Gillerman and R.S. Lewis).

Member, American Geophysical Union (W.M. Phillips).

Member, Geological Society of America (R.L. Breedlovestrout, V.S. Gillerman, R.S. Lewis, W.M. Phillips).

Member, Geothermal Resources Council (J.A. Welhan).

Member, Idaho Ground Water Monitoring Technical Committee, Nitrate Priority-Area Subcommittee (J.A. Welhan).

Member, Tobacco Root Geological Society (R.S. Lewis and W.M. Phillips).

Member, Western States Seismic Policy Council (W.M. Phillips).

Minerals Committee Chair, American Association of State Geologists (M.E. Ratchford).

Panelist, Roy J. Shlemon Mentor Program in Applied Geoscience Luncheon, Geological Society of America Rocky Mountain Section Meeting, May (R.L. Breedlovestrout).

Participant, American Exploration and Mining Association annual meeting, Spokane, Washington, December (R.S. Lewis and V.S. Gillerman).

Participant, Boise Section of SME Meetings (V.S. Gillerman).

Participant, Center for Advanced Energy Studies University of Wyoming Meet and Greet event, January (John A. Welhan).

Participant, CAES Water-Energy Nexus Partnership Meeting, October (John A. Welhan).

Participant, Committee for Production of Emergency Response to Earthquakes Handbook, Western States Seismic Policy Council teleconferences (W.M. Phillips).

Participant, Executive Committee, Idaho State Hazard Mitigation Plan teleconference, November (W.M. Phillips).

Participant, Geology and Geohazards Community of Use, US TOPO meeting, August (L.R. Stanford).

Participant, GIS Day, University of Idaho, November (L.R. Stanford).

Participant, Idaho Emergency Operations Center, Emergency Support Function Coordinating Group teleconference, Idaho Bureau of Homeland Security, Boise, October (W.M. Phillips).

Participant, Idaho Environmental Forum Meetings (V.S. Gillerman).

Participant, Local Emergency Planning Committee, Nez Perce County, Lewiston, September (W.M. Phillips).

Participant, Mine Safety and Health Administration Refresher Training, Boise, November (V.S. Gillerman).

Participant, National Science Foundation Survey on Grant Proposal Merit Review Process, November (W.M. Phillips).

Participant, Seismic Technical Working Group, Idaho Bureau of Homeland Security, Boise, October (W.M. Phillips).

Participant, Tobacco Root Geological Society Field Conference, Elliston, Montana, July (W.M. Phillips).

Participant, Yellowstone Volcano Observatory Consortium, Bi-monthly Teleconferences (W.M. Phillips).

Reviewer, Geological Society of America manuscript, May (J.A. Welhan).

Reviewer, Geosphere manuscript, May (J.A. Welhan).

Reviewer, Geothermal Energy Science Journal manuscript, October (J.A. Welhan).

Session Chair, Energy Resources and New Plays in Western North America, Geological Society of America Rocky Mountain Section Meeting, May (R. L. Breedlovestrout).

Technical Advisor, Governor's Staff Meetings on Mineral Withdrawal Related to Greater Sage Grouse, Boise, October to December (V.S. Gillerman).

Technical Advisor, Idaho State University Geosciences Ground-water Study of Pharmaceuticals in Drinking Water (J.A. Welhan).

*Technical Advisor, Idaho State University's National Science Foundation
"Opportunities for Educational Diversity in the Geosciences" (J.A. Welhan).*

*Technical Advisor, Shoshone-Bannock Tribes' Water Resources Department
(J.A. Welhan).*

*Technical Advisor, Shoshone-Bannock Tribes' Water Resources Department
(J.A. Welhan).*

Vice President, Tobacco Root Geological Society (W.M. Phillips).

Graduate Thesis Committees

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

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

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

Clay McDonie, M.S. Geology, Washington State University (R.S. Lewis).

Cody Parker, M.S. Geology, University of Idaho (W.M. Phillips).

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 1, 2014-
June 30, 2017, \$70,000).*

*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 3: R.S. Lewis
(Idaho Department of Lands, Dec. 2014-February 2017, \$122,560).*

*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 in the Rexburg, Weiser, and Salmon areas: R.S. Lewis, W.M.
Phillips, and D.M. Feeney (U.S. Geological Survey STATEMAP
Program, June 2016-May 2017, \$167,755).*

Surficial and Bedrock Mapping of Burnt Log Corridor: V.S. Gillerman and R.S. Lewis (Midas Gold, Inc., June 1, 2016-September 30, 2017, \$27,277).

Seismic Site Class and Liquefaction Susceptibility Study of Portions of Kootenai County, Idaho: W.M. Phillips (Idaho Bureau of Homeland Security, March 1-August 31, 2015, \$9,349).

Snake River Plain Heat Flux Estimation via Groundwater Heat Transport Modeling: J.A. Welhan, co-PI (DOE-INL LDRD, June, 2015-October 2015, \$24,600).

US Geological Survey FY2014 Data Preservation Program: R.S. Lewis (United States Geological Survey, September 2014-September 2015, \$15,150).

US Geological Survey FY2015 Data Preservation Program: R.S. Lewis (United States Geological Survey, August 2015-August 2016, \$22,025).

US Geological Survey FY2015-2019 Reservoir Characterization and Petroleum Assessment of Miocene Sedimentary Rocks, Southwestern Idaho: M.E. Ratchford (United States Geological Survey, August 2015-August 2019, \$75,000).