
Fiscal Year 2015

On the cover: A portion of the Geologic Map of the East Half of the Bonners Ferry 30 x 60 Minute Quadrangle, Idaho and Montana.
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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.
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.
# 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**  
  Senior Geologist, Moscow
- **Jane S. Freed**  
  Cartographer, Moscow
- **Dean L. Garwood**  
  Senior Geologist, 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

- **Glenda K. Bull**  
  Administrative Specialist
- **Russell F. Burmester**  
  Geologist
- **Skye W. Cooley**  
  Geologist
- **Collette K. Gantenbein**  
  Research Support
- **Jesse A. Hinshaw**  
  Work Study-Research Support
- **Susan J. Jones**  
  Research Support
- **Alyson R. Kral**  
  Technical Records Specialist
- **Mark D. McFadden**  
  Geologist
- **Daniel K. Moore**  
  Geologist
- **Kurt L. Othberg**  
  Geologist
- **Matthew A. Peterson**  
  Work Study
- **Duncan B. Rightler**  
  Work Study
- **Keegan L. Schmidt**  
  Geologist
- **Darin M. Schwartz**  
  Research Support
- **David E. Stewart**  
  Geologist
- **Eric D. Stewart**  
  Geologist
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.

<table>
<thead>
<tr>
<th>Category</th>
<th>Beginning Balance</th>
<th>Income or Appropriation</th>
<th>Actual</th>
<th>Expense</th>
<th>Ending Balance</th>
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</thead>
<tbody>
<tr>
<td>Personnel</td>
<td>$777,700.00</td>
<td>$694,820.95</td>
<td>$694,820.95</td>
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<tr>
<td>Operating Expense</td>
<td>$22,000.00</td>
<td>$52,550.04</td>
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<tr>
<td>Capital Outlay</td>
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<td>$73,729.01</td>
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<tr>
<td>Total</td>
<td>$821,100.00</td>
<td>$379,093.72</td>
<td>$821,100.00</td>
<td>$821,100.00</td>
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<tr>
<td>U/I Personnel Funds</td>
<td>$82,573.99</td>
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<td>$42,931.03</td>
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<td>$81,293.28</td>
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<td>Y Accounts</td>
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<td>$18,000.00</td>
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<td>$115,048.83</td>
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<td>F and A Accounts</td>
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<td>$379,093.72</td>
<td>$379,093.72</td>
<td>$379,093.72</td>
<td>$379,093.72</td>
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<td>Grants and Contracts</td>
<td>$193,725.57</td>
<td>$878,768.02</td>
<td>$1,200,193.72</td>
<td>$1,255,245.20</td>
<td>$182,751.61</td>
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<td>TOTAL</td>
<td>$1,255,245.20</td>
<td>$2,766,885.49</td>
<td>$3,050,591.87</td>
<td>$3,409,906.47</td>
<td>$182,751.61</td>
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</tbody>
</table>

Sources of Funding

- State Appropriations: 59%
- Federal Grants and Contracts: 15%
- State Agency Grants and Contracts: 9%
- Industry Grants and Contracts: 3%
- General Operating: 8%
- Y Accounts: 6%
- F and A Accounts: 8%
### Trends in Personnel Costs and Grants and Contracts

#### Fiscal Years 2007-2015

<table>
<thead>
<tr>
<th>Year</th>
<th>Personnel Costs</th>
<th>Grants and Contracts</th>
</tr>
</thead>
<tbody>
<tr>
<td>FY 07</td>
<td>$802,200</td>
<td>$462,094</td>
</tr>
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<td>FY 08</td>
<td>$872,286</td>
<td>$456,372</td>
</tr>
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<td>FY 09</td>
<td>$860,034</td>
<td>$468,971</td>
</tr>
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<td>FY 10</td>
<td>$730,840</td>
<td>$598,421</td>
</tr>
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<td>FY 11</td>
<td>$698,932</td>
<td>$644,803</td>
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<td>FY 12</td>
<td>$625,115</td>
<td>$635,580</td>
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<td>FY 13</td>
<td>$618,936</td>
<td>$874,357</td>
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<td>FY 14</td>
<td>$573,945</td>
<td>$371,023</td>
</tr>
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<td>FY 15</td>
<td>$694,821</td>
<td>$379,094</td>
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</table>

The chart above illustrates the trends in personnel costs and grants and contracts from fiscal years 2007 to 2015.
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

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

<table>
<thead>
<tr>
<th>American Geological Institute</th>
<th>National Science Foundation, Geoscience Directorate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Association of American State Geologists</td>
<td>North Idaho College</td>
</tr>
<tr>
<td>Bannock County Groundwater Overlay Advisory Committee</td>
<td>Northwest Knowledge Network</td>
</tr>
<tr>
<td>Bannock County Planning and Zoning Department</td>
<td>Northwest Mining Association/AEMA</td>
</tr>
<tr>
<td>Belt Association</td>
<td>Oregon Department of Geology and Mineral Industries</td>
</tr>
<tr>
<td>Boise Section, Society of Mining Engineers</td>
<td>Oregon State University</td>
</tr>
<tr>
<td>Boise State University</td>
<td>Portneuf Watershed Partnership</td>
</tr>
<tr>
<td>Brigham Young University-Idaho</td>
<td>Shoshone-Bannock Tribal Water Resources Department</td>
</tr>
<tr>
<td>Center for Advanced Energy Studies</td>
<td>Schlumberger Petroleum Services</td>
</tr>
<tr>
<td>City of Pocatello Water Department, Planning Department, and Environmental Department</td>
<td>Spokane Community College</td>
</tr>
<tr>
<td>Energy and Geoscience Institute, Utah</td>
<td>Tobacco Root Geological Society</td>
</tr>
<tr>
<td>ETH Zurich</td>
<td>U.S. Army Corps of Engineers</td>
</tr>
<tr>
<td>Franklin and Marshall Department of Earth and Environment Sciences</td>
<td>U.S. Bureau of Land Management</td>
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<tr>
<td>Hecla Mining Company</td>
<td>U.S. Forest Service</td>
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<tr>
<td>Ice Age Floods Institute</td>
<td>U.S. Geological Survey—Advanced National Seismic System</td>
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<tr>
<td>Idaho Concrete and Aggregate Producers Association</td>
<td>U.S. Geological Survey—Idaho National Lab</td>
</tr>
<tr>
<td>Idaho Department of Environmental Quality</td>
<td>U.S. Geological Survey—Minerals Program</td>
</tr>
<tr>
<td>Idaho Department of Lands</td>
<td>U.S. Geological Survey—STATEMAP</td>
</tr>
<tr>
<td>Idaho Department of Water Resources</td>
<td>U.S. Geological Survey—US Topo</td>
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<tr>
<td>Idaho Environmental Forum</td>
<td>U.S. Geological Survey—Water Resources Division</td>
</tr>
<tr>
<td>Idaho Geospatial Council</td>
<td>U.S. Silver and Gold Inc.</td>
</tr>
<tr>
<td>Idaho Ground Water Monitoring Technical Committee</td>
<td>University of Alaska-Fairbanks</td>
</tr>
<tr>
<td>Idaho Historical Society</td>
<td>University of Idaho</td>
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<tr>
<td>Idaho Mining Association</td>
<td>University of Montana</td>
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<tr>
<td>Idaho Museum of Mining and Geology</td>
<td>University of Utah</td>
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<tr>
<td>Idaho National Laboratory</td>
<td>University of Wisconsin-Madison</td>
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<td>Idaho Public Television</td>
<td>Utah Geological Survey</td>
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<tr>
<td>Idaho Science Teachers Association</td>
<td>Utah State University</td>
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<tr>
<td>Idaho State Tax Commission</td>
<td>Valley County Local Emergency Planning Group</td>
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<td>Idaho State University</td>
<td>Wallace District Mining Museum</td>
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<td>Idaho Transportation Department</td>
<td>Washington Division Geology and Earth Resources</td>
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<td>IHS Energy</td>
<td>Washington State University</td>
</tr>
<tr>
<td>Inside Idaho</td>
<td>Western States Seismic Policy Council</td>
</tr>
<tr>
<td>Intermountain Forest Tree Nutrition Cooperative</td>
<td>Wyoming Geological Survey</td>
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<tr>
<td>Midas Gold Corporation</td>
<td>Yellowstone National Park</td>
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<td>Montana Bureau of Mines and Geology</td>
<td>Yellowstone Volcano Observatory</td>
</tr>
<tr>
<td>National Association of Geoscience Teachers</td>
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</tbody>
</table>
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.
Geologic Mapping Projects
1992-2015

New Mapping FY2015
New Mapping
Completed and In-Progress Projects
STATemap, edimap, and other partners: 1992-2014
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 bi-monthly YVO teleconference briefings. In the event of volcanic ash
FY2015 Idaho Earthquakes

Magnitude
- 0 - 2
- 2 - 3
- 3 - 4
- 4 - 4.9

Kootenai County seismic site class and liquefaction susceptibility study area

Long Valley seismic site class and liquefaction susceptibility study area
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 laboratory-based study of the alteration, geochronology, and mineral paragenesis of the gold-antimony-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-carbonate-sulfide 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.
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° 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.

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Publication Sales in Dollars

Overview: All Sales Categories FY 11-15

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</tr>
</tbody>
</table>
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


Abstracts


Reports


Presentations


*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.


*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.


*Hydrothermal Alteration, Mineralization and Geochronology of the Stibnite District, Idaho*, by Virginia S. Gillerman, Mark Schmitz, Vince


*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.


Web Products


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.


Media Interviews


**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).


*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).


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, 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, Geological Society of America Annual Meeting, Vancouver, B.C., October (V.S. Gillerman, R.S. Lewis).


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).


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


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**


*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).


Recruiting and Retaining Native American Students in the Geosciences: J.A. Welhan (subcontract to ISU, NSF, December 2011-August 2014, $17,122)


