# ANNUAL REPORT

## FISCAL YEAR 2021

IDAHO
GEOLOGICAL SURVEY

## On the Cover

Oblique aerial photograph of a rockfall on U.S. Highway 95 south of Riggins near milepost 188. The initial rockfall occurred July 3, 2020, followed by subsequent slope failures. Mitigation included scaling and blasting to stabilize this slope.

# Annual Report of the Idaho Geological Survey

## Fiscal Year 2021

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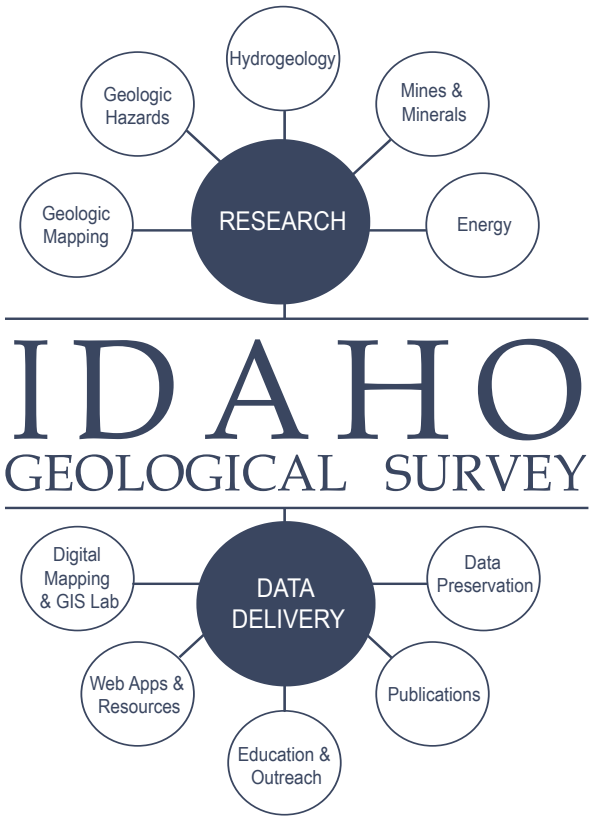
# INTRODUCTION

The Idaho Geological Survey (IGS) is a non-regulatory state agency that leads in the collection, interpretation, and dissemination of geologic and mineral data for Idaho. IGS is hosted by the University of Idaho. Formerly known as the Idaho Bureau of Mines and Geology, the agency has served the state since 1919.

## Mission

The Survey's mission is to provide the state with timely and relevant geologic information. Members of the IGS fulfill this mission through applied geologic research and strong collaborations with federal and state agencies, academia, and the private sector. IGS research focuses on geologic mapping, geologic hazards, hydrogeology, geothermal energy, oil and gas, and metallic and industrial minerals. The Survey's Digital Mapping Laboratory is central to compiling, producing, and delivering new digital geologic maps and publications for the agency. The IGS is also engaged in the dissemination of historic mining records, community service, and earth science education. As Idaho's population grows, demand is increasing for geologic and geospatial information related to energy, mineral, and water resource development, and landslide and earthquake hazards.



# Vision

IGS is committed to the advancement of geosciences and emphasizes the practical application of geology to benefit society. The Survey seeks to accomplish its responsibilities through research, service, education, and outreach.

# FY 2021 By the Numbers

**89** Collaborating partners

**16** Active awards

**7** Funding partners

**18** Publications

**18** Professional presentations

**7** Educational presentations

**3** Web products

**14** Reports

**21** Media interviews

# From the Director

It is with pride that I present you the IGS Annual Report for Fiscal Year (FY) 2021. It has been a challenging year on many fronts worldwide, yet I can confidently say that the Survey was able to weather the situation, perform superlatively, and exceed all expectations.

In a year of budget cuts and restrictions mandated by the exceptional circumstances of the ongoing pandemic, a conservative financial approach has allowed the Survey to complete its mandate, and a very successful extramural funding effort has guaranteed a large presence in the field and the acquisition of new scientific instrumentation.

Many staff members worked remotely for most of the year, adapting to a “new normal” quickly and efficiently. We discovered new meanings and uses for “porch sitting” and turned backyards into open-air workspaces. Everyone rose to the occasion and generously contributed to the success of the agency.

IGS onboarded four new staff members who bring new expertise and perspectives to the already diverse pool of technical skills. Dr. Nathan Hopkins is the new Manager of the Digital Mapping and GIS Lab, a core function of the Survey. Ben Bailey is a new addition to the lab as a GIS Analyst. Dr. Jess Starnes joined as Data Preservation Specialist and will assist the ever-growing effort of data preservation. Mary Tkach is the new Junior Geologist, assisting senior staff in the recent and expanding effort in critical minerals research. We are all working hard to guarantee that all grant-funded positions can extend long into the future in the service of the state.

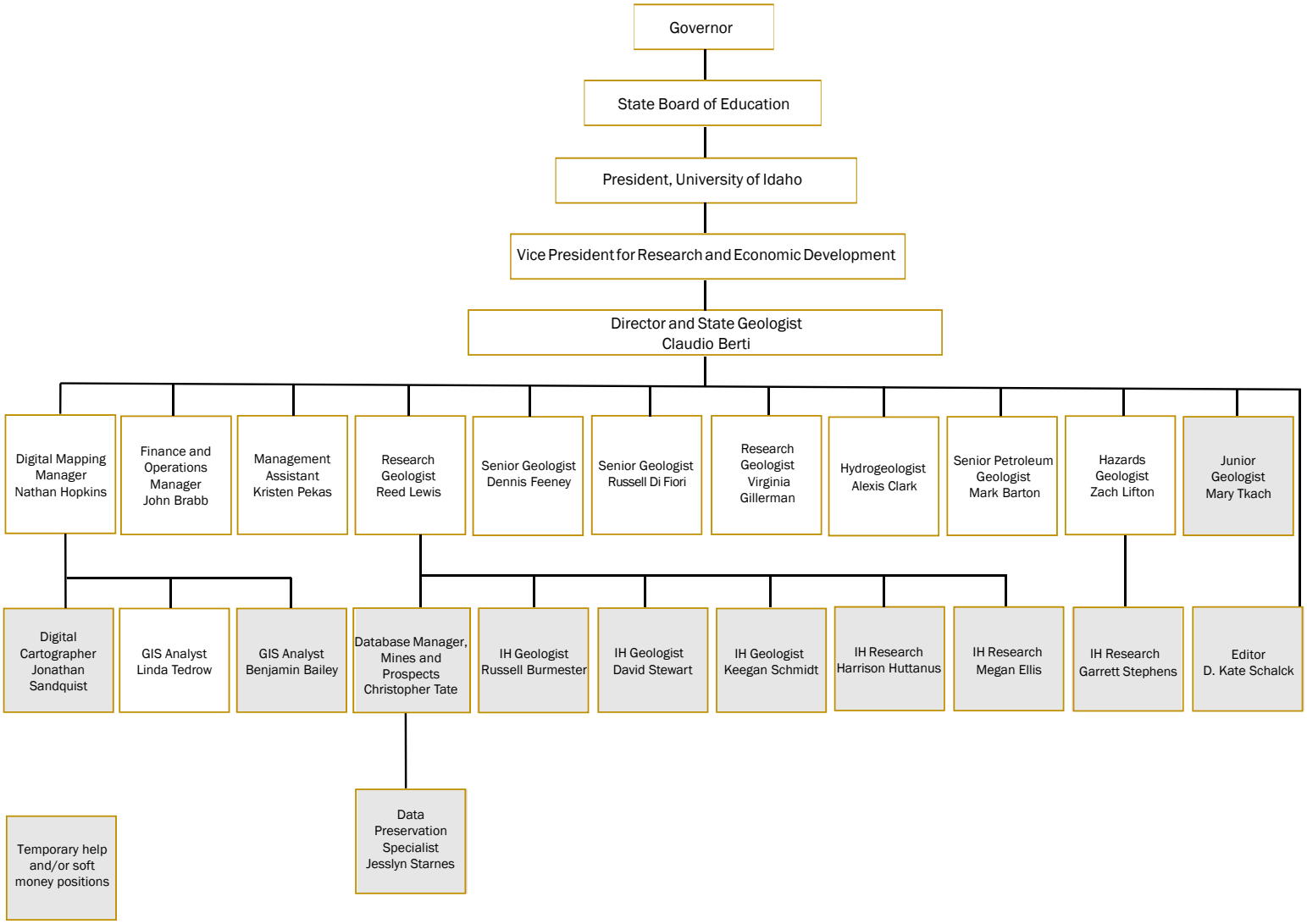
The year has also been characterized by excellent scientific progress: new maps have been completed, the statewide landslide inventory has been completed and published, and progress has been made in the active fault database. Hydrogeologic studies in key basins have progressed, and results are in the final phase of publication. New collaborations with neighboring states have been established on geothermal studies. In the field of critical minerals, IGS has made a tremendous effort both in research and in serving as a regional coordinator for several initiatives from the U.S. Geological Survey (USGS). Much progress has been made in several other fields, as you will learn throughout the report. Our collaboration with industry partners, sister agencies, and local stakeholders has proven beneficial for all parties involved. IGS has a new website, which we designed to address customer needs, improve searchability, and facilitate access to the wealth of data that the Survey produces and collects.

Thank you for taking the time to browse through the following pages. I hope you will enjoy learning about the exciting progress and the many accomplishments of the IGS, as well as the many future opportunities for better serving Idaho’s constituents.

*Claudio Berti*
*Director and State Geologist*

# ORGANIZATION AND PERSONNEL

## Organization Chart



# Directory

## Moscow Office

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

## Boise Office

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

## Administrative and Support Staff

Claudio Berti . . . . . Director and State Geologist
Interim Digital Mapping and GIS Lab Manager, Moscow (July 2020-January 2021)
John R. Brabb . . . . . Finance and Operations Manager, Moscow
Nathan Hopkins* . . . . . Digital Mapping and GIS Lab Manager (January 2021-present)
Kristen Pekas . . . . . Management Assistant, Moscow

## Research, Full-Time

Benjamin Bailey* . . . . . GIS Analyst, Moscow
Mark Barton . . . . . Senior Petroleum Geologist, Boise
Alexis Clark . . . . . Hydrogeologist, Boise
Russell Di Fiori . . . . . Senior Geologist, Moscow
Dennis M. Feeney . . . . . Senior Geologist, Moscow
Virginia S. Gillerman . . . . . Research Geologist, Boise
Reed S. Lewis . . . . . Research Geologist, Moscow
Zach Lifton . . . . . Hazards Geologist, Boise
Jonathan E. Sandquist . . . . . Digital Cartographer, Moscow
Jesslyn Starnes* . . . . . Data Preservation Specialist, Moscow
Christopher A. Tate . . . . . Mines and Prospects Database Manager, Moscow
Linda Tedrow . . . . . GIS Analyst, Moscow
Mary Tkach* . . . . . Junior Geologist, Moscow

## Research and Support, Part-Time

Russell F. Burmester . . . . . Geologist
Andrew Canada . . . . . Geologist
James C. Coogan . . . . . Geologist
Skye W. Cooley . . . . . Geologist
Scott Ducar . . . . . Research Support
Harrison Huttanus . . . . . Research Support
Siara Prpich . . . . . Work Study
Wes Sandlin . . . . . Research Support
D. Kate Schalck . . . . . Geologic Editor
Keegan L. Schmidt . . . . . Geologist
William Schuster . . . . . Research Support
Garrett Stephens . . . . . Research Support
David E. Stewart . . . . . Geologist

*New hire in FY 2021.

# Idaho Geological Survey Advisory Board

# Idaho Geological Mapping Advisory Committee

Dale Kerner – Chair
Permitting Manager
Perpetua Resources Idaho, Inc
(formerly Midas Gold Idaho, Inc.)

Dominique Brough
Geologist
Caribou-Targhee National Forests

John Chatburn
Administrator
Idaho Office of Energy and Mineral Resources

Shawn Enright
District Geologist
Idaho Transportation Department

David Hawk
Representative, Office of the Governor
IGS Advisory Board
E2A Energy Analysis and Answers

Mark Kimsey
Research Assistant Professor
Intermountain Forestry Cooperative
Department of Forest, Rangeland and Fire Sciences
University of Idaho

Joe Larsen
Geologist
Mining Law Program Lead
Bureau of Land Management

Sean Long
Associate Professor
Earth Sciences
Washington State University

Mike McVay
Hydrogeologist
Idaho Department of Water Resources

Jonathan Moore
Project Geologist
Hecla Silver Valley, Inc.

Shawn Nield
State Soil Scientist
Natural Resources Conservation Services

David Pearson
Associate Professor
Department of Geosciences
Idaho State University

John Rice
President
Rocky Mountain Environmental Associates, Inc.

Lydia M. Staisch
Research Geologist
U.S. Geological Survey
Geology, Minerals, Energy, and Geophysics Science Center

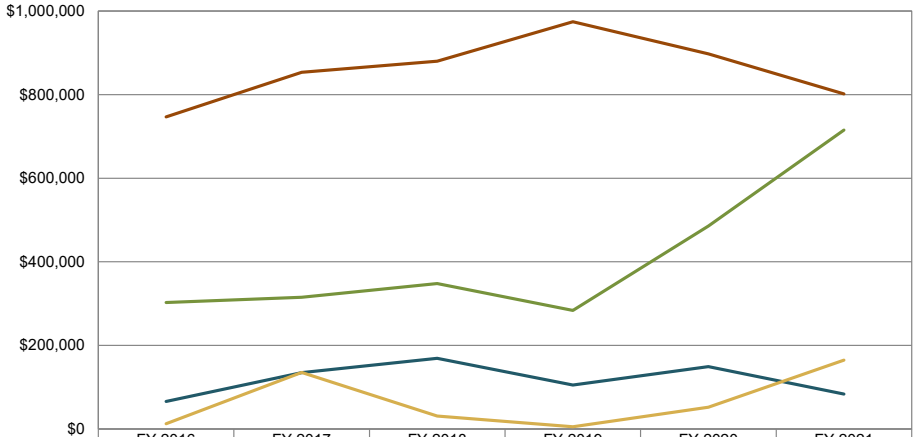
Katie Wilkes
Mine Geologist
JR Simplot Co., Smoky Canyon Mine

# FINANCIALS

## FY 2021 Budget Table

| Category | Beginning Balance | Income or Appropriations | Expenses | Ending Balance |
|---|---|---|---|---|
| Personnel | | $ 1,094,500.00 | $ 801,703.20 | |
| Operating Expense | | $ 10,700.00 | $ 83,453.30 | |
| Capital Outlay | | $ - | $ 164,743.50 | |
| Total Appropriations | | $ 1,105,200.00 | $ 1,049,900.00 | $ 55,300.00 |
| UI Personnel Funds (Furlough Reduction) | | $ (55,300.00) | $ - | $ (55,300.00) |
| Local Service | $ 49,073.71 | $ 43,212.79 | $ 9,778.01 | $ 82,508.49 |
| Service Center | $ 40,249.88 | $ 29,527.81 | $ 28,841.17 | $ 40,936.52 |
| Restricted Gifts | $ 7,367.62 | $ - | $ - | $ 7,367.62 |
| Sponsored Programs | $ 828,274.39 | $ 677,424.00 | $ 715,253.53 | $ 790,444.86 |
| TOTAL | $ 924,965.60 | $ 1,855,364.60 | $ 1,803,772.71 | $ 976,557.49 |

## Trends in Expenditures

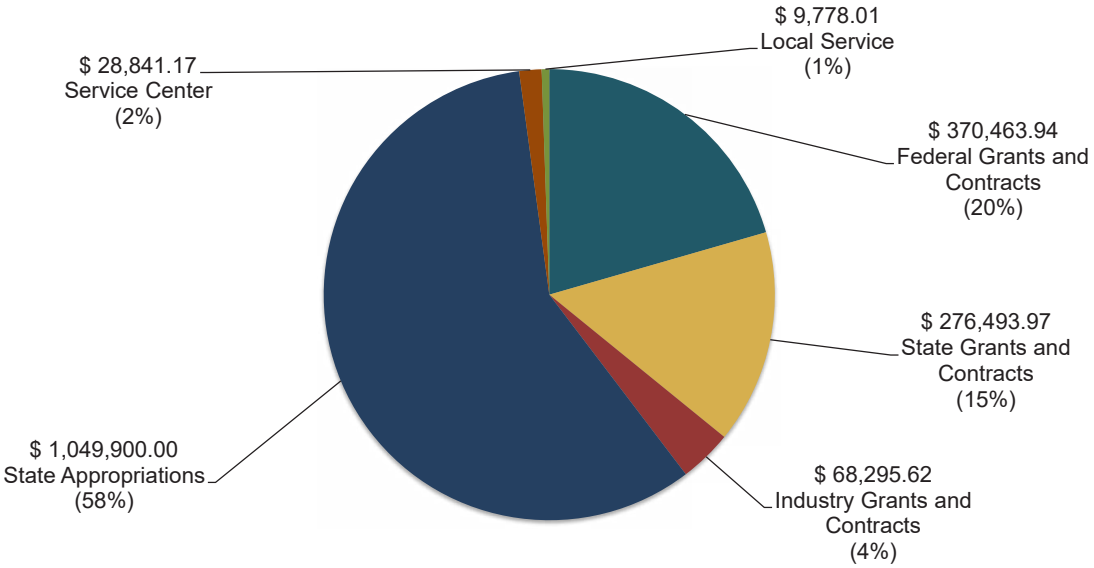



| | FY 2016 | FY 2017 | FY 2018 | FY 2019 | FY 2020 | FY 2021 |
|---|---|---|---|---|---|---|
| Personnel | $746,726 | $853,400 | $880,169 | $974,399 | $897,632 | $801,703 |
| Grants and Contracts | $302,424 | $314,970 | $347,857 | $283,673 | $485,390 | $715,253 |
| Operating Expense | $65,899 | $134,696 | $169,101 | $105,337 | $149,046 | $83,453 |
| Capital Outlay | $12,566 | $135,204 | $31,103 | $5,364 | $52,222 | $164,744 |

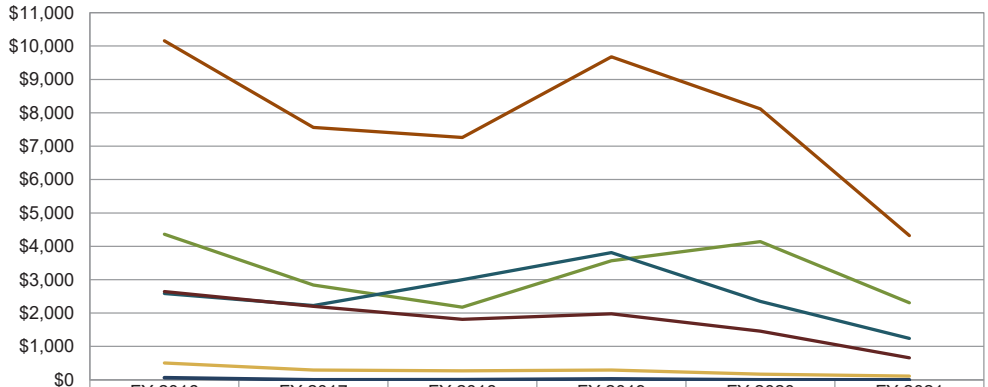
## FY 2022 Budget Request

The FY 2022 budget request included no line items in accordance with the Governor's Office directives. IGS was allocated $1,094,500 in personnel costs with additions of $4,200 in changes for benefit costs and a $18,900 (2%) change in employee compensation bringing the personnel allocation to $1,117,600. The Other Expense (OE) allocation remained at $10,700 for a total budget of $1,128,300. Approximately 40% of the awarded salary and associated benefits increase are projected to be generated by grant-funded salary and benefit savings.

# Sources of Funding




# Publication Sales




| | FY 2016 | FY 2017 | FY 2018 | FY 2019 | FY 2020 | FY 2021 |
|---|---|---|---|---|---|---|
| TOTAL SALES | $10,158 | $7,564 | $7,261 | $9,678 | $8,117 | $4,321 |
| IGS Publications | $4,362 | $2,840 | $2,176 | $3,569 | $4,140 | $2,311 |
| IGS Geologic Maps | $2,585 | $2,227 | $3,000 | $3,811 | $2,352 | $1,240 |
| Topographic Maps | $2,644 | $2,203 | $1,811 | $1,978 | $1,458 | $659 |
| Other Maps | $504 | $294 | $270 | $295 | $167 | $111 |
| Books | $63 | $0 | $4 | $25 | $0 | $0 |

Since its release in 2012, *Geologic Map of Idaho* (M-9) has continued to be the best-selling IGS publication. Nearly all publications are available for free download on the IGS website.

# PARTNERSHIPS

## Funding Partners

**Idaho Department of Lands**

Abandoned Mine Lands Project

**Idaho Department of Water Resources**

Big Lost River Valley; Raft River Valley

**Idaho Transportation Department**

Landslide Inventory Database

**Idaho Office of Emergency Management**

Fault Database

**Integra Resources**

De Lamar and Swisher Mountain mapping

**U.S. Geological Survey**

STATEMAP, Data Preservation, NEHRP, Earth MRI

**Wilmat Petroleum Company**

Yellow Pine mapping

# Collaborators

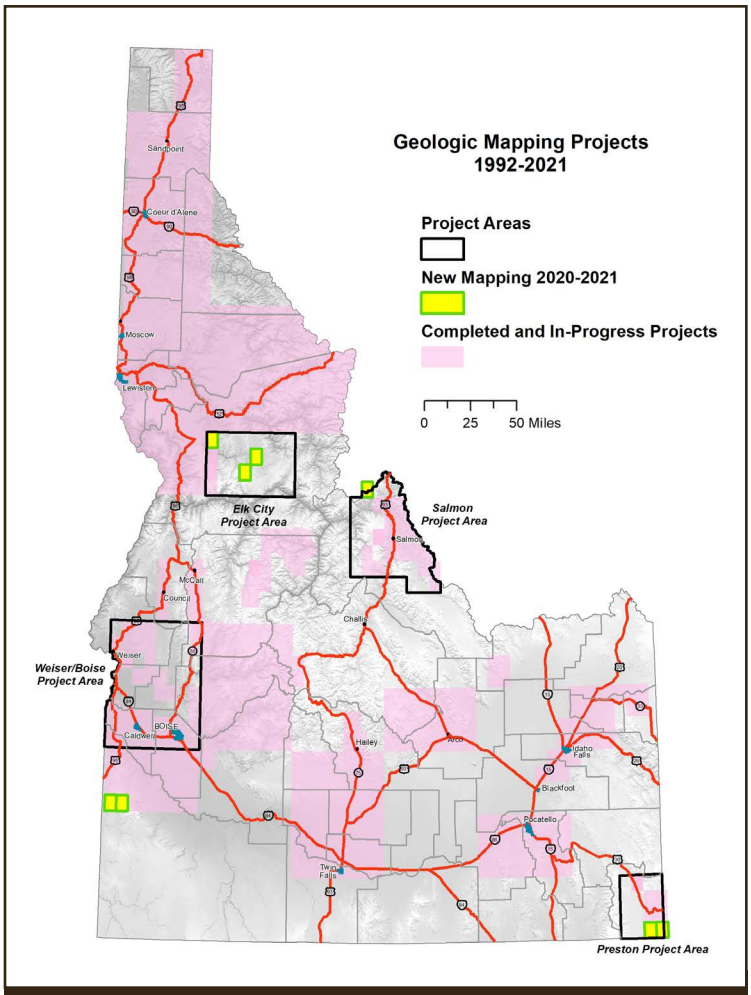
American Exploration and Mining Association
American Geophysical Union
American Geosciences Institute
American Water Resources Association, Idaho State Section
Association of American State Geologists
Belt Association
Beta Analytic
BGC Engineering
Boise State University
Brigham Young University-Idaho
Center for Advanced Energy Studies
Centro Nacional de Investigación sobre la Evolución Humana
College of Idaho
College of Western Idaho
Earthquake Engineering Research Institute
Eastern Washington University
Federal Emergency Management Agency
First Cobalt
Franklin and Marshall College
Frontier Precision
Geological Society of America
GeoMark Research
GeoSep Services
Governor's Office, State of Idaho
Hecla Mining Company
Hells Canyon Gem Club
Horse Heaven Syndicate
Ice Age Floods Institute
Idaho Department of Environmental Quality
Idaho Department of Lands
Idaho Department of Water Resources
Idaho Governor's Office of Energy and Mineral Resources
Idaho Ground Water Monitoring Technical Committee
Idaho Historical Society
Idaho Mining Association
Idaho Museum of Mining and Geology
Idaho Office of Emergency Management
Idaho Oil and Gas Conservation Commission
Idaho Public Television
Idaho State University
Idaho Transportation Department
Indiana State University
Integra Resources
Intermountain Forestry Cooperative
Instrumental Software Technology, Inc.
Incorporated Research Institutions for Seismology Portable Array Seismic Studies of the Continental Lithosphere
Lehigh University
Lettis Consultants International
Lewis-Clark State College
Perpetua Resources Idaho, Inc. (formerly Midas Gold Idaho, Inc.)
Missouri State University
Montana Bureau of Mines and Geology
Nanometrics
National Academy of Sciences
Nevada Bureau of Mines and Geology
New Jersey Mining Company
Northwest Knowledge Network
Oregon Department of Geology and Mineral Industries
Orma J. Smith Museum of Natural History
Owyhee Gem and Mineral Society
Revival Gold
Snake River Oil and Gas
Schlumberger Petroleum Services
Society of Mining Engineers, Boise Section
Spokane Community College
Tobacco Root Geological Society
U.S. Bureau of Land Management
U.S. Bureau of Reclamation
U.S.D.A. Agriculture Research Service
U.S. Forest Service
U.S. Geological Survey—Minerals Program
U.S. Geological Survey—NEHRP
U.S. Geological Survey—Water Resources Division
U.S. Geological Survey—Data Preservation
U.S. Geological Survey—Earth MRI Program
U.S. Geological Survey—NCGMP
University of Alaska, Fairbanks
University of Idaho
University of Massachusetts, Lowell
University of Montana
University of Nevada, Las Vegas
University of Potsdam
Utah Geological Survey
Washington Geological Survey
Washington State University
Western Colorado University
Western States Seismic Policy Council
Wyoming Geological Survey
Yellowstone Volcano Observatory

# RESEARCH

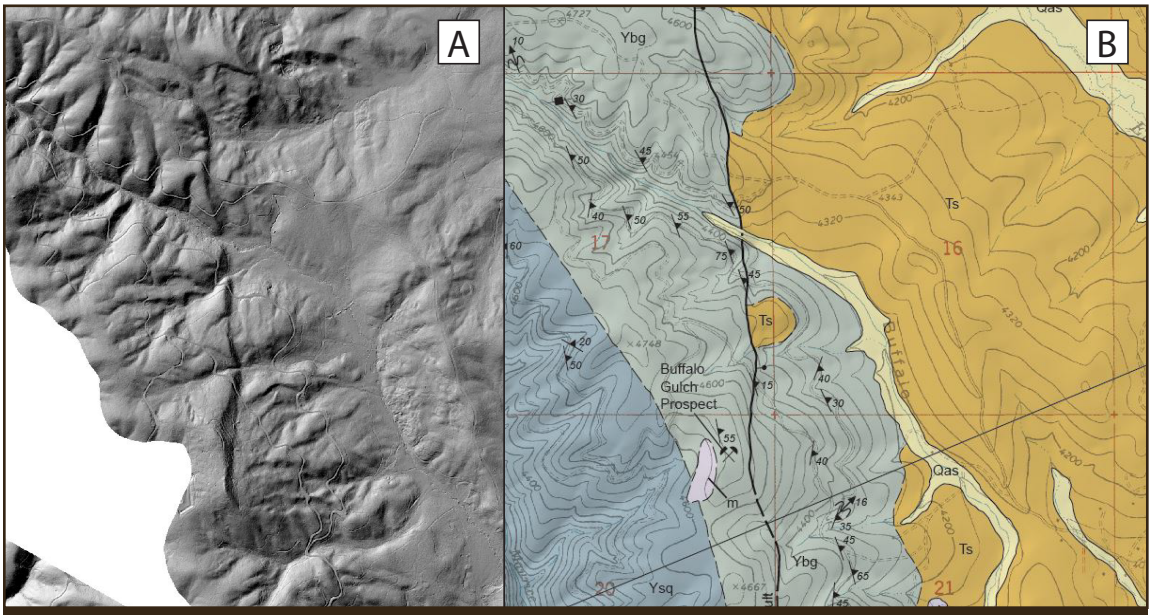
Applied geologic research is the primary function of the IGS. Projects are related to geologic mapping, hydrogeology, geologic hazards, mineral resources, geothermal energy, and oil and gas.

## Geological Mapping and Related Studies

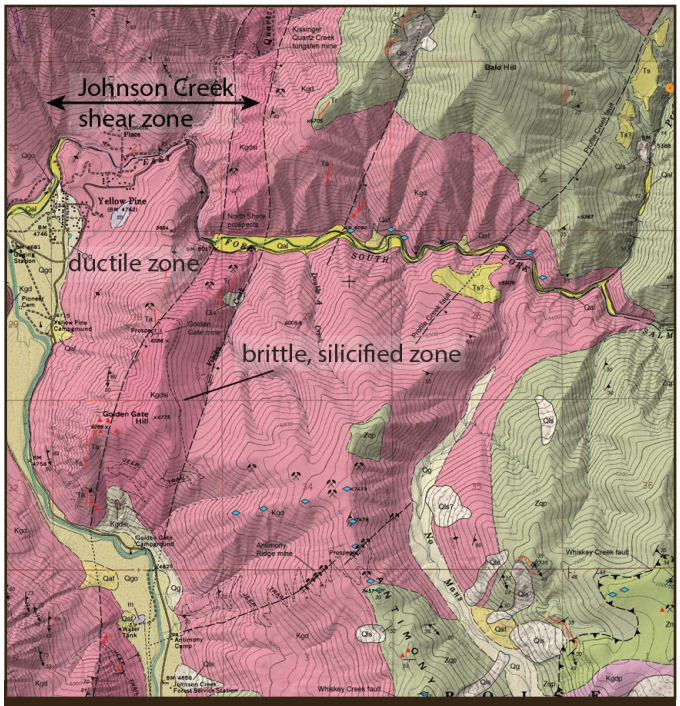
Geologic map products from the IGS are a critical tool for communicating and distributing foundational geologic information to Idaho's constituents. IGS primarily focuses on mapping 7.5′ and 30′ x 60′ quadrangles, and these geologic map products are utilized by a diverse suite of stakeholders in a variety of tasks such as defining groundwater resources, identifying and categorizing geological materials for engineering needs, aiding in infrastructure, identifying seismic and landslide hazards, assisting with timber management, and providing geologic data for potential mineral and aggregate resources on public lands. The largest source of funding for Idaho's geologic mapping program is provided by the STATEMAP component of the USGS National Cooperative Geologic Mapping Program (NCGMP). The Idaho Geological Mapping Advisory Committee helps the IGS determine Idaho's geologic mapping needs and develop long-term planning for geologic mapping.




*Progress of the geologic mapping effort in Idaho, 1992-2021.*




*A) LiDAR-derived imagery from the Elk City 7.5′ quadrangle highlighting a young to recent normal fault scarp, and B) 1:24,000-scale geologic map of the same area.*




*Close-up view of the northwest part of the 2021 geologic map of the Yellow Pine quadrangle (DWM-190). Mapping delineated the Johnson Creek shear zone, along and near which Au, W, and Sb mineralization occurs.*

In FY 2021:

- New mapping was conducted in the Elk City, Preston, and Salmon project areas, where Survey geologists mapped six 7.5′ quadrangles (Harpster, Orogrande, Elk City, Henderson Ridge, Boundary Ridge, and Pegram Creek).
- New maps were published for the Yellow Pine 7.5′ quadrangle, Sandpoint 30′ x 60′ quadrangle, and 1:24,000-scale maps of the Burke, Murray, Osburn, Bayhorse, Clayton, and Leadore areas.

### *Research Spotlight: Earth MRI*

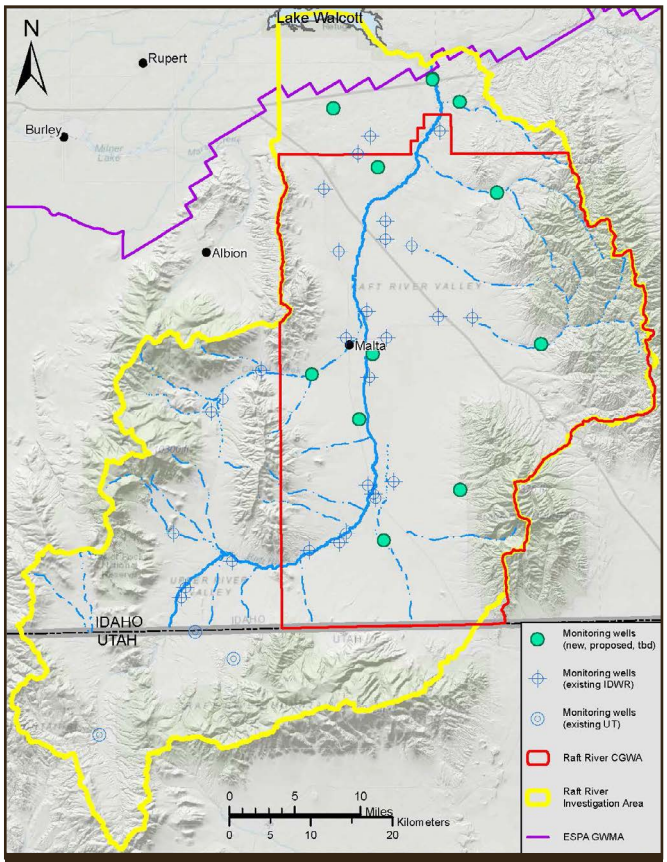
To reduce the country's dependance on foreign-sourced minerals that are fundamental to our security and economy, the USGS developed the Earth Mapping Resources Initiative (Earth MRI). The IGS continued work on a two-year Earth MRI mapping project funded in FY 2020 in the Idaho cobalt belt near Salmon. Both cobalt and rare-earth elements (REEs) are the focus of this effort. Field work in the Degan Mountain, Taylor Mountain, and Cobalt quadrangles was finished, and a detailed compilation of the geology in the Blackbird mine area was nearing completion.

# Hydrogeology

During FY 2021 the hydrogeology program supported the IGS mission through research, collaboration with other agencies, and communication with the public on groundwater supply resources and groundwater quality topics for Idaho.

In FY 2021:

- IGS completed Phase 1 of the Raft River Basin Hydrogeology Study (See Research Spotlight).
- IGS started Phase 2 of the Raft River Basin Hydrogeology Study (See Research Spotlight).
- IGS continued preparation of groundwater budgets spanning 2000-2019 at a watershed scale for the Big Lost River Basin in south-central Idaho. The project is part of a larger study conducted during 2018-2021 in collaboration with Idaho Department of Water Resources (IDWR) and the USGS with Department of Energy Supplemental Environmental Project funding. Publication of the groundwater budget results as a separate chapter in a USGS scientific investigation report is scheduled for Spring 2022.




*Raft River Basin study extent and proposed new monitoring well sites.*

### *Research Spotlight: Raft River Basin Hydrogeology Study*

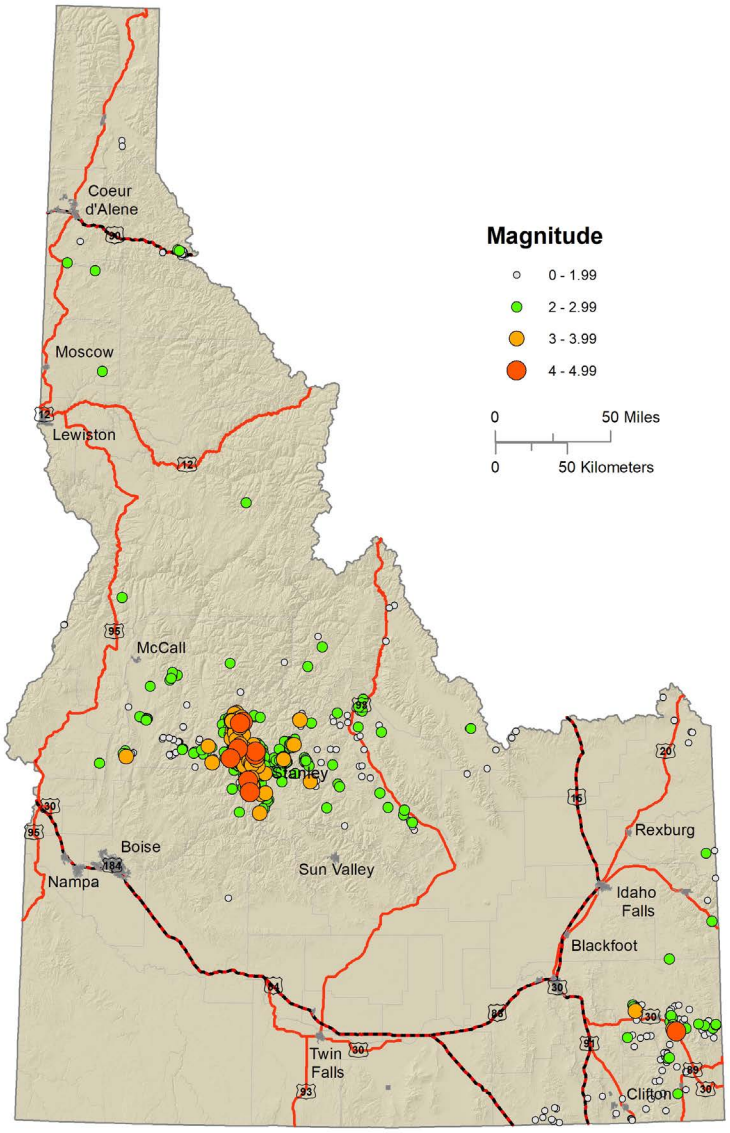
*Clear Creek (Raft River Basin).*

In November 2020 IGS completed a one-year hydrogeology study (Phase 1) of the Raft River Basin in southern Idaho with IDWR, funded by the Idaho Water Resources Board (IWRB). Project objectives were to address declining groundwater level trends in the basin. This first project phase included compilation of existing hydrogeologic datasets, field reconnaissance in support of future data collection, and identification of perceived data gaps with recommendations for future investigations. IGS supported siting of 12 new monitoring wells, scheduled for installation by IDWR in Spring 2022, to be incorporated into IDWR's existing monitoring well network. In 2020 the USGS installed two new dedicated streamgage stations (Cassia Creek and Raft River), and IDWR installed stream monitoring equipment in other drainages as part of the investigation. In December 2020 IGS commenced Phase 2 of a three-year hydrogeology study of the Raft River Basin in collaboration with IDWR through an IWRB grant. This project spans 2021-2023 and includes preparation by IGS of a hydrogeologic framework and groundwater budget. IGS publication of the study findings is planned for late fall 2023.

## Geologic Hazards

FY 2021 saw significant landslide and earthquake activity within Idaho. Several landslides and rockfall impacted highways, including major events on U.S. Highway 95 near Riggins and State Highway 55 near Smiths Ferry. Aftershocks from the March 31, 2020 Mw6.5 Stanley earthquake continued to shake central Idaho throughout FY 2021. This aftershock activity is normal and expected following an earthquake of this size.

*Drone aerial photograph of rockfall blocking U.S. Highway 95 south of Riggins.*

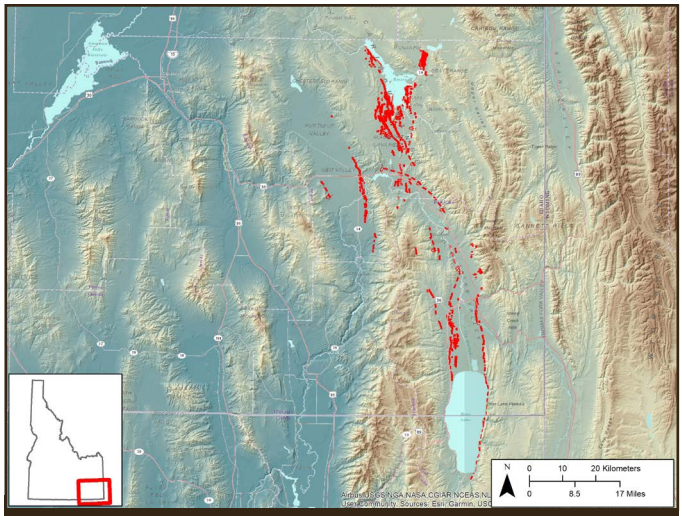



*Earthquakes during FY 2021 in Idaho. Source: USGS ANSS Comprehensive Earthquake Catalog for 07-01-2020 to 06-30-2021.*

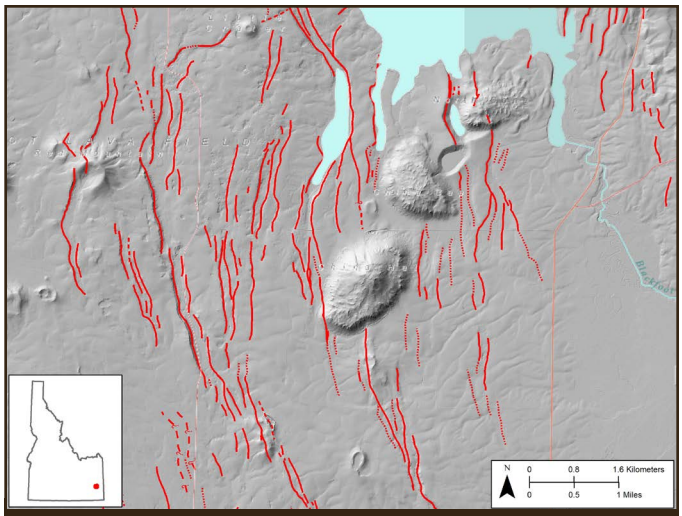
The geologic hazards program continued studies on existing and potential hazards and disseminating data. In FY 2021:

- New surficial fault mapping, funded by the USGS National Earthquake Hazards Reduction Program (NEHRP), of Bear Lake Valley, Gem Valley, and Blackfoot Volcanic Field was completed. Recent LiDAR data covering southeast Idaho allows for the highest-resolution surface fault trace mapping yet published. The new mapping is being incorporated into the updated fault database.

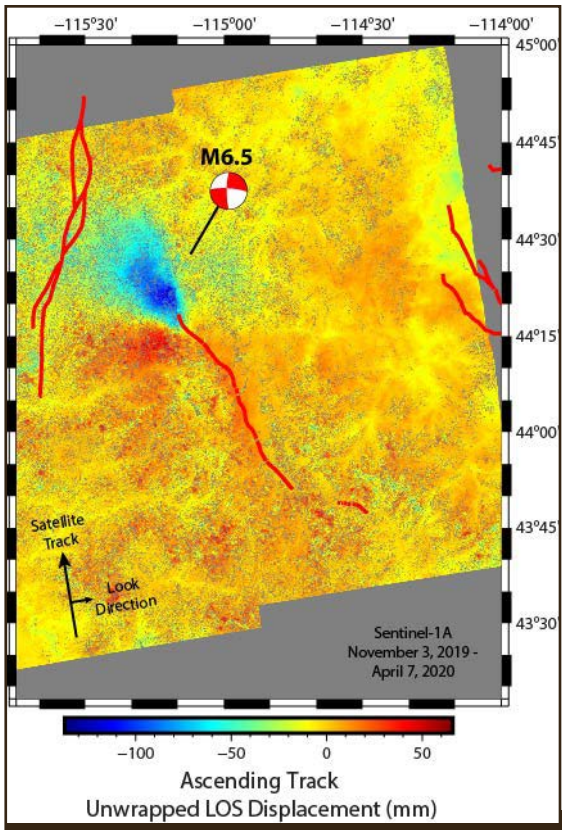
- The IGS and Boise State University published a peer-reviewed article in *Seismological Research Letters* on the tectonic and geophysical background of the 2020 Mw6.5 Stanley earthquake.




*Map of southeast Idaho showing new surface fault mapping in Bear Lake Valley, Gem Valley, and the Blackfoot Volcanic Field.*




*LiDAR hillshade map of the south end of Blackfoot Reservoir, showing China Hat, China Cap, and North Cone rhyolite domes and mapped fault scarps.*



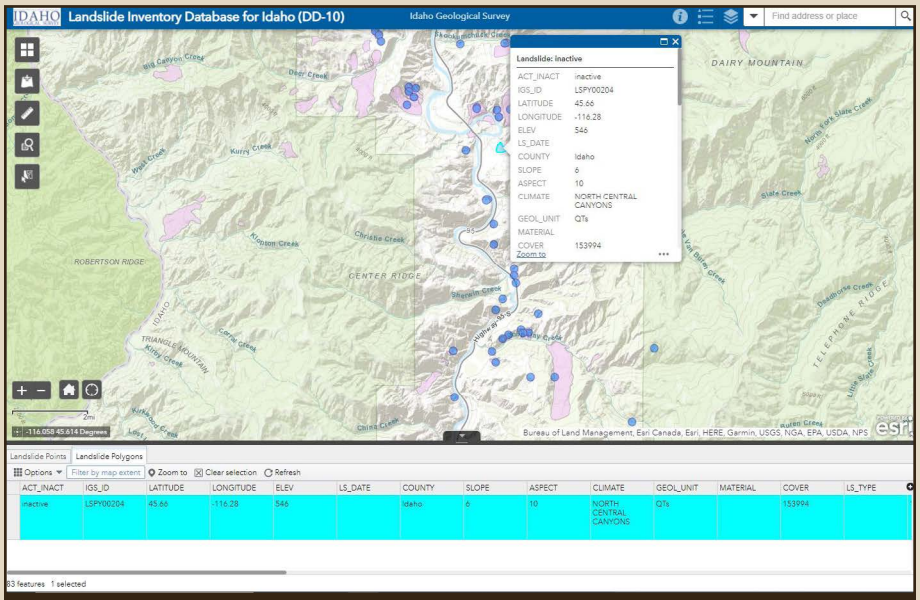

*InSAR displacement map showing ground deformation related to the March 31, 2020 Mw6.5 Stanley earthquake. Modified from Liberty et al., 2020.*

## *Research Spotlight: Landslide Inventory and Active Faults Databases*

One of the primary goals of the geologic hazards program in recent years has been to compile and publish two fundamental datasets: a landslide inventory database and an active faults database. Toward that goal, the Survey has made significant progress in FY 2021. With the help of a two-year research grant from the Idaho Transportation Department, the Survey compiled available landslide mapping and published it as a digital landslide inventory database. The new landslide database contains more than 4,000 records and is available as an interactive webmap and a GIS geodatabase. This is a significant improvement over previous versions of the statewide landslide database and provides users with an important tool for assessing slope stability hazards.

*Drone aerial photograph of a recent landslide near Horseshoe Bend. This is one of over 4,000 landslides contained in the new landslide inventory database.*

With the help of grants from the Idaho Office of Emergency Management and the USGS Data Preservation program, the Survey is also currently working on updating and revising the statewide active faults database. This database contains mapping of surface fault traces and fault source parameters for known or suspected active faults. A new database with a modern interactive webmap interface was built to house the fault data and new mapping is being completed as LiDAR becomes available. In addition, the Survey digitized hundreds of hardcopy reports referenced in the database.

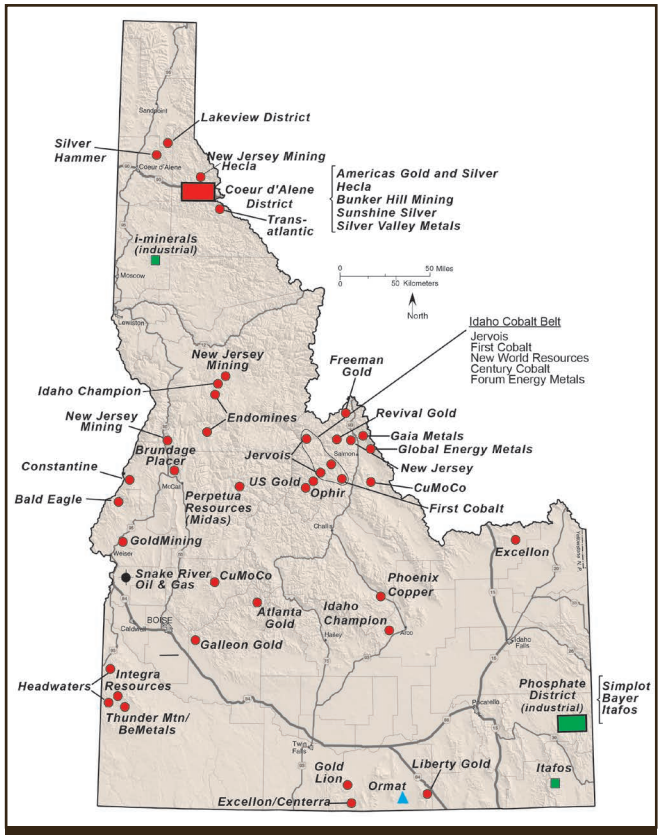



*Screenshot of the new Landslide Inventory Database for Idaho (DD-10).*

# Mines and Minerals

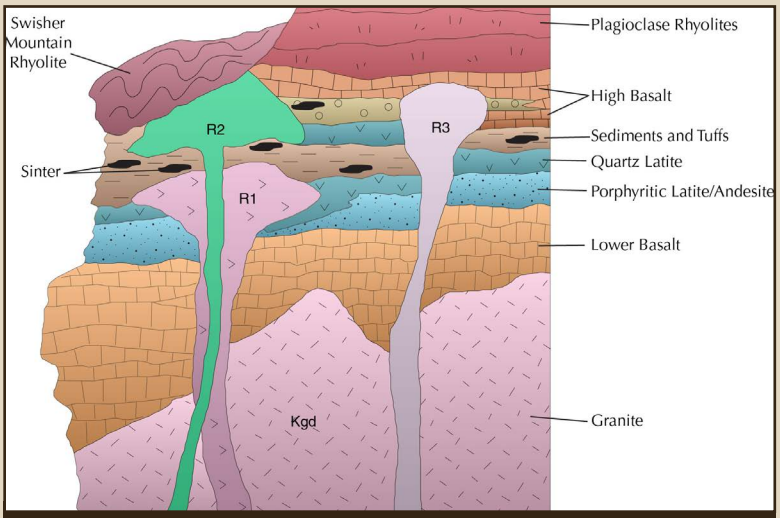
Idaho's mining was alive and well in FY 2021. The IGS continued to research and report on Idaho's mineral industry. Two IGS Staff Reports (S-21-01 and S-21-02) with annual descriptions for 2014-2017 were released. Active mining and exploration activity in FY 2021 included:

- Hecla's Lucky Friday mine in the Silver Valley returning to full production in November after a long strike.
- Exploration drills turning at the Galena mine of Americas Gold and Silver Corporation.
- New work being done at the Bunker Hill mine.
- New Jersey continuing to mine gold at Murray.
- Three large phosphate plants and mines operating in Caribou County.
- The largest exploration projects, all for gold and silver, operated by Integra Resources at De Lamar, Revival Gold at Beartrack and Arnett Creek, and Liberty Gold at Black Pine; in each case deeper, higher-grade mineralization being explored below open pit mines which closed around 2000.
- Two projects in the Idaho cobalt belt continuing, and precious metal rich polymetallics also being targeted.




*Idaho minerals and energy exploration in 2021.*

## *Research Spotlight: De Lamar and Swisher Mountain Quadrangles Mapping Project*




*Idealized cross-section, looking north, showing De Lamar geology. R1, R2, and R3 are rhyolite to dacitic volcanic domes and flows.*

Integra Resources Corporation funded a two-year, regional-style geologic mapping study of two 1:24,000 scale quadrangles in Owyhee County, surrounding their project on the De Lamar and Florida Mountain mine sites. Mapping of the De Lamar and adjacent Swisher Mountain 7.5′ quadrangles was completed at the end of FY 2021. Work focused on refining the Mid-Miocene stratigraphy of the volcanic rocks and distinguishing the multiple rhyolite domes, mapping multiple ages of faults, seeking controls on alteration and mineralization, and understanding the geologic history of the region. The Silver City district produced approximately 1.3 million troy ounces of gold and over 72 million troy ounces of silver from three epithermal mineralized centers (De Lamar, Florida Mountain, and War Eagle) discovered in the 1860s. Mining ceased in 1998, and Integra is currently drilling the Florida Mountain deposit to define additional resources.

The map includes 37 XRF whole-rock chemical analyses of the volcanic units and eight new U-Pb ID-TIMS age determinations on zircons from the silicic units, analyzed by Boise State University. Petrographic descriptions and the new ages document three groups of Miocene-age silicic magmatism. The oldest group includes the quartz-sanidine rhyolite domes which host mineralization (R1 and later R2) and range from 16.398 ± 0.007 Ma to 16.176 ± 0.008 Ma (5 samples); the next group is the overlying plagioclase rhyolites with one unit dated at 15.722 ± 0.011 Ma and the post-mineral Millsite rhyolite at De Lamar at 15.706 ± 0.007 Ma; and the third group is the unaltered, voluminous Swisher Mountain Rhyolite dated at 14.746 ± 0.008 Ma. Mineralization at De Lamar is bracketed in age between groups 1 and 2. Much of the faulting and basin development in the western part of the map area is interpreted to have occurred after or during eruption of the group 2 volcanic units and prior to emplacement of the Swisher Mountain Rhyolite.

# Energy

## Geothermal Energy

Information on Idaho's geothermal exploration and development status was published in FY 2021 for 2015-14 and 2016-17, respectively as staff reports S-21-01 and S-21-02. These reports also summarize Idaho's activities related to mining and oil and gas.

### *Research Spotlight: INGENIOUS*

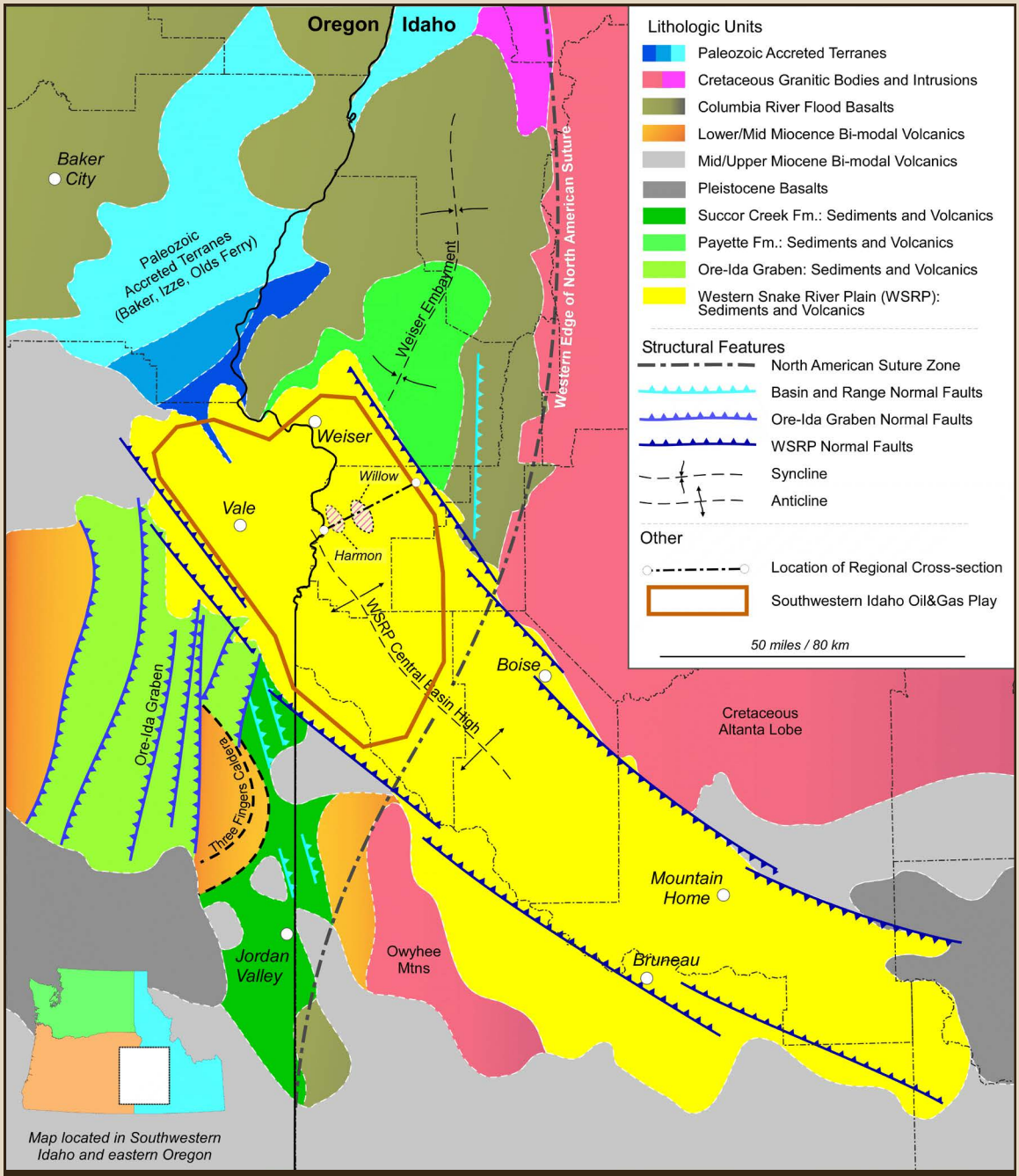
IGS is part of a geothermal energy research team working on an initiative funded by U.S. Department of Energy to promote advancement of emerging and innovative, commercially viable geothermal energy technologies. Goals of the Innovative Geothermal Exploration through Novel Investigations of Undiscovered Systems (INGENIOUS) geothermal project are to reduce costs and risks associated with geothermal energy development. The Great Basin Center for Geothermal Energy, within the Nevada Bureau of Mines and Geology, is the project lead. This 4.5-year project focuses on exploration research and development of hydrothermal and low temperature resources in hidden geothermal systems in the Basin and Range province, including areas in Idaho, Nevada, and Utah. Under the Geothermal Technologies Office Play Fairway Analysis (PFA) initiative, the project anticipates drilling at five sites and conducting geophysical surveys. Analyses will incorporate PFA, machine learning, and advanced geostatistical approaches. The PFA technique, adapted from the oil and gas industry, uses statistical methods to create a risk-based ranking for better understanding the occurrence and distribution of heat flow. During FY 2021 IGS assisted the compilation and synthesis of Idaho datasets for preparation of a regional map.

## Oil and Gas

During FY 2021 the oil and gas program advanced the understanding of petroleum resources in Idaho by:

- Conducting primary research on the formation and occurrence of proven and possible petroleum systems.
- Providing new information that highlights the exploration potential of frontier and underexplored basins.
- Preparing assessments on the hydrocarbon potential of select geologic provinces.
- Storing, archiving, and disseminating a wide variety of subsurface geological data.
- Transferring knowledge and information to operators, scientists, policymakers, and the public.

## Research Spotlight: Western Snake River Plain Petroleum System

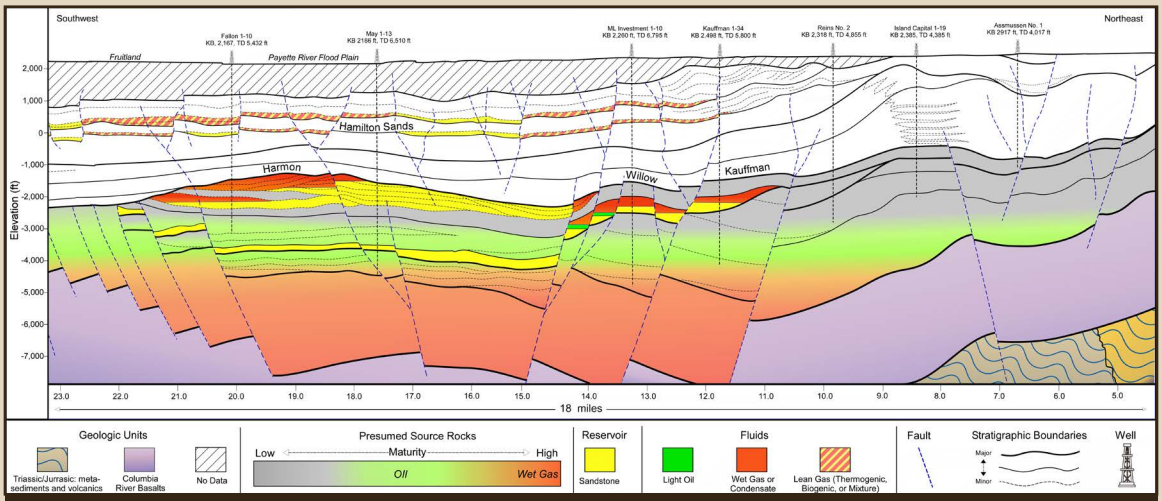



*Map illustrating the tectonic and stratigraphic setting of the WSRP and surrounding areas. Known hydrocarbon accumulations occur in the northern portion of the basin.*

Recent work at the IGS integrating seismic and well data from the Western Snake River Plain (WSRP) illustrates the stratigraphic and structural configuration of known hydrocarbon accumulations beneath the WSRP and their relationship to presumed source rocks. Within the deeper portion of the basin, conventional accumulations of wet gas,

condensate, and light oil have been discovered from sandstones units (Harmon and Willow) associated with the syn-rift succession. The Willow Sandstone represents a high-net fluvial sandstone body that extends across several half-graben structures. The Harmon Sandstone represents a mix of fluvial sandstones and overbank mudstones deposited during the last phase of graben formation. A variety of potential trapping structures exist including faulted anticlines, tilted fault blocks, and stratigraphic pinch-outs. Lacustrine mudstones that directly overlie the syn-rift succession act as a high-quality regional seal. Within the shallow section, lean gas to wet gas is commonly encountered in the shallow, toe-of-slope sandstones of the upper sag sequence. Potential trapping structures include folds and faults associated flower structures.

Geochemical data from produced fluids and gases suggests hydrocarbons in the deeper syn-rift reservoirs were generated from sediments rich in terrestrially derived organic matter as they were heated and buried to depths of 5,000-8,000 ft. Candidate source rocks for the hydrocarbons are paludal and near-shore lacustrine sediments that comprise the pre-rift and initial syn-rift successions. Hydrocarbons from the upper Sag sequence are made up of variable mixtures of shallow biogenic gas and thermogenic gas produced at depth.




*Cross-section illustrating the structural and stratigraphic configuration of hydrocarbon accumulations and relationship to presumed source rocks that occur beneath the WSRP of southwest Idaho. Location of cross-section indicated on previous map.*

# Instrumentation

In FY 2021 IGS acquired new instrumentation and software in an effort to initiate filling a historic gap in data collection. The lack of instrumentation has affected the ability to collect data critical for hazard mitigation, among many other important applications, and IGS intends to increase its instrumental capabilities in the years to come. In FY 2021 the acquisition of new instruments was possible thanks to a conservative approach in IGS finances combined with savings related to travel and operations restrictions due to COVID-19. IGS acquired:

## Seismometers

- 4 broadband seismometers and digitizer (Nanometrics Trillium Compact Horizon and Nanometrics Centaur)
- 1 broadband and strong motion seismometer and digitizer (Nanometrics Trillium Cascadia and Nanometrics Centaur)
- 1 quick deployment broadband seismometer kit (Nanometrics Trillium Compact Horizon and Nanometrics Pegasus)
- The seismic monitoring instruments will add to the pool of 6 GEObit S-100 wide band seismometers and GEObit GEOthree digitizers purchased at the end of FY 2020.

## Passive seismic stratigraphy and Vs30/VsH soil characterization

- 1 MoHo Tromino

## Magnetic susceptibility meters

- 2 Terraplus KT-10 v2 PLUS

*High resolution profiling of the Boulder front fault scarp in the Boulder Creek drainage between Ketchum and Galena Summit with the aid of the Trimble R8s-R9s RTK system.*

## Differential RTK GPS units

- 1 Trimble R8s Rover
- 1 Trimble R9s Base
- 1 Trimble Zephyr 3 GPS antenna
- 1 Trimble TSC5 data collector
- 1 Trimble Business Center software

## Digital geologic mapping, structural geology, and 3D modelling software

- 1 license of Petroleum Expert MOVE Core

# DATA PRESERVATION

Archiving, digitizing, and disseminating our state's historical geological data is an essential service provided by the IGS, and our data preservation products are second only to IGS publications for public interest and downloads. Our data preservation effort was formally organized in 2007 with funding from the USGS National Geologic and Geophysical Data Preservation Program (NGGDPP) and has expanded with funding from the Idaho Department of Lands in 2009. This work has resulted in thousands of physical documents and other media being digitized and made accessible to the public. In FY 2021:

- The Mines and Prospects database (Mines) underwent operational improvements as well as continued efforts to expand content and improve accuracy. A new version was published in the IGS Digital Database series (DD-1). Functionality was added and improved for filtering Mines webmap searches by the presence of placers, drilling, underground workings, on-site ore processing facilities, and surface or pit mining.
- Sixty-five new references were added to the database, and 267 existing references were reviewed improving location and attributes for up to 4,891 distinct properties and resulting in the addition of 332 new properties with associated location, attribute data, and metadata added to Mines.

*Data rescue efforts this year included the retrieval of paper copies of unpublished major-oxide and trace-element analyses performed in the 1980s which had been stored in the researcher's backyard shed for several years. These geochemical data were digitized and are now accessible on our website as DAD -19.*

- Forty-three new Abandoned Mine Land videos were digitized, adding five additional hours of audio-visual footage to our collection. Currently there are 139 geolocated video clips discoverable and available for download via the Mines webmap and for streaming through the IGS YouTube channel.
- Digitization of the Sandpoint 1° x 2° quadrangle mineral property files was completed, resulting in the availability of 1,232 files for the quad within our database.

- Eight additional Idaho State Annual Mine Inspector Reports (1900-1909) were digitized and posted on the IGS Current and Historic Mining Activity webpage, with two years (1901-1902) data-mined for incorporation into the Mines database.
- Two Regional Development years (1989-1990) were data-mined and incorporated into the Mines database.
- Sixteen well logs for Idaho oil and gas wells were converted from wireline log data to the more versatile LAS industry-standard format.
- Ninety-six unpublished or difficult to locate references concerning Idaho faults were scanned and cataloged.
- Support was provided for the Earth MRI national critical minerals resources inventory.

## *Data Preservation Spotlight: The "Buckhorn Bob" Collection*

In early 2020 Denice Hogan contacted us about a possible donation of Mineral Property Files after the passing of her uncle, Robert "Buckhorn Bob" Causton. Bob had owned an Idaho mining property that had been in the family since the early 1920s and had accumulated a good deal of records dating between 1966 and 2014.

Denice shipped the first installment of records from Bob's residence in Hawaii in the spring of 2020. These were organized and scanned during the 2020-2021 NGGDPP grant cycle.

A brief history of the Idaho Buckhorn Mine property, written by Bob, can be found in our Mines webmap (see SA0058_095). The majority of the collection can be browsed and downloaded from Property Number SA0058 beginning with SA0058_053. There are other cultural and historical points of interest. The building and collapse of the Eileen dam intended to provide power to the mine is a notable example. During the digitization process, some records were discovered which related to other mining properties not controlled by Bob and were processed accordingly.


*A photograph depicting the pet bear kept by miners with the Cynide Gold Mining Company in the 1920s. This photograph is part of our Buckhorn Bob collection.*

# 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.

## Website

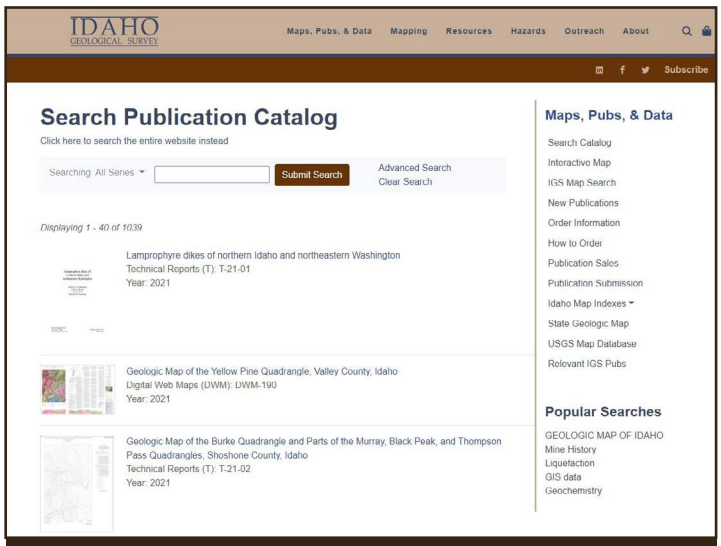
*idahogeology.org*

In FY 2021 IGS worked with First Step Internet to launch a new website. The website has a new look and feel, and, most importantly, a more powerful search function.

The IGS website is the most important tool for providing the public access to publications and data. Nearly all Survey publications (over 1,000) are available for download at no cost. IGS also offers interactive webmaps to search, locate, and download documents and data.

With the launch of our new website, IGS started collecting web stats on April 29, 2021. The number of website viewers was 21,388, and the number of website products used or downloaded was 5,621. Extrapolated over the entire fiscal year, the number of website viewers would exceed 120,000, and the number of website products used or downloaded would approach 32,000.


*Screenshot of the new IGS homepage.*




*Screenshot of the new IGS Publication Catalog.*

# Social Media

The 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, hazards, warnings, and drills; post general geoscience information; and post job announcements.

# Digital Mapping and GIS Laboratory

In FY 2021 the Digital Mapping and GIS lab:

- Supported six new mapping projects encompassing eight 7.5′ quadrangles. Projects funded through the STATEMAP program will be submitted in the early months of FY 2022, through an extension of the USGS grant.
- Made progress on backlogged publications. Though the number of publications in FY 2021 remained low, IGS expects a significant increase in publication of Digital Web Maps in the coming year, thanks in large part to the implementation of the USGS Geologic Map Schema (GeMS), which was introduced in 2020.

## *Digital Mapping Lab Spotlight: GeMS*

Geologic Map Schema (GeMS) is a geodatabase format for digital geologic maps designed through collaboration between the USGS and state geologic surveys with the objective of digitally encoding the content contained in traditional geologic maps. IGS has embraced this geodatabase standard, participated in technical discussion and interagency working groups, and has made significant progress towards compliance with the schema. IGS expects to fully transition to GeMS for all geologic map production within the coming year. As part of the FY 2021 STATEMAP program, the lab has worked with IGS mapping staff to develop three large map compilations compliant with Level 3 GeMS standards. These compilations include a total of 51 7.5′ quadrangles, many of which are currently unpublished. As part of this effort, IGS plans to publish many of those currently unpublished works.

# Earth Science Education

The IGS seeks to promote excellence in the teaching and practice of the earth sciences. In FY 2021 IGS:

- Participated in the American Geosciences Institute sponsored Earth Science Week by distributing fifty Earth Science Week Toolkits to earth science and physical science teachers in southern Idaho and teachers on our mailing list who continually use these kits.
- Celebrated "Geologic Map Day" during Earth Science Week by highlighting the recently published *Geologic Map of the Crane Creek Reservoir Quadrangle, Washington County, Idaho* on the IGS website and social media.
- Partnered with other state and federal agencies in support of "The Great Idaho ShakeOut" on October 15, 2020, a statewide earthquake drill which encourages Idahoans to prepare for major earthquakes.
- Produced a virtual field trip: *1983 Borah Peak Earthquake Virtual Fieldtrip Video*, by Zach Lifton, Susan Cleverley, and Chris Smart: IGS YouTube channel, October 2020.
- Presented educational presentations and participated in outreach events statewide:

  *Career paths in Geology Panel Discussion*, Claudio Berti panelist: Lehigh University, November 2020.

  *Earthquakes in Idaho. Where, why (and when…)*, by Claudio Berti and Zach Lifton: 18th National Weather Service Groundhog Day Event, Virtual Meeting, January 2021.

  *Geothermal Resource Development in Idaho – A Current Overview*, by Alexis Clark: University of Idaho/ Washington State University Geology Seminar, Virtual meeting, March 2021.

  *Mining History of the Boise Foothills and Career Opportunities in Mining Industry*, by Virginia S. Gillerman: Boise State University Geoscience Club, Boise or virtual, October 2020.

  *Mapping to the Beat of a Different Accordion: Helpful Tips from a Pragmatic Optimist*, by Dennis Feeney: Eastern Washington University Geology Seminar, Virtual meeting, May 2021.

  *My American Adventure or The Theory of Chaos to Professional Career Paths*, by Claudio Berti: University of Chieti Graduate symposium, April 2021.

  *Part 107: FAA Rules and Regulations for Drone Operations*, by Zach Lifton: University of Idaho iDrone Camp, Virtual event, April 2021.

# PUBLICATIONS AND ACTIVITIES

## Publications

*Analysis of the Paraglacial Landscape in the Ny-Ålesund Area and Blomstrandøya (Kongsfjorden, Svalbard, Norway)*, by Ivar Berthling, Claudio Berti, Vania Mancinelli, Laura Stendardi, Tommaso Piacentini, and Enrico Miccadei, Journal of Maps, v.16-2, 2020.

*Application of Anisotropy of Magnetic Susceptibility (AMS) Fabrics to Determine the Kinematics of Active Tectonics: Examples From the Betic Cordillera, Spain, and the Northern Apennines, Italy*, by David J. Anastasio, Frank J. Pazzaglia, Josep M. Pares, Ken P. Kodama, Claudio Berti, James A. Fisher, Alessandro Montanari, and Loren K. Carnes: Solid Earth, v.12, 2021.

*Database of the Mines and Prospects of Idaho (version 1.2021)*, by Christopher A. Tate, Victoria E. Mitchell, and Loudon R. Stanford: Idaho Geological Survey Digital Database 1, 2021.

*Early Sevier Orogenic Deformation Exerted Principal Control on Changes in Depositional Environment Recorded by the Cretaceous Newark Canyon Formation*, by Anne C. Fetrow, Kathryn E. Snell, Russell V. Di Fiori, Sean P. Long, and Joshua W. Bonde: Journal of Sedimentary Research, v. 90, 2020.

*Geologic Map of the Burke Quadrangle and Parts of the Murray, Black Peak, and Thompson Pass Quadrangles, Shoshone County, Idaho*, by James L. Browne: Idaho Geological Survey Technical Report 21-02, scale 1:24,000, 2021.

*Geologic Map of the Butte City 7.5′ Quadrangle, Butte County, Idaho*, by Samuel L. Helmuth, Evan J. Martin, Mary K.V. Hodges, and Duane E. Champion: Idaho Geological Survey Technical Report 20-04, scale 1:24,00, 2021.

*Geologic Map of the Sandpoint 30′ x 60′ Quadrangle, Idaho and Montana, and the Idaho part of the Chewelah 30′ x 60′ Quadrangle*, by Reed S. Lewis, Russell F. Burmester, Roy M. Breckenridge, Mark D. McFaddan, and William M. Phillips: Idaho Geological Survey Digital Web Map 189, scale 1:100,000, 2020.

*Geologic Map of the Northern Part of the Leadore Quadrangle, Lemhi County, Idaho*, by Stuart D. Parker and David M. Pearson: Idaho Geological Survey Technical Report 20-03, scale 1:24,000, 2021.

*Geologic Map of the Osburn and Southern Prichard Quadrangles, Shoshone County, Idaho*, by James L. Browne: Idaho Geological Survey Technical Report 21-03, scale 1:24,000, 2021.

*Geologic Map of the Yellow Pine Quadrangle, Valley County, Idaho*, by Reed S. Lewis, David E. Stewart, Eric D. Stewart, and Zachery M. Lifton: Idaho Geological Survey Digital Web Map 190, scale 1:24,000, 2021.

*Idaho Mining and Exploration, 2014-2015*, by Virginia S. Gillerman, Alexis Clark, Mark Barton, and Earl H. Bennett: Idaho Geological Survey Staff Report 21-01, 2021.

*Idaho Mining and Exploration, 2016-2017*, by Virginia S. Gillerman, Alexis Clark, Mark Barton, and Earl H. Bennett: Idaho Geological Survey Staff Report 21-02, 2021.

*Lamprophyre Dikes of Northern Idaho and Northeastern Washington*, by Andrew M. Buddington, Cody J. Steven, Basil Tikoff, and Richard M. Gaschnig: Idaho Geological Survey Technical Report 21-01, 2021.

*Landslide Inventory Database for Idaho*, by Zachery M. Lifton, Scott D. Ducar, and Christopher A. Tate: Idaho Geological Survey Digital Database 10, 2021.

*Late Cretaceous Upper-crustal Thermal Structure of the Sevier Hinterland: Implications for the Geodynamics of the Nevadaplano*, by Nolan R. Blackford, Sean P. Long, Austin Stout, David W. Rodgers, Catherine Cooper, Kim Kramer, Russell V. Di Fiori, and Emmanuel Soignard: Geosphere, v. 17, n. 4., 2021.

*The 31 March 2020 Mw 6.5 Stanley, Idaho, Earthquake: Seismotectonics and Preliminary Aftershock Analysis*, by Lee M. Liberty, Zachery M. Lifton, and T. Dylan Mikesell: Seismological Research Letters, 2020.

*The Blackfoot Volcanic Field of Southeast Idaho—a Result of Interaction Between the Yellowstone Hotspot and Tectonic Activity*, by Zach Lifton: Yellowstone Volcano Observatory Caldera Chronicles, 2020.

*Shortening Episodes in the Sevier Hinterland Within the Larger Context of the Cordilleran Retroarc Thrust System: Insights From the Cretaceous Newark Canyon Formation in Central Nevada*, by Russell V. Di Fiori, Sean P. Long, Anne C. Fetrow, Kathryn E. Snell, Joshua W. Bonde, and Jeffrey D. Vervoort: Tectonics, v. 40, n. 5, 2021.

# Abstracts

*Exploration Potential in the DeLamar-Silver City District, Idaho: Paleosurface Preservation and Active Analogues*, by Jeffrey W. Hedenquist, E. Max Baker, Alex Deatherage, Virginia Gillerman, and Joe A. Kizis, Jr.: Geological Society of Nevada Symposium, 2020.

*Idaho's Current Mineral Exploration and Mining Projects: Ore Deposits through the Ages*, by Virginia S. Gillerman: Geological Society of Nevada Symposium, 2020.

*Paleoaltimetry Estimates Suggest Low Surface Elevations for the Mid-Cretaceous Newark Canyon Formation Within the Sevier Hinterland*, by Anne C. Fetrow, Kathryn E. Snell, Russell V. Di Fiori, Sean P. Long, and Joshua W. Bonde: American Geophysical Union 101 Fall Meeting, 2020.

*Preliminary Geologic Mapping of the DeLamar and Swisher Mountain Quadrangles, Owyhee Mountains, Idaho*, by Andrew S. Canada, Virginia S. Gillerman, Dennis M. Feeney, Keegan L. Schmidt, Alex Deatherage, and Max Baker: Geological Society of Nevada Symposium, 2020.

*Shortening Episodes in the Sevier Hinterland Within the Larger Context of the Cordilleran Retroarc Thrust System: Insights From the Cretaceous Newark Canyon Formation in Central Nevada*, by Russell V. Di Fiori, Sean P. Long, Anne C. Fetrow, Kathryn E. Snell, Joshua W. Bonde, and Jeffrey D. Vervoort: American Geophysical Union 101 Fall Meeting, 2020.

*Timing and Structural Analysis of the McClure Spring Syncline: a ~15 km-long Isoclinal Fold in the Central Pancake Range in Eastern Nevada*, by Russell V. Di Fiori, Sean P. Long, and Jeff Vervoort: Geological Society of Nevada Symposium, 2020.

*Upper-crustal Thermal Structure of the Sevier Hinterland Plateau, Eastern Nevada and Western Utah: Constraints From RSCM and CAI Thermometry Integrated With Structural Reconstructions*, by Nolan R. Blackford, Sean P. Long, Austin Stout, David W. Rodgers, Kimberly Kramer, Russell V. Di Fiori, and Emmanuel Soignard: Geological Society of America Meeting Abstracts With Programs, Vol. 52, No. 6, 2020.

# Reports

*Data Preservation Final Report*, by Christopher A. Tate and Reed S. Lewis: Final report to U.S. Geological Survey National Geological and Geophysical Data Preservation Program, October 2020.

*Detailed Mapping of the East and West Bear Lake Fault Zones, Utah and Idaho, and the Oquirrh, Southern Oquirrh Mountains, Topliff Hills, and Rush Valley Fault Zones, Utah—Using New High-Resolution LiDAR Data to Reduce Earthquake Risk*, by Adam I. Hiscock, Zachery M. Lifton, Greg N. McDonald, and Emily J. Kleber: Final Technical Report to U.S. Geological Survey, March 2021.

*Development of a Statewide Landslide Inventory Database for Idaho*, by Zachery M. Lifton, Scott D. Ducar, and Christopher Tate: Deliverable to Idaho Transportation Department, December 2020.

*Geodatabase of Regional Strategic and Critical Mineral Occurrences in Idaho*, by Reed S. Lewis, Virginia S. Gillerman, and Christopher A. Tate: Deliverable to U.S. Geological Survey, December 2020.

*Geologic Map of the De Lamar and Swisher Mountain Quadrangles, Idaho*, by Virginia S. Gillerman, Dennis M. Feeney, Andrew S. Canada, and Keegan L. Schmidt: Report to Integra Resources Inc., June 2021.

*Geologic Map of the Georgetown Quadrangle, Bear Lake County, Idaho*, by James C. Coogan, Dennis M. Feeney, and Skye W. Cooley: Deliverable to U.S. Geological Survey STATEMAP Program, scale 1:24,000, August 2020.

*Geologic Map of the Hungry Ridge Quadrangle, Idaho County, Idaho*, by Reed S. Lewis, David E. Stewart, Loudon R. Stanford, Russell F. Burmester, Paul E. Myers, and Keegan L. Schmidt: Deliverable to U.S. Geological Survey STATEMAP Program, scale 1:24,000, August 2020.

*Geologic Map of the Leesburg Quadrangle, Lemhi County, Idaho*, by Reed S. Lewis, Russell F. Burmester, Andrew S. Canada, and David E. Stewart: Deliverable to U.S. Geological Survey STATEMAP Program, scale 1:24,000, August 2020.

*Geologic Map of the Sawyer Ridge Quadrangle, Idaho County, Idaho*, by Reed S. Lewis, David E. Stewart, Loudon R. Stanford, Russell F. Burmester, and Keegan L. Schmidt: Deliverable to U.S. Geological Survey STATEMAP Program, scale 1:24,000, August 2020.

*Geologic Map of the Weiser Cove Quadrangle, Washington and Payette counties, Idaho*, by Dennis M. Feeney, Mark D. Barton, and Loudon R. Stanford: Deliverable to the U.S. Geological Survey STATEMAP Program, scale 1:24,000, August 2020.

*Geology of Farragut State Park*, by Russell V. Di Fiori: Deliverable to Idaho State Parks and Recreation, January 2021.

*Geology of Harriman State Park*, by Dennis M. Feeney: Deliverable to Idaho State Parks and Recreation, January 2021.

*Progress Report Year 2, Geologic Mapping of DeLamar and Swisher Mtn. Quadrangles project*, by Virginia S. Gillerman: Memo to Integra Resources, December 2020.

*Raft River Hydrogeologic Investigation – Phase 1 Project Summary*, by Alexis Clark: Deliverable to Idaho Department of Water Resources and Idaho Water Resources Board, November 2020.

# Presentations

*Application of X-Ray Fluorescence Analytical Geochemistry in Mapping: Lessons Learned From Idaho Geological Survey*, by Dennis Feeney: USGS Geologic Mapping Forum, Virtual meeting, February 2021.

*Earth MRI Projects in the Idaho Cobalt Belt*, by Claudio Berti and Reed Lewis: Association of American State Geologist Annual Meeting, Virtual meeting, May 2021.

*Idaho Earthquake Geology Update*, by Zach Lifton: Basin and Range Province Earthquake Working Group Meeting, Virtual meeting, February 2021.

*Idaho Geological Survey Financial Report*, by John Brabb: Idaho Geological Survey Advisory Board Meeting, Virtual meeting, December 2020.

*Idaho Geological Survey Geologic Hazards Update*, by Zach Lifton: Idaho Geological Survey Advisory Board Meeting, Virtual meeting, December 2020.

*Idaho Geological Survey Hydrogeology Program Update*, by Alexis Clark: Idaho Geological Survey Advisory Board Meeting, Virtual meeting, December 2020.

*Idaho Geological Survey Oil and Gas Program Update*, by Mark Barton: Idaho Geological Survey Advisory Board Meeting, Boise, Virtual event, December 2020.

*Idaho Mining and Exploration, 2020*, by Virginia S. Gillerman: American Exploration and Mining Association Convention, Virtual convention, December 2020.

*Geologic Mapping As It Relates to Mineral Exploration in Idaho*, by Reed S. Lewis: Columbia Basin Geological Society Meeting, Virtual meeting, April 2021.

*Geologic Mapping As It Relates to Mineral Exploration in Idaho*, by Reed S. Lewis: Idaho Mining Association Annual Meeting, Virtual meeting, October 2020.

*Mineral Resources and Mining (FY20)*, by Virginia S. Gillerman: Idaho Geological Survey Advisory Board Meeting, Virtual meeting, December 2020.

*Overview of the Idaho Geological Survey*, by Claudio Berti: Idaho Geological Survey Advisory Board Meeting, Virtual meeting, December 2020.

*Raft River Hydrogeologic Investigation (2019-2020)*, by Alexis Clark: Idaho Water Resources Board meeting, Boise, November 2020.

*Shortening Episodes in the Sevier Hinterland Within the Larger Context of the Cordilleran Retroarc Thrust System: Insights From the Cretaceous Newark Canyon Formation in Central Nevada*, by Russell V. Di Fiori: American Geophysical Union Fall Meeting, Virtual conference, December 2020.

*Stanley Earthquake Field Recon and Future Work*, by Zach Lifton: Idaho Office of Emergency Management Executive Team Meeting, Boise, November 2020.

*State Survey Capabilities in Support of the US GeoFramework Initiative – Challenges and Solutions*, by Claudio Berti: National Cooperative Geologic Mapping Program Strategic Plan Review Workshop, Virtual workshop, April 2021.

*The March 31, 2020 Mw6.5 Stanley, Idaho Earthquake*, by Zach Lifton: Basin and Range Province Earthquake Working Group Meeting, Virtual meeting, February 2021.

*Update on Geological Mapping in Idaho*, by Reed S. Lewis, Dennis M. Feeney, and Russ Di Fiori: Idaho Geological Survey Advisory Board Meeting, Virtual meeting, December 2020.

# Web Products

*U.S. Atomic Energy Commission Documents Webpage*, by Christopher A. Tate: Idaho Geological Survey Webpage: https://idahogeology.org/geologic-resources/mines-minerals/us-atomic-energy-commission-documents, September 2020.

*IGS Landslide Database*, by Zachery M. Lifton and Christopher A. Tate: Idaho Geological Survey Web Application, https://uidaho.maps.arcgis.com/apps/webappviewer/index.html?id=7b0168f1958f48e28cf79ea2bfea9264, December 2020.

*Mines Web Application*, by Christopher A. Tate, Reed S. Lewis, and Dustin Thomas: Idaho Geological Survey Web Application, https://www.idahogeology.org/WebMap/?show=mines, August 2020.

# Operational Improvements

*GeMS Tools for IGS*, by Linda Tedrow and Skye Swoboda-Colberg: Idaho Geological Survey, April 2021.

*IGS Digital Web Map Publication Procedures*, by Nathan Hopkins: Idaho Geological Survey, August 2021.

*Mines and Prospects Database Data Entry Interfaces for General Attributes Including Autogenerated Metadata*, by Christopher A. Tate: Idaho Geological Survey, July 2020.

*Modeling Evapotranspiration*, by Alexis Clark and Christopher A. Tate: Idaho Geological Survey, April 2021.

*Regional Development and Idaho State Mine Inspector Report Functionality*, by Christopher A. Tate: Idaho Geological Survey, January 2021.

# Media Interviews

*4.3 Magnitude Earthquake, Three Others Shake Central Idaho*, IdahoNews, https://idahonews.com/news/local/43-magnitude-earthquake-three-others-shake-central-idaho, November 13, 2020 (Idaho Geological Survey).

*$10 Million DOE Grant to College Boosts Geothermal Energy Exploration*, Hydrogen Fuel News, https://www.hydrogenfuelnews.com/10-million-doe-grant-to-college-boosts-geothermal-energy-exploration/8540645/, October 6, 2020 (Idaho Geological Survey).

*A Small Idaho Agency is a Counter Balance to China*, KLIX, https://newsradio1310.com/a-small-idaho-agency-is-a-counter-balance-to-china/, January 4, 2021 (Idaho Geological Survey).

*Cobalt in Idaho*, CNN, In preparation, June 9, 2021 (V.S. Gillerman).

*Earthquakes Leave Their Mark in the Sawtooths*, Idaho Mountain Express, https://www.mtexpress.com/news/environment/earthquakes-leave-their-mark-in-the-sawtooths/article_022f2676-bcbb-11ea-b677-dfe14a3a24cc.html, July 3, 2020 (C. Berti).

*Geothermal Energy Exploration to Get Boost From University Research*, Nevada Today, https://www.unr.edu/nevada-today/news/2020/geothermal-exploration?fbclid=IwAR3AT9Rm7TW24pNpFMR-1DoWxO4mmlDydloPadCu47GCXXROJPnWHKLPELs, September 25, 2020 (Idaho Geological Survey).

*Highway 55 Reopens to Limited Traffic After Rockslide*, KMVT, https://www.kmvt.com/2021/03/24/highway-55-reopens-to-limited-traffic-after-rockslide/, March 24, 2021 (C. Berti).

*Idaho's Geology: Beautiful and Problematic*, Lewiston Tribune, https://lmtribune.com/northwest/idaho-s-geology-beautiful-and-problematic/article_55b45ea4-72eb-534b-8729-46929d742a33.html, July 16, 2020 (C. Berti).

*Idaho Started Shaking March 31. Why Hasn't It Stopped? Geologists Research Sawtooth Fault*, Idaho Statesman, https://www.idahostatesman.com/news/local/environment/article243943677.html?, July 6, 2020 (C. Berti).

*New Database Project Can Help Locate 'Problematic Hot Spots' for Idaho Landslides*, KTVB, https://www.ktvb.com/article/tech/science/environment/idaho-database-landslide-project-hotspot/277-9ef29369-b972-4777-96dd-6e847944da8f, June 29, 20201 (C. Berti).

*New Idaho Landslide Inventory Database to Assist With Hazard Mitigation*, University of Idaho News, https://www.uidaho.edu/news/news-articles/news-releases/2021-spring/062921-landslideinventorydatabase, June 29, 2021 (C. Berti).

*New Information Being Learned After March 2020 Earthquake*, KMVT, https://www.kmvt.com/2021/01/20/new-information-being-learned-after-march-2020-earthquake/, January 20, 2021 (C. Berti).

*One Year Later: Geologists Survey Changes Around Stanley Lake After 6.5 Earthquake*, IdahoNews, https://idahonews.com/news/local/one-year-later-geologists-survey-changes-around-stanley-lake-after-65-earthquake, March 30, 2021 (C. Berti).

*Pollock Slide Remains Closed Today; Locals-only Detour Being Looked Into*, Idaho County Free Press, https://www.idahocountyfreepress.com/news/pollock-slide-remains-closed-today-locals-only-detour-being-looked-into/article_10ba675e-bfbe-11ea-a588-6ffbf4d9fcdd.html, July 6, 2020 (Z. Lifton).

*Seeking Silver at Bunker Hill: New Effort Underway to Ramp Up North Idaho Mine*, Spokesman-Review, https://www.spokesman.com/stories/2020/nov/29/seeking-silver-at-bunker-hill-new-effort-underway-/, November 29, 2020 (V. Gillerman).

*Stanley Still Shaking As Tourism Season Heats Up*, Boise State Public Radio, https://www.boisestatepublicradio.org/environment/2020-07-02/stanley-still-shaking-as-tourism-season-heats-up#stream/0, July 2, 2020 (C. Berti).

*Treasure Valley Spotlight: Claudio Berti*, Idaho Press, https://www.idahopress.com/community/life/treasure-valley-spotlight-claudio-berti/article_f6a837e3-a87a-5b5b-a496-d316857a293f.html, July 9, 2020 (C. Berti).

*University of Idaho Geologist Discusses Cause of Rockslide Near Riggins*, KTVB, https://www.ktvb.com/article/tech/science/rockslide-near-riggins-what-caused-it/277-b5968eff-a643-44ea-bdc1-7e67aa3a0a42, July 9, 2020 (C. Berti).

*Weekend Earthquake Shakes Town North of Boise*, KMVT, https://www.kmvt.com/2021/03/15/weekend-earthquake-shakes-town-north-of-boise/, March 15, 2021 (C. Berti).

*Why Idaho Hasn't Stopped Shaking Since March 31*, Popular Mechanics, https://www.popularmechanics.com/science/environment/a33238811/idaho-earthquake-shaking/, July 8, 2020 (C. Berti).

*Yellowstone Volcano Latest: Idaho Quake Tremors Spark Fear Over Huge Supervolcano Eruption*, Daily Express, https://www.express.co.uk/news/science/1308037/Yellowstone-volcano-eruption-latest-Idaho-earthquake-news-aftershocks-USGS, July 13, 2020 (C. Berti).

# Professional Activities

*Affiliate Faculty*, Boise State University (V.S. Gillerman, Z.M. Lifton).

*Affiliate Faculty*, University of Idaho (M.D. Barton, C. Berti, V.S. Gillerman, R.S. Lewis, Z.M. Lifton).

*Affiliate Faculty*, Washington State University (R.S. Lewis).

*Contributor*, USGS National Seismic Hazard Model 2023 Update (Z.M. Lifton).

*Federal Aviation Administration Remote Pilot Certificate* (Z.M. Lifton).

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

*Idaho Certified Water Rights Examiner* (A.L. Clark).

*Idaho Registered Professional Geologist* (A.L. Clark, R.V. Di Fiori, D.M. Feeney, V.S. Gillerman, R.S. Lewis, Z.M. Lifton).

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

*Member*, American Geophysical Union (C. Berti, R.V. Di Fiori, Z.M. Lifton).

*Member*, American Water Resources Association (A.L. Clark).

*Member*, Association of American State Geologists (C. Berti).

*Member*, Basin and Range Province Earthquake Working Group (Z.M. Lifton).

*Member*, Eastern Snake Hydrologic Modeling Committee (A.L. Clark).

*Member*, Geological Society of America (C. Berti, R.V. Di Fiori, V.S. Gillerman, N. Hopkins, R.S. Lewis, Z.M. Lifton).

*Member*, Geological Society of Nevada (V.S. Gillerman).

*Member*, Ground Water Monitoring Technical Committee (A.L. Clark).

*Member*, Idaho Association of Professional Geologists (A.L. Clark, Z.M. Lifton).

*Member*, Idaho LiDAR Consortium (Z.M. Lifton).

*Member*, Idaho Office of Emergency Management Seismic Technical Working Group (Z.M. Lifton).

*Member*, Idaho Office of Emergency Management Technical Committee (A.L. Clark).

*Member*, Incorporated Research Institutions for Seismology (IRIS) Portable Array Seismic Studies of the Continental Lithosphere (PASSCAL) (C. Berti).

*Member*, National Ground Water Association (A.L. Clark).

*Member*, Society for Mining, Metallurgy, and Exploration and Boise Section of Society for Mining, Metallurgy, and Exploration (V.S. Gillerman).

*Member*, Tobacco Root Geological Society (R.V. Di Fiori, R.S. Lewis).

*Member*, Treasure Valley Modeling Technical Advisory Committee (A.L. Clark).

*Member*, Western States Seismic Policy Council (C. Berti, Z.M. Lifton).

*Member*, Yellowstone Volcano Observatory (Z.M. Lifton).

*Oregon Certified Water Rights Examiner* (A.L. Clark).

*Oregon Registered Professional Geologist* (A.L. Clark).

*Participant*, 88th Annual Western Snow Conference: Bridging the Gap between Research and Operations, Virtual Meeting, April 2021 (A.L. Clark).

*Participant*, American Exploration and Mining Association Convention, Virtual convention, December 2020 (V.S. Gillerman).

*Participant*, American Geophysical Union Fall Meeting, Virtual conference, December 2020 (R.V. Di Fiori).

*Participant*, Boise Section of Society for Mining, Metallurgy, and Exploration Meetings, Virtual meetings, September 2020 and February 2021 (V.S. Gillerman).

*Participant*, Collaborative Database Effort for Geology Monthly Meetings, Virtual Meetings, July 2020-June 2021 (N. Hopkins, L. Tedrow).

*Participant*, Digital Mapping Techniques Lite, Virtual conference, October 2020 (R.V. Di Fiori).

*Participant*, Digital Mapping Techniques Workshop, Virtual workshop, June 2021 (B. Bailey, N. Hopkins, J. Sandquist, L. Tedrow).

*Participant*, Geologic Mapping Forum Online, Virtual event, October 2020 (R.V. Di Fiori), January-April 2021 (N. Hopkins).

*Participant*, Geological Society of Nevada Meetings, Virtual meetings, October-November 2020 and February-May 2021 (V.S. Gillerman).

*Participant*, Idaho Mining Association Conference, Virtual conference, October 2020 (R.V. Di Fiori, V.S. Gillerman, R.S. Lewis).

*Participant*, U.S. Geological Survey Earth MRI Critical Minerals Workshop, Virtual workshop, September 2020 (V.S. Gillerman, R.S. Lewis, C. Berti).

# Graduate Thesis Committees

Dana Drinkall, M.S. Geology, Idaho State University (Z.M. Lifton).

John Murphy, M.S. Geology, Washington State University (R.S. Lewis).

# Grants and Contracts

*Abandoned Mine Lands Project*, Task 5: R.S. Lewis (Idaho Department of Lands, March 2019-April 2021, $141,677).

*Abandoned Mine Lands Project, Task 6*: R.S. Lewis (Idaho Department of Lands, April 2021-March 2023, $169,445).

*Data Preservation 12*: R.S. Lewis and V.S. Gillerman (U.S. Geological Survey Data Preservation Program, July 2019-July 2020, $67,496).

*Data Preservation 13*: R.S. Lewis and V.S. Gillerman (U.S. Geological Survey Data Preservation Program, July 2020-July 2021, $68,505).

*Detailed Mapping of the Holocene- and Late Quaternary-Active Traces of Northern Utah/ Southern Idaho Active faults*: Collaborative Research With Idaho Geological Survey and Utah Geological Survey: Z.M. Lifton (U.S. Geological Survey National Earthquake Hazard Reduction Program, July 2019-December 2020, $28,218.56).

*Development of a Statewide Landslide Inventory Database*: Z.M. Lifton (Idaho Transportation Department Research Grant, October 2018-December 2020, $90,114).

*Geologic Mapping of De Lamar and Swisher Mountain 7.5′ Quadrangles*: V.S. Gillerman and D.M. Feeney (Integra Resources, May 2019-June 2021, $ 103,261).

*Geologic Mapping in the Idaho Cobalt Belt*: R.S. Lewis (U.S. Geological Survey Earth-MRI Program, August 2019-October 2021, $100,000).

*Geologic Mapping in the Preston, Weiser, Salmon, and Elk City areas*: R.S. Lewis and D.M. Feeney (U.S. Geological Survey STATEMAP Program, June 2020-May 2021, $162,342).

*Geologic Map Schema Databases for Weiser, Salmon, and Rexburg*: R.S. Lewis and D.M. Feeney (U.S. Geological Survey STATEMAP Program, June 2020-May 2021, $156,050).

*Geologic Mapping in the Yellow Pine Quadrangle*: R.S. Lewis (Wilmat Petroleum Company, May 2019-September 2020, $39,999).

*Groundwater Budget for the Big Lost River Valley*: A.L. Clark (Idaho Department of Water Resources, December 2018-October 2021, $125,000).

*Mapping and Neotectonic Investigation of the Sawtooth Fault, Central Idaho: Collaborative Research With Idaho Geological Survey, Idaho State University, and BGC Engineering, Inc.*: Z.M. Lifton (U.S. Geological Survey National Earthquake Hazard Reduction Program, June 2021-May 2022, $23,528.60).

*Raft River Valley Hydrogeologic Investigation Phase 1*: A.L. Clark (Idaho Department of Water Resources, December 2019-November 2020, $107,500).

*Raft River Basin Hydrogeologic Investigation – Phase 2 (Hydrogeologic Framework and Water Budget)*: A.L. Clark (Idaho Department of Water Resources, January 2021-December 2023, $375,000).

*Update to Idaho's Active Fault Database*: Z.M. Lifton (Idaho Office of Emergency Management, October 2020-July 2021, $40,945.00).