

# **Annual Report of the Idaho Geological Survey**

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Fiscal Year  
1997

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of the  
Idaho Geological Survey  
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**Idaho Geological Survey  
University of Idaho  
Moscow, Idaho**

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# Introduction

A spate of natural disasters nationwide, including floods and landslides in Idaho, kept the word "geology" before the public all year long. The Survey was actively involved in emergency responses to events in the state through the Governor's Landslide Task Force and the Bureau of Disaster Services. The agency also worked on a test version of a computer-based hazard evaluation program that should greatly improve disaster response and mitigation.

Another disaster of fiscal dimensions sent state agencies reeling. Governor Philip Batt ordered a 2.5 percent reduction in the FY-97 budget year. This came on the back of a 2 percent cut ordered by the governor for FY-96. The percentages may seem small but the impact on personnel-intensive agencies like the Survey is not. The Survey compensated by partially shifting a research geologist position to the University of Idaho.

The extensive remodeling of Morrill Hall, the home of the Survey's main office as well as other university departments, took about a year. Bringing the second-oldest building on campus up to current fire, safety, and handicapped-access codes called for an interior transformation. From the outside the building looks the same; inside there are dramatic changes. To accommodate an elevator required eliminating the central stairway, the offices between floors adjoining the stairs, and those offices occupying space in the hallways on each floor. Another stairway built at the east end of the building to replace the central stairs also eliminated offices on three floors. The reclaimed hallways now allow secondary entry and egress at both ends of the building. The overhaul was also "geologically correct" in that it included a seismic retrofitting of the floors and bearing walls. Finally, the addition of

restrooms on each floor instituted a most welcome component in the renovation.

The Digital Mapping and Information Lab completed nine 1:100,000-scale digital geologic map compilations for the Clearwater and Nez Perce National Forests and another twelve 7.5-minute quadrangles. The lab now has a working metadata design. All new digital map releases or publications are complete with metadata.

Work continues on a cooperative project with the Montana Bureau of Mines and Geology to establish a seismic network to monitor faults along the Lewis and Clark Line and in associated areas of northern Idaho. The Survey also completed the first statewide inventory of potentially active faults.

The Survey's hydrogeologist began a major study at the Idaho National Engineering and Environmental Laboratory. The work is funded by the Department of Energy through a contract with the Idaho Water Resources Research Institute. The project will design a model of the hydrology and geology beneath the federal facility and will look at ways to define and remediate contaminant plumes at the site. A digital mapping laboratory was built at Idaho State University in cooperation with the Geology Department to process the vast amount of data collected during this project.

Field work began on inventorying inactive and abandoned mine lands in northern Idaho for Region I of the U.S. Forest Service (USFS). About 150 properties were examined and videotaped for physical and environmental hazards in the Lakeview Mining District and the Prichard and Eagle creeks's area. The report and videotape for the Lakeview district had been delivered to the USFS

by year's end.

The Survey finished its cooperative project with the Association of American State Geologists (AASG) and the National Park Service (NPS) to compile bibliographies of maps and other materials published by state surveys nationwide for the lands in their states administered by the NPS. The Survey handled the compilation under subcontract to the AASG and brought together almost 5,000 references from the other state surveys into a comprehensive digital database.

The completion of the geologic map of the Pocatello North quadrangle for StateMap extends the interpretation of surficial geology started in the Pocatello South quadrangle in 1994. Surficial geologic maps were also completed for the Post Falls quadrangle in 1996 and the Liberty Lake, Newman Lake, and Rathdrum quadrangles in 1997 under the second year of a project in the area of Coeur d' Alene in Kootenai County. Next summer, a new StateMap project will undertake geologic mapping applicable to understanding ground-water systems in the Moscow-Pullman and Lewiston-Clarkston areas.

Nola Steuer resigned her position with the Survey late last fall. For the past five years she worked in the Publications and Maps Sales office. During her tenure, she reorganized the filing of nearly 2,000 maps and instituted new accounting procedures with business computer software; neither were tasks for the faint of heart. For most callers and visitors, Nola was the first and perhaps only Survey employee they would meet. She excelled in making people feel welcome and relaxed. She greeted everyone, customers and fellow employees alike, with cheerful good humor. We will miss her warm friendliness.

In January, Keri Moore was hired to replace Nola Steuer in the Publications and Maps Sales office. Keri came to us from the University of Idaho Bookstore where she ordered textbooks for college courses. Keri has been a resident of the Moscow-Lewiston area for thirty years. She has two degrees from the University of Idaho: a B.S. in bacteriology-medical technology and a B.S. in elementary education.

Robert W. Bartlett, Director of the Survey and Dean of the College of Mines and Resources at the University of Idaho, announced his retirement effective June 30, 1997. Dr. Bartlett arrived on campus in October 1987. Within a few years he began developing plans for a new high-tech building to unite the college's academic departments under one roof. He tirelessly pursued both public money and private donations to achieve this \$11 million dream. In October, 1995, the dedication of the James A. McClure Hall acknowledged the generous contributions of many but also the crowning achievement of Dr. Bartlett's tenure as dean. The pinnacle of his professional career came with his nomination into the National Academy of Engineering in 1995. He is one of only a handful in Idaho's history chosen for this honor. He also managed to find time to serve as President of the Minerals, Metals and Materials Society of the American Institute of Mining and Petroleum Engineers (TMS-AIME) in 1989, to write a book on solution mining in 1992 (second edition is in the works), and to receive the Society of Metallurgical Engineers's Wadsworth Award in 1996 and TMS's Extracting and Processing Distinguished Lecturer Award in 1997. Bob and Betty Bartlett plan on making their retirement home near their children and grandchildren in southern California.



# Service

## Digital Mapping and Information Lab

The Digital Mapping and Information Laboratory performs services ranging from digital cartography to spatial data management. Map making at the lab is divided into two areas: one is preparing new mapping for publication, and the other is fashioning new and existing geologic maps into digital map compilations. To accomplish this, the lab uses an eclectic assortment of software including computer aided design (CAD) and geographic information systems (GIS).

Twelve new 7.5-minute geologic maps were added to the state's geologic database. Seven of these are the result of StateMap projects. The maps will eventually be published separately or as part of a compilation. As with all new maps published now at the Survey, these data are available in digital GIS format.

The lab completed digital geologic compilations on nine 30 x 60 minute maps for the Nez Perce and Clearwater National Forests. These maps cover an area from the main Salmon River in central Idaho to the St. Joe River in northern Idaho. They are the first digital compilations done at the Survey and incorporate the new geology mapped by the Idaho Initiative field crews from 1990 to 1992. All maps include metadata (information about the data). Eventually these maps will be available as both plot-on-demand products and digital GIS publications.

Most of the digitizing has been completed for the Pocatello 30 x 60 quadrangle, a StateMap-funded geologic compilation. This

map will be released in 1998 as a plot-on-demand map and as GIS data.

The map, *Geology of the Boise Basin and Vicinity*, will be published in full color by late summer or early fall 1997. The map uncovers the geology of the state's richest gold mining area and will be fully digital including the base map.

## Earth Science Education

Support for earth science education keeps the Survey busy on many levels. The staff is always willing to meet with public and private agencies, professional organizations, school classes, hobbyists, local clubs, and youth groups. Through close working relationships with the geology departments at the three state universities, Survey geologists make their expertise available to college-level students, teachers, and other scientists by participating in seminars, field trips, and workshops, by teaching selected upper division courses, and by directing graduate students on thesis and dissertation research (see *Graduate Thesis Committees* under the section, Staff Publications & Activities). The Survey, the geosciences in general, and the minerals industry recognize the need to educate the public in matters concerning geology and mineral resources. The earth science community is consequently strengthened by this willingness of its members to involve themselves with the general public in areas of their special knowledge and experience.

At the request of the Geoscience Department at Boise State University, the Survey's geologist in Boise taught a new course

spring semester. The course integrated the geology of ore deposits with mining processes, the industry, and the environmental issues surrounding mineral extraction. By including speakers from regulatory agencies and using balanced examples of mining techniques, the course satisfied the needs of industry and regulatory agencies alike.

On the elementary and secondary school level, the Survey is primarily engaged with promoting earth science education with the state's teachers. The agency keeps current with teachers through its long interest in the Idaho Earth Science Teachers Association (IESTA) and its programs. In addition, each summer the Survey conducts field workshops so that teachers can observe the methods and science of geology in earth's own laboratory.

A Survey geologist serves on the advisory board of the IESTA and helps plan the annual fall conference, summer field conference, business meetings, and other special events. The fall conference was held in Pocatello this year, where the IESTA sponsored technical sessions, a rock raffle, a field trip, and an information booth at which both IESTA and selected Survey publications were sold. At the winter business meeting held in Hagerman in March, association officers were able to break from routine operational matters to tour the fossil site at the Hagerman Fossil Beds National Monument. In April several members of IESTA, including a Survey geologist, attended the National Science Teachers Association annual meeting in New Orleans. Their purpose was to present to the assembly a report on the success of IESTA's "Partnership Program" developed especially to keep Idaho's mostly rural earth science teachers up-to-date and motivated. Idaho is one of a handful of states in which the state's geological survey and earth science teachers work closely to improve and enrich the teaching

of earth science.

In July the Survey conducted its summer field workshop for teachers in cooperation with the Idaho Bureau of Disaster Services (IBDS) and the IESTA. This session was the seventeenth workshop for teachers since 1986. Again this year the limited enrollment filled quickly and by March forty participants had signed on. Because of its popularity, the Survey set up a second workshop in July that attracted twenty participants. The summer 1996 workshops exposed teachers from every part of the state to the world-class geology near the Teton Valley. In the adjoining eastern Snake River Plain, geologic features included the Menan Buttes volcanic cones, a lava tube cave within one of the large shield volcanoes in the northeastern Snake River Plain, the St. Anthony sand dunes, and the site of failed Teton Dam. In nearby Jackson Hole, teachers traced the active Teton fault and examined the effects of glaciation, the results of which have created the spectacular scenery in this popular recreational area. Finally, a hike into the Teton Range provided a first-hand look into Paleozoic rocks that contain marine fossils. Teachers also received training in assessing the safety of buildings in a high-risk earthquake zone.

Survey staff prepared a display on the geology of Glacial Lake Missoula and the Clark Fork ice dam for the University of Idaho's Clark Fork field campus. Another display on local geology is nearly complete for the visitor center at Farragut State Park. These displays feature the Survey's mapping projects. Both highlight digital models of past geologic scenery developed in the agency's Digital Mapping and Information Laboratory.

The Survey's digital reconstructions of the prehistoric Lake Missoula floods are also being used in a new *Discovery* channel tele-

vision series. Research on the Ice Age flood and the collapse of the ice dam has also involved the agency with the NASA Pathfinder Mission to Mars. In July, 1997, Pathfinder will land on Mars in a terrain genetically similar to the Channeled Scabland. Educators throughout the U.S. will have classroom activities directly linked to the Pathfinder and its vehicle. The Martian lander carries a plaque inscribed with the names of researchers nationwide—including those at the Survey!

## Geologic Hazards

Floods, landslides, and heavy snowloads were the cause of a second consecutive winter season of federal disaster declarations for Idaho. Survey staff were busy participants in the emergency management process both in the field and at many meetings. During the 1996-1997 storm events, landslides were the dominant geologic process. Highways and lifelines were disrupted by widespread slope movements. The Survey was actively involved with the state's Landslide Task Force. Geologists spent considerable time in the field evaluating the Lowman area, Little Salmon River canyon, and Boundary County for the Bureau of Disaster Services.

The severity of natural disasters this year meant a busy time for the Survey's Boise office in interagency meetings called to deal with fires, landslides, and floods. The Boise geologist met with Bureau of Disaster Services interagency teams to evaluate risk and hazard mitigation from actual and potential events: (1) debris flows in the Boise foothills following the 8th Street fire; (2) subsequent mudslides threatening the community of Lower Banks and surrounding area after the January 1, 1997, flood; (3) future landslides in the state reviewed in conjunction with the Governor's Landslide Task Force; and (4)

the winter floods in both the northern and southern parts of the state. This successful interagency cooperation produced two major reports. One was the Federal Emergency Management Agency/State Interagency Technical Report on the Boise County debris flow. The other was for the Governor's Landslide Task Force. The Boise office also represents the Survey on the Idaho Emergency Response Commission. In addition, the geologist continues with informal efforts throughout the year to promote public awareness of geologic hazards such as floods, landslides, and earthquakes. The expanding urban growth in the state will inevitably continue to bring these issues to the public's attention and to the Survey.

The Survey participated in a training session for a new computer-based hazard evaluation program called HAZUS. The program, distributed by the Federal Emergency Management Agency, uses a GIS database to model specific hazard events and predict losses and damages. The Survey has been asked to provide geologic parameters for the state and to implement the program after the testing stage. The HAZUS program should prove to be a valuable tool for disaster response and mitigation in the state.

The state's earthquake database and earthquake observatory are continually being improved with new data. Earthquake information for Idaho is now available on the agency's homepage on the University of Idaho's website and linked with other earthquake information sites. The website contains an overview of the state's seismicity and earthquake preparedness. New seismic design maps of the United States are being produced for the 1997 edition of the National Earthquake Hazard Reduction Program's *Recommended Provisions for Seismic Regulations for New Buildings*, a report produced by the Building Seismic Safety Council. Survey geologists worked on developing

these code maps. The building industry is preparing for the implementation of new international seismic standards by 2001. All codes in Idaho are the responsibility of local jurisdictions.

The Survey continues to be active in the Western States Seismic Policy Council (WSSPC). This organization of eighteen western states and Canadian provinces and territories was restructured in 1995. At the 1996 conference held in Polson, Montana, WSSPC presented its "Award for Excellence in Education" to the Survey for the annual Idaho Earthquake Education Workshops. This successful program, now in its fifth year, is the result of a productive partnership between the Survey, the Idaho Bureau of Disaster Services, the Federal Emergency Management Agency, and the Idaho Earth Science Teachers Association. The Survey also attended WSSPC's Basin and Range Province Seismic Hazard Summit where criteria for defining active basin and range style faults are being refined.

## **Idaho Gold Miners Do It Again!**

Preliminary statistics gathered by the Survey indicate that Idaho's gold miners have, for the second year in a row, set a production record for the "Gem State." The total of 347,000 ounces of gold for 1996 easily surpasses last year's surprising record of just over 300,000 ounces, which was over twice the previous high set in 1941. To get this remarkable output, several mines excelled in individual production. Kinross Gold set a record at its DeLamar operation in Owyhee County of almost 44,000 ounces, thanks to rich ore from the new Stone Cabin open pit. In its first full year of production, Meridian Gold's new Beartrack mine in Lemhi County recovered 108,630 ounces, just a little more than last year's high mark of 108,495 ounces by Pegasus Gold's Black Pine mine in

Cassia County. Both Black Pine and Beartrack's records far exceed any previous single mine's annual production in the state. Beartrack's record is an auspicious start to a mine that is believed to be the largest single gold deposit ever found in Idaho.

## **Mining Industry Review**

Highlights for 1996 included the new record gold production of 347,471 ounces and the increasing silver production from mines in the Silver Valley. The Survey's Boise-based economic geologist visited twenty mines and exploration projects around the state. Presentations on Idaho's mining and exploration were made to the Northwest Mining Association's annual meeting in December, to the Idaho County Tax Assessors Conference in Soda Springs in November, and the Department of Lands' minerals workshop. The Boise office also represented the agency on the Department of Lands' mining advisory committee. The Survey prepares a report on the state's exploration activity that is published annually in the May issue of *Mining Engineering*, a popular industry journal.

In November, the Survey and the Silver Valley Trustees presented an overview of Idaho's mining industry and cleanup efforts in the Coeur d'Alene Mining District to the North Idaho Chamber of Commerce Legislative Tour. About 50 legislators attended the 30-minute briefing and ensuing question/answer session. The lure of attractive door prizes furnished by Sunshine Mining Company, Hecla Mining Company, and Emerald Creek Garnet were a big draw to attract the distinguished audience.

At the old Blackbird mine site, about 20 miles west of Salmon, Noranda Mining Company is involved with a major environmental cleanup. The property was mined in

the past for copper, cobalt, and gold. Noranda became interested in Blackbird when cobalt prices skyrocketed in 1979-1981, although the property was never placed in production. The company produced a video showing the substantial progress in cleanup at the site. The state geologist was asked to furnish historical background and to participate in making the video.

The Survey has reviewed Gulf Resources Corporation's exploration records for Idaho, which are now owned by Hart Bettis, a Missoula-based consultant. These files contain information on over 700 properties that were examined by geologists from the Bunker Hill and Gulf Resources companies. In early November, Survey personnel copied selected files. This information is now being integrated into the Survey's mineral property files, which contain data on over 8,300 mines and prospects in the state.

When the Bunker Ltd. Partnership held the last auction at the Bunker Hill mine, the Survey inherited all of the company's files stored in the Engineering-Geology building. Among these documents were bound sets of the *Mining and Scientific Press* (1906-1922) and the *Engineering and Mining Journal* (1890-1945). The journals are leather bound in six-month sets and are stamped with the name of Fred Bradley, who was president of Bunker Hill from 1897-1924. The Survey copied the indices for each set and bound those for future reference. In addition, articles dealing with Idaho mining properties were copied for the Survey's files. The bound journals will be transferred to the University of Idaho Library for storage. Missing indices will be added to the Survey's collection from the Library's collection. The two journals were primary publications dealing with mining and contain information found nowhere else.

A session at the Pacific Northwest Metals

Conference was devoted to an update of mining in the Coeur d'Alene Mining District. A survey geologist presented an overview of the district, and company geologists filled in details about their respective mines. The presentation included a short history of how past mining practices resulted in what is now perceived as environmental problems in the area. The talk noted the recent accomplishments of the companies and the state and federal agencies who are involved with the Superfund cleanup in the Silver Valley and the activities of the Silver Valley Trustees.

## **National Minerals Workshop**

The state geologists from Idaho and Nevada and representatives from the U.S. Geological Survey (USGS) hosted a workshop in Washington, D.C., to examine how national mineral statistics and data are collected and interpreted. The workshop was put together over concerns brought about by the demise of the U.S. Bureau of Mines and the transfer of the bureau's mineral statistics program to the USGS. About 50 people from industry and state and federal government agencies attended the workshop. The presentations and discussions helped to explain how the data will be collected and reported in the future.

## **National Park Service Bibliography**

Work was finished on a cooperative project with the American Association of State Geologists and the National Park Service (NPS) to compile bibliographies of maps and other materials published by state surveys for lands administered by the NPS. Over 4,800 references were collected for these bibliographies. The entries were encoded in the ProCite database manager used by the NPS nationwide.

# Research

## Abandoned and Inactive Mines

The Survey began field work in the summer of 1996 on inventorying the abandoned and inactive mines in the U.S. Forest Service's Region I in the panhandle of Idaho. This year's work concentrated on two areas: (1) Prichard and Eagle creeks near the towns of Murray and Prichard on the North Fork of the Coeur d'Alene River and (2) Gold Creek-Lakeview Mining District at the south end of Lake Pend Oreille. The Survey examined 135 sites; 111 were in the Prichard-Eagle creeks area and 24 in the Lakeview District. The project identified physical hazards such as open mine workings, dangerous buildings, and environmental problems including mill tailings and acid mine drainage. All sites were videotaped and photographed. The importance of this inventory was unfortunately amplified by the tragic deaths in 1995 of two young men in an abandoned mine in the Lakeview District and the resulting \$1.5 million lawsuit brought by their families against the Forest Service. The project will examine the rest of the mine sites in the Coeur d'Alene basin next summer.

This project includes preparing thorough individual histories for several of the key mines in Region I. In addition, a composite history of eight mines in the Pine Creek drainage was completed. These histories will become part of the Survey's mineral property files, which are available for inspection at the main office in Moscow. Funding for these histories was obtained from Region I of the U.S. Forest Service and the Idaho State Office of the U.S. Bureau of Land Management.

## Coeur d'Alene Urban Mapping

The Coeur d'Alene urban mapping project concludes the second year of funding under the U.S. Geological Survey's STATEMAP program. The Survey completed surficial geologic maps of the Post Falls quadrangle in 1996 and the Liberty Lake, Newman Lake, and Rathdrum quadrangles in 1997. Mapping has revealed important geologic relationships in the Rathdrum-Spokane valley aquifer, the sole water source for the region. Increased urban growth in the area has raised concerns regarding the management of this critical resource and the consequent need for geologic information.

Studying the surficial geology of the Rathdrum Prairie will further understanding of the stratigraphy and facies of the gravels. Most of the valley-fill deposits are derived locally including rocks from the Precambrian Belt Series, Tertiary and Cretaceous plutons, lower Paleozoic sediments, and Miocene basalts. The units are mainly glaciofluvial in origin and mantled with eolian deposits. Bouldery gravels deposited by catastrophic floods from Pleistocene glacial Lake Missoula dominate much of the section. These latest periods of emptying cycles occurred 12,000 to 17,000 years ago. The thalweg of the valley is occupied by large bars with giant current ripples. Eddy and pendant bars are common at valley margins.

In addition to distinctions in gravel facies, field investigations have revealed the persistent occurrence of cementation in the exposed units. This important characteristic has not been previously reported. The ce-

mentation is prevalent in the proximal flood deposits in the Rathdrum Prairie as well as in the flood deposits within the Lake Missoula basin. In the field the calcium carbonate cement reacts actively in dilute HCL. Scanning electron microscope analysis also shows that fine angular silica is incorporated in the carbonate coatings. A likely source of the silica appears to be volcanic ash. Though the coatings must have originally formed near the ground-water level, they are now far above the static level in the aerated zone. The diagenetic history of the rinds may provide an understanding of the aquifer's development. These data are crucial for creating a hydrologic model of the system.

The flood deposits are also an important source of construction materials. Sand and gravel, crushed rock, rip rap, and decorative boulders are in demand in the rapidly growing urban area. The Survey is developing standardized criteria for characterizing the aggregates and recognizing facies changes in the deposits. Local sand and gravel operators have been very supportive of the mapping and realize the benefits of describing the deposits.

Also under study are the relationships among the Columbia River basalts in the Coeur d'Alene embayment. Columbia River basalt flows form embayments at the margins of the Northern Rocky Mountains. The basalts are complexly interbedded with lacustrine and alluvial units, and together they form important aquifer systems for the region. Paleomagnetism and chemical types establish the stratigraphic position of these flows within the Grande Ronde and Wanapum basalts. Chemical analyses show both Grande Ronde and Priest Rapids flows in the Coeur d'Alene area. Paleomagnetic directions suggest two Grande Ronde flows of normal polarity and at least two Priest Rapids flows of reverse polarity. Research to the south in the Moscow basin has revealed im-

portant aspects of the Miocene stratigraphy and paleogeomorphology. These relationships have been extended to the Coeur d'Alene area.

## **Fault Mapping**

The Survey continues to update the active fault map of the state under funding by the Idaho Bureau of Disaster Services and in cooperation with the U.S. Geological Survey. Staff geologists have compiled data on 188 faults and fault systems in a digital database. The 1997 versions of the map and database were presented at the Basin and Range Seismic Summit sponsored by the Western States Seismic Policy Council. These data are also being edited for entry into the U.S. Geological Survey's National Fault Database. The Survey will continue to update the catalog and is also preparing a digital map and linked database for users of neotectonic information.

## **Ground Water in a Subalpine Environment**

The Survey is concluding research on the distribution and timing of ground-water recharge in a subalpine watershed. Using light stable isotopes to track ground-water, scientists investigated the flow and transport processes within a small, instrumented field laboratory developed in the Mink Creek watershed. The work was conducted cooperatively with the U.S. Forest Service and the U.S. Natural Resources Conservation Service with whom the Survey shared hydrologic data and equipment. Field data gathered during the three-year program were used to construct ground-water flow and transport models with which to evaluate the timing and impact of melting snow on shallow ground-water storage. A major result of the research demonstrated that subtle, low-am-

plutide stable isotope variations in ground water were measurable and could be used to constrain residence time and dispersion characteristics of the shallow ground-water flow system. Results of the research were presented in a poster session at the American Geophysical Union national meeting in Baltimore.

## **Landslide Hazards**

Heavy rains in late December on top of a thick snowpack precipitated numerous landslides, mudslides, and flooding in early January throughout Idaho. At the request of the Federal Emergency Management Agency (FEMA) and the Idaho Bureau of Disaster Services, the Boise office geologist assisted in an emergency evaluation of the potential hazards and imminent threat from mudslides to the community of Lower Banks in Idaho County. The FEMA/State Interagency Team surveyed the area on the ground and from the air. Record rainfall and rapidly melting snow had saturated the soil and weathered granitic bedrock. High pore pressures caused the material on the steep hillsides to lose cohesion and fail. Near-channel slumps and stored sediment in the channel mixed with the excess water to generate a series of mudslides and debris flows which moved downstream and inundated the community of Lower Banks. Scientists concluded that a serious threat of mudslides or debris flows still remained. Based on that recommendation, the county took steps to evacuate the town's residents.

As a follow-up to the disasters in both southern and northern Idaho, the Governor's office initiated a Landslide Task Force, composed of state, federal, and other technical experts. The Boise office participated fully in many hours of meetings as a member of the science committee. The Boise

geologist arranged a FEMA-sponsored helicopter reconnaissance of the State Highway 17 Banks-Lowman corridor, one of the areas hardest hit by landslides. The task force's findings and recommendations concerning the effects of future landslides on the state's communities, infrastructure, and resources are summarized in a report prepared for the Governor through the Bureau of Disaster Services. Recommendations include implementing a statewide landslide mitigation plan, mapping and assessing landslide hazards in critical areas, updating the Survey's landslide database, conducting studies of landslide processes, and improving public awareness of landslide hazards and mitigation.

## **Lewis and Clark Line**

The Survey and the Montana Bureau of Mines and Geology worked together under the National Earthquake Hazards Reduction Program to study earthquake hazards associated with the Lewis and Clark Line. The Lewis and Clark Line is a major, west northwest-trending shear zone that has been seismically active since Precambrian time. The zone extends over 400 kilometers from Coeur d'Alene to Helena, Montana, and encompasses similar extensional faults to the north. In 1935, a sequence of destructive earthquakes (magnitudes up to 6.25) within the eastern part of the zone caused four fatalities and serious damage to over 60 percent of the buildings in Helena. More recent earthquakes with magnitudes up to 5.0 have fault plane solutions compatible with continued dextral slip on west northwest-trending faults. Despite the significant levels of this past seismicity, the Lewis and Clark Line has never been monitored by a permanent seismograph network. The joint Idaho-Montana project has taken steps to correct this by installing ten new seismic



stations and reconfiguring several others.

## **Missouri Mine**

The Survey continued geologic mapping and sample collecting at the Missouri and Gold Hill mines in Boise Basin. This modest environmental study is an outgrowth of the inactive and abandoned mines inventory conducted in the Boise National Forest in 1994. Scientists are trying to determine why the Missouri mine has significantly more acid mine drainage and heavy metal contamination than the similar Gold Hill mine, a much larger producer. Researchers will compare the geology and mineralogy of the two sites. The work is being done in cooperation with scientists from the U.S. Forest Service and the Chemistry Department at Boise State University.

## **National Cooperative Geologic Mapping Act**

The State Geologist worked with Idaho's senior senator, Larry Craig, to reauthorize the National Cooperative Geologic Mapping Act (NCGMA) that is administered by the U.S. Geological Survey. One component of this program, called StateMap, provides about \$4 million in competitive contracts to state surveys for mapping the geology of urban areas and for compiling 1:100,000-scale geologic maps that will become part of the National Geologic Map Database. Since the NCGMA was passed in 1992, state surveys have generated over 700 new geologic maps under StateMap. The act is supported by the Association of American State Geologists and is also endorsed by the National Governors Association and other groups who recognize the crucial importance of geologic maps in dealing with a host of land use and natural resource issues. A new type

of StateMap proposal was approved by the program's advisory board. This change will enable other federal agencies and the private sector to participate in StateMap.

Another part of NCGMA is called FedMap. This is the U.S. Geological Survey's geologic mapping program. A workshop in February developed a strategic plan for FedMap. The state geologists from Idaho and Colorado attended the meeting to insure that state surveys would be consulted on new FedMap programs so that the states would be aware of the impact on their regions. The plan arising from the workshop guarantees future consultations between the states and the USGS on this nationally important program.

## **Pocatello Earthquake Setting**

New methods for assessing the earthquake shaking hazard of Pocatello were used in completing a study funded by the Idaho Bureau of Disaster Services. Last year the Survey covered half of the city in finishing the Pocatello South quadrangle. This year Survey geologists completed the Pocatello North quadrangle and the other half of the city. For both quadrangles, design factors were determined for a large regional seismic event and a smaller local source using the SHAKE© software program. Shaking values show that substantial damage would occur in Pocatello particularly to unreinforced masonry structures. With funds also provided by the Idaho Bureau of Disaster Services, the Survey is producing a less technical report for use by local planners and officials.

## **Portneuf Ground Water Forum and Ground Water Guardian Program**

The Survey's Pocatello office has taken on

the task of chairing and coordinating the monthly meetings of the Portneuf Ground Water Forum that was created by the city of Pocatello and the Survey in 1992. The group advises city, county, and tribal governments on ground-water quality and water supply matters. The forum has focused primarily on development-related ground-water issues for the past year and has coordinated discussions on numerous topics of technical interest to local governments and planners. The forum came about as part of a regional ground-water resource master plan commissioned by Bannock County and the cities of Pocatello and Chubbuck. In April, the Survey presided over a meeting in Pocatello where recommendations for developing such a master plan were presented to both city and county officials.

The Pocatello Office is also a principal member in the local chapter of the national Ground Water Guardian Program. This project, initiated by members of the Portneuf Ground Water Forum, aims to arouse public awareness of ground-water resources by providing speakers and educational materials to the greater Pocatello-Chubbuck area. The Survey has prepared technical materials, text, and graphics for a set of brochures being designed by the group for the general public. These brochures were included recently in local water bill mailings.

## **Quad-Cities Mapping**

The newest STATEMAP project has begun in the Pullman-Moscow and Lewiston-Clarkston area or what is informally referred to as the "quad cities." This project will study three geologic elements in the area: the configuration of the Precambrian-Cretaceous basement; the extent and stratigraphic relationships of the Columbia River basalts and associated sediments; and the post-Miocene erosion and drainage develop-

ment and the deposition and evolution of the Palouse landscape.

The Columbia River Plateau is juxtaposed with the Northern Rocky Mountains in an irregular boundary where flood basalts form embayments. Pre-Miocene valleys, cut into Mesozoic and Precambrian rocks, were partially buried during eruptions of Grand Ronde, Wanapum, and Saddle Mountains basalts. Coeval sediments interfinger with the basalt flows and locally form members of the Latah Formation. Reëntrenchment by the major rivers occurred relatively quickly, cutting many canyons and deep valleys. The lower energy tributaries have yet to significantly cut through the basalt and form the broad, low-gradient valleys of the eastern Palouse. Following the change toward a cooler climate in the Pliocene, thick loess deposits blanketed the eastern plateau. The loess accumulated in pulses. Between these pulses soils developed with strong B horizons. Loess sections show multiple buried soils with argillic to fragipan characteristics that represent a 2 million-year interval. The embayments can be subdivided into two hydrologic systems: the deep, sediment-interlayered basalt, and the shallow, loess and low gradient stream deposits. Both systems have distinct recharge and flow characteristics that impart constraints on aquifer pumping and agricultural practices.

## **Snake River Plain Aquifer and INEEL**

Funded by the federal Department of Energy, the Survey is studying ways to improve predictive models of ground-water contaminant transport at the Idaho National Engineering and Environmental Laboratory (INEEL). Advanced statistical modeling and simulation techniques as well as stochastic ground-water modeling methods are being used to demonstrate the feasibility of this

approach in the Snake River Plain aquifer's complex geologic environment of basalt and sedimentary rock. Two papers on the first year's research were presented at the Engineering Geology/Geotechnical Engineering Symposium in Boise, and another is awaiting publication in the Bulletin of the Geological Society of America.

## **Snake River Plain Seismicity**

Research continued in conjunction with the University of Idaho on the seismic hazards in southeast Idaho. Although the volcanic hazards of hot spots are well-recognized, the associated earthquake hazards are less understood. A comparison of seismicity in Idaho and Hawaii suggests that the effects of hot spots are widespread both in geographical space and geologic time. Most of the seismic hazard in Idaho is attributable to the migration of the Yellowstone hot spot. Seismic events have occurred recently near Draney Peak on the southern limb of the hot-spot track and in the Custer Graben on the northern limb. The historical earthquake catalog and studies of Holocene faults have established the area within the seismic parabola about the eastern Snake River Plain as a valid seismic zone.

## **Urban Geology**

The Survey completed the geologic map of the Pocatello North quadrangle for the U.S. Geological Survey's STATEMAP program. The map extends the interpretation of surficial geology started in the Pocatello South quadrangle in 1994. Pocatello North includes the broad expansion bar comprising the Michaud Gravel where the energy of the Bonneville flood dissipated as it exited the lower Portneuf Valley. Another prominent geologic feature is the Pocatello Bench, a broad apron north of Pocatello that extends westward from the Pocatello Range. The apron is a relict coalescence of alluvial fans now buried by thick loess. The late Pleistocene geologic history of this area was also affected by lava that dammed the Snake River. One such event created the Pleistocene American Falls Lake, which probably extended into the Pocatello North area about 70,000 years ago. Before the Bonneville Flood, broad flood plain, delta, and lake deposits formed a nearly flat surface from Pocatello to the present location of American Falls Reservoir. The Bonneville Flood at first eroded this area, but the immense flow also transported an enormous entrained gravel load that began to deposit the giant gravel bar, now called the Michaud Gravel. As the flood decreased, lower flow channels formed on the surface of the Michaud Gravel, leaving the topography essentially as it is today.

# Publications

In FY-97, the Survey released the following publications and reports:

**GeoNote 38.** *Nonfuel Mineral Production in Idaho—1995*, by Earl H. Bennett and Virginia S. Gillerman, 2 p.

**GeoNote 39.** *Historic Mineral Production in the Greater Coeur d'Alene Mining Region, Idaho*, by Don Springer, 1 p.

**Staff Report 97-1.** *History of the Triumph, Independence, and North Star Mines, Blaine County, Idaho*, by Victoria E. Mitchell, 58 p.

**Staff Report 97-2.** *History of Selected Mines in the Alder Creek Mining District, Custer County, Idaho*, by Victoria E. Mitchell, 54 p.

**Staff Report 97-3.** *History of the Boulder Mines Group, Blaine County, Idaho*, by Victoria E. Mitchell, 22 p.

**Staff Report 97-4.** *History of the Copper Cliff Mine, Adams County, Idaho*, by Victoria E. Mitchell, 11 p.

**Staff Report 97-5.** *History of the Goldstone Mine, Lemhi County, Idaho*, by Victoria E. Mitchell, 13 p.

**Staff Report 97-6.** *History of the Greyhound Mine, Custer County, Idaho*, by Victoria E. Mitchell, 13 p.

**Staff Report 97-7.** *History of the Harmony Mine, Lemhi County, Idaho*, by Victoria E. Mitchell, 16 p.

**Staff Report 97-8.** *History of the Hoodoo Mine, Custer County, Idaho*, by Victoria E. Mitchell, 13 p.

**Staff Report 97-9.** *History of the Idaho Gold Coin Mine (Maid of Erin and Summit Mines), Adams County, Idaho*, by Victoria E. Mitchell, 9 p.

**Staff Report 97-10.** *History of the Livingston Mine, Custer County, Idaho*, by Victoria E. Mitchell, 45 p.

**Staff Report 97-11.** *History of the Lost Packer Mine, Custer County, Idaho*, by Victoria E. Mitchell, 26 p.

**Staff Report 97-12.** *History of the Mines on Estes Mountain, Custer County, Idaho*, by Victoria E. Mitchell, 15 p.

**Staff Report 97-13.** *History of the Mountain King Mine, Custer County, Idaho*, by Victoria E. Mitchell, 11 p.

**Staff Report 97-14.** *History of the Peacock Mine, Adams County, Idaho*, by Victoria E. Mitchell, 23 p.

**Staff Report 97-15.** *History of the Pope-Shenon Mine, Lemhi County, Idaho*, by Victoria E. Mitchell, 20 p.

**Staff Report 97-16.** *History of the Queen of the Hills Mine, Lemhi County, Idaho*, by Victoria E. Mitchell, 8 p.

**Staff Report 97-17.** *History of the Silver Star Mine, Lemhi County, Idaho*, by Victoria E. Mitchell, 6 p.

**Staff Report 97-18.** *History of the Sunbeam Mine, Custer County, Idaho*, by Victoria E. Mitchell, 19 p.

**Staff Report 97-19.** *History of the Mines in the Texas Mining District Near Gilmore, Idaho*, by Victoria E. Mitchell, 72 p.

**Staff Report 97-20.** *History of the Valley Creek Mine, Custer County, Idaho*, by Victoria E. Mitchell, 11 p.

**Staff Report 97-21.** *History of the Yellowjacket Mine, Lemhi County, Idaho*, by Victoria E. Mitchell, 28 p.

**Technical Report 96-1.** *Annual Report of the Idaho Geological Survey, Fiscal Year 1996*, 23 p.

**Technical Report 97-1.** *Geologic Map of Part of the Galena Peak and Ryan Peak Quadrangles, Blaine and Camas Counties, Idaho*, by Keegan L. Schmidt, 1 plate.

*List of Publications—1997*, 61 p.

# Staff Publications and Activities

## Publications

- The 1993 Idaho Report to the Western States Seismic Policy Council*, by R.M. Breckenridge and Stephen Weiser: Western States Seismic Policy Council, Annual Report of the XVI Annual Meeting, 1997, p. 114-116.
- The 1994 Idaho Report to the Western States Seismic Policy Council*, by Stephen Weiser and R.M. Breckenridge: Western States Seismic Policy Council, Annual Report of the XVII Annual Meeting, 1997, p. 80-84.
- The 1996 Idaho Report to the Western States Seismic Policy Council*, by Stephen Weiser and R.M. Breckenridge: Western States Seismic Policy Council, Eighteenth Annual Conference Proceedings and Report, 1997, p. 215-216.
- The 1996 USGS National Seismic Hazard Maps: An Idaho Perspective*, by R.M. Breckenridge and K.F. Sprenke: Western States Seismic Policy Council, Eighteenth Annual Conference Proceedings and Report, 1997, p. 217-221.
- Boise County Debris Flow, January 1-3, 1997*, by Federal Emergency Management Agency/State Interagency Team (others and V.S. Gillerman): Federal Emergency Management Agency FEMA-DR-1154-ID, February, 1997, 15 p.
- Exploration in Idaho—1996*, by V.S. Gillerman: Mining Engineering, 1997, v. 49, no. 5, p. 56-58.
- Fault Map of Idaho—1997 Update*, by R.M. Breckenridge, R.S. Lewis, G.W. Adema, and K.F. Sprenke: Western States Seismic Policy Council, Basin and Range Province Seismic Hazards Summit Program, 1997, p. 81.
- History of Selected Mines in the Alder Creek Mining District, Custer County, Idaho*, by Victoria E. Mitchell: Idaho Geological Survey Staff Report 97-2, 1997, 54 p.
- History of the Boulder Mines Group, Blaine County, Idaho*, by Victoria E. Mitchell: Idaho Geological Survey Staff Report 97-3, 1997, 22 p.
- History of the Copper Cliff Mine, Adams County, Idaho*, by Victoria E. Mitchell: Idaho Geological Survey Staff Report 97-4, 1997, 11 p.
- History of the Goldstone Mine, Lemhi County, Idaho*, by Victoria E. Mitchell: Idaho Geological Survey Staff Report 97-5, 1997, 13 p.
- History of the Greyhound Mine, Custer County, Idaho*, by Victoria E. Mitchell: Idaho Geological Survey Staff Report 97-6, 1997, 13 p.
- History of the Harmony Mine, Lemhi County, Idaho*, by Victoria E. Mitchell: Idaho Geological Survey Staff Report 97-7, 1997, 16 p.
- History of the Hoodoo Mine, Custer County, Idaho*, by Victoria E. Mitchell: Idaho Geological Survey Staff Report 97-8, 1997, 13 p.
- History of the Idaho Gold Coin Mine (Maid of Erin and Summit Mines), Adams County, Idaho*, by Victoria E. Mitchell: Idaho Geological Survey Staff Report 97-9, 1997, 9 p.
- History of the Livingston Mine, Custer County, Idaho*, by Victoria E. Mitchell: Idaho Geological Survey Staff Report 97-10, 1997, 45 p.
- History of the Lost Packer Mine, Custer County, Idaho*, by Victoria E. Mitchell: Idaho Geological Survey Staff Report 97-11, 1997, 26 p.
- History of the Mines in the Texas Mining District Near Gilmore, Idaho*, by Victoria E. Mitchell: Idaho Geological Survey Staff Report 97-19, 1997, 72 p.
- History of the Mines on Estes Mountain, Custer County, Idaho*, by Victoria E. Mitchell: Idaho Geological Survey Staff Report 97-12, 1997, 15 p.
- History of the Mountain King Mine, Custer County, Idaho*, by Victoria E. Mitchell: Idaho Geological Survey Staff Report 97-13, 1997, 11 p.
- History of the Peacock Mine, Adams County, Idaho*, by Victoria E. Mitchell: Idaho Geological Survey Staff Report 97-14, 1997, 23 p.
- History of the Pope-Shenon Mine, Lemhi County, Idaho*, by Victoria E. Mitchell: Idaho Geological Survey Staff Report 97-15, 1997, 20 p.
- History of the Queen of the Hills Mine, Lemhi County, Idaho*, by Victoria E. Mitchell: Idaho Geological Survey Staff Report 97-16, 1997, 8 p.
- History of the Silver Star Mine, Lemhi County, Idaho*, by Victoria E. Mitchell: Idaho Geological Survey Staff Report 97-17, 1997, 6 p.
- History of the Sunbeam Mine, Custer County, Idaho*, by Victoria E. Mitchell: Idaho Geological Survey

- Staff Report 97-18, 1997, 19 p.
- History of the Triumph, Independence, and North Star Mines, Blaine County, Idaho*, by Victoria E. Mitchell: Idaho Geological Survey Staff Report 97-1, 1997, 58 p.
- History of the Valley Creek Mine, Custer County, Idaho*, by Victoria E. Mitchell: Idaho Geological Survey Staff Report 97-20, 1997, 11 p.
- History of the Yellowjacket Mine, Lemhi County, Idaho*, by Victoria E. Mitchell: Idaho Geological Survey Staff Report 97-21, 1997, 28 p.
- Idaho 1995 Annual Estimate*, by A. Tanner (with V.S. Gillerman): Mineral Industry Surveys, U.S. Geological Survey, 5 p.
- Interagency Hazard Mitigation Team Report, Heavy Snow, Landslides and Floods, November 1996-January 1997*, by State of Idaho and FEMA Team (others and R.M. Breckenridge): Federal Emergency Management Agency Document DR-1154, 1997, p. 43.
- Nonfuel Mineral Production in Idaho—1995*, by Earl H. Bennett and Virginia S. Gillerman: Idaho Geological Survey GeoNote 38, 1996, 2 p.
- Seismic Potential of the Lewis and Clark Zone, Montana and Idaho*, by K.F. Sprenke, R.M. Breckenridge, and M.C. Stickney: American Geophysical Union, EOS Transactions, 1996, v. 77, no. 46, p. F522.
- Stochastic Modeling of Hydraulic Conductivity in the Snake River Plain Aquifer; 1. Hydrogeologic Constraints and Conceptual Approach*, by J.A. Welhan, T. Funderberg, A. Wylie, and R.P. Smith: Proceedings, 32nd Symposium Engineering Geology Geotechnical Engineering, Boise, 1997, p. 75-91.
- Stochastic Modeling of Hydraulic Conductivity in the Snake River Plain Aquifer; 2. Evaluation of Lithologic Controls at the Core and Borehole Scales*, by J.A. Welhan and A. Wylie: Proceedings, 32nd Symposium Engineering Geology Geotechnical Engineering, Boise, 1997, p. 93-107.

## Abstracts

- Geochemical Evolution of Mafic Lavas in the Central Part of the Western Snake River Plain, Idaho*, by C.M. White, Bill Bonnicksen, W.K. Hart, and R.A. Duncan: American Geophysical Union,

western region annual meeting, Abstract Volume, San Francisco, California, December, 1996.

- Geologic Characteristics of the Rathdrum Aquifer*, by R.M. Breckenridge, K.L. Othberg, J.A. Welhan, C.R. Knowles, and P.A. McDaniel: Inland Northwest Water Resources Conference Program and Abstracts, Spokane, Washington, 1997, April, p. 23.

- Geomorphic Setting of the Eastern Margin of the Columbia River Plateau*, by K.L. Othberg, R.M. Breckenridge, and P.A. McDaniel: Northwest Science, Program and Abstracts for the Seventieth Annual Meeting of the Northwest Scientific Association, 1997, 22 p. and unnumbered appendix.

- Seismicity in the Tracks of Migrating Hot Spots: Hawaii and Idaho*, by K.F. Sprenke and R.M. Breckenridge: Geological Society of America Abstracts with Programs, 1997, v. 29, no. 5, p. 46.

- Stratigraphy and Paleogeomorphology of Columbia River Basalt, Eastern Margin of the Columbia River Plateau*, by Roy M. Breckenridge, Kurt L. Othberg, and John H. Bush: Geological Society of America Abstracts with Programs, 1997, v. 29, no. 5, p. 6.

- Styles of Phreatomagmatic Volcanism in the Western Snake River Plain, SW Idaho, U.S.A.*, by M.M. Godchaux and Bill Bonnicksen: International Association of Volcanology and Chemistry of the Earth's Interior (IAVCEI), General Assembly: Volcanic Activity and the Environment, Puerto Vallarta, Mexico, 1997, p. 9.

- Tectonic and Chemical Evolution of Snake River Plain Basalt, Southwestern Idaho, U.S.A.*, by Bill Bonnicksen, M.M. Godchaux, and C.M. White: International Association of Volcanology and Chemistry of the Earth's Interior (IAVCEI), General Assembly: Volcanic Activity and the Environment, Puerto Vallarta, Mexico, 1997, p. 122.

## Reports and Presentations

- The Abandoned or Inactive Mine Program of the Idaho Geological Survey*, by Earl H. Bennett: College of Mines and Earth Resources's advisory board meeting, April.

- Aqueous Geochemistry*, by John A. Welhan: Guest lectures, Geology class 617, Environmental

- Geochemistry, Idaho State University, Pocatello, January.
- Big Mines and Geology of Northern Chile*, by Virginia S. Gillerman: Society for Mining, Metallurgy, and Exploration, Inc., Boise section; Boise State University graduate seminar, Boise, February.
- Development of an Idaho HAZUS Training Program*, by Guy Adema, K.F. Sprenke, R.M. Breckenridge, and S. Weiser: Poster presentation at the Montana/Idaho Geographic Information System Conference, Bozeman, Montana, 1997.
- Digital Geologic Map Compilation of Part of the Warren 30 x 60 Minute Quadrangle, Idaho County, Idaho*, compiled by Loudon R. Stanford: Idaho Geological Survey unpublished database.
- Digital Geologic Map Compilation of the Elk City 30 x 60 Minute Quadrangle, Idaho County, Idaho*, compiled by Loudon R. Stanford: Idaho Geological Survey unpublished database.
- Digital Geologic Map Compilation of the Grangeville 30 x 60 Minute Quadrangle, Idaho and Nez Perce Counties, Idaho*, compiled by Loudon R. Stanford: Idaho Geological Survey unpublished database.
- Digital Geologic Map Compilation of the Hamilton 30 x 60 Minute Quadrangle, Idaho County, Idaho*, compiled by Loudon R. Stanford: Idaho Geological Survey unpublished database.
- Digital Geologic Map Compilation of the Headquarters 30 x 60 Minute Quadrangle, Idaho, Shoshone, and Clearwater Counties, Idaho*, compiled by Loudon R. Stanford: Idaho Geological Survey unpublished database.
- Digital Geologic Map Compilation of the Kooskia 30 x 60 Minute Quadrangle, Idaho and Clearwater Counties, Idaho*, compiled by Loudon R. Stanford: Idaho Geological Survey unpublished database.
- Digital Geologic Map Compilation of the Missoula West 30 x 60 Minute Quadrangle, Idaho, Shoshone, and Clearwater Counties, Idaho*, compiled by Loudon R. Stanford: Idaho Geological Survey unpublished database.
- Digital Geologic Map Compilation of the Nez Perce Pass 30 x 60 Minute Quadrangle, Idaho County, Idaho*, compiled by Loudon R. Stanford: Idaho Geological Survey unpublished database.
- Digital Geologic Map Compilation of the Riggins 30 x 60 Minute Quadrangle, Idaho County, Idaho*, compiled by Loudon R. Stanford: Idaho Geological Survey unpublished database.
- Digital Geology Map of the Boise Basin Vicinity, Boise and Ada Counties, Idaho*, by Thor Kiilsgaard: Idaho Geological Survey unpublished database.
- Digital Map Production at the Idaho Geological Survey*, by Loudon R. Stanford: Workshop on digital mapping techniques, Lawrence, Kansas, June.
- Earthquakes and Geology of Southwestern Idaho*, by Virginia S. Gillerman: Ada County Emergency Management seismic tremor workshop, Boise, July.
- Environmental Geology of Puget Sound, Case Studies*, by Kurt L. Othberg: Geologic hazards class, University of Idaho, April.
- The Fabulous Coeur d'Alene Mining District*, by Earl H. Bennett: Idaho Mining Museum, Boise, April; Spokane Community College, Spokane, Washington, June.
- Fault Map of Idaho*, by R.M. Breckenridge and K.F. Sprenke: Poster session, Basin and Range Seismic Hazards Summit, Reno, Nevada, May.
- Field Trip Guide to the Geology of the Boise Valley*, by V.S. Gillerman, W. Barrash, and T. Buu: 32nd Symposium on Engineering Geology and Geotechnical Engineering, Boise, unpublished report, March, 6 p.
- Geological Mapping the IGS Way*, by Jane S. Freed: Computer mapping class, University of Idaho, April.
- Geologic Characteristics of the Rathdrum Aquifer*, by Roy M. Breckenridge, Kurt L. Othberg, John H. Welhan, Charles R. Knowles, and P.A. McDaniel: Northwest Regional Water Conference, Spokane, Washington, April.
- Geologic History of Idaho*, by Virginia S. Gillerman: Idaho Gem Club, Boise, June.
- Geologic Map, Eastern Portion of the Balanced Rock 7.5-Minute Quadrangle, Twin Falls County, Idaho*, by Bill Bonnichsen and M.M. Godchaux: Idaho Geological Survey unpublished report, scale 1:24,000.
- Geologic Map of the Buhl 7.5-Minute Quadrangle, Twin Falls County, Idaho*, by Bill Bonnichsen and M.M. Godchaux: Idaho Geological Survey unpublished report, scale 1:24,000.
- Geologic Map of the Liberty Lake Quadrangle, Kootenai County, Idaho*, by Roy M. Breckenridge and Kurt L. Othberg: Idaho Geological Survey unpublished report, April.



- Geologic Map of the Newman Lake Quadrangle, Kootenai County, Idaho*, by Roy M. Breckenridge and Kurt L. Othberg: Idaho Geological Survey unpublished report, April.
- Geologic Map of the Pocatello North Quadrangle, Bannock County, Idaho*, by Kurt L. Othberg: Idaho Geological Survey unpublished report, April.
- Geologic Map of the Post Falls Quadrangle, Kootenai County, Idaho*, by Roy M. Breckenridge and Kurt L. Othberg: Idaho Geological Survey unpublished report, April.
- Geologic Map of the Rathdrum Quadrangle, Kootenai County, Idaho*, by Roy M. Breckenridge and Kurt L. Othberg: Idaho Geological Survey unpublished report, April.
- Geologic Map, Southern Portion of the Jerome 7.5-Minute Quadrangle, Twin Falls County, Idaho*, by Bill Bonnicksen and M.M. Godchaux: Idaho Geological Survey unpublished report, scale 1:24,000.
- Geology and Earthquakes of the Teton Region: A 35mm Slide Set for Earth Science Educators*, by R.M. Breckenridge and K.L. Othberg: Idaho Geological Survey unpublished report, 5 p. and 20 slides.
- Geology of Southwestern Idaho*, by Virginia S. Gillerman: Out of the Rock Minerals education workshop and field trip, Eagle, June.
- Geology of the Dairy Mountain 7.5-minute Quadrangle, Idaho*, by Earl H. Bennett: digital map incorporated in the Grangeville geologic map compilation, scale 1:100:000, U.S. Forest Service contract.
- Geology of the Goodwin Meadows 7.5-minute Quadrangle, Idaho*, by Earl H. Bennett: digital map incorporated in the Grangeville geologic map compilation, scale 1:100:000, U.S. Forest Service contract.
- Geology of the Grangeville East 7.5-minute Quadrangle, Idaho*, by Earl H. Bennett: digital map incorporated in the Grangeville geologic map compilation, scale 1:100:000, U.S. Forest Service contract.
- Geology of the Hungary Ridge 7.5-minute Quadrangle, Idaho*, by Earl H. Bennett: digital map incorporated in the Elk City geologic map compilation, scale 1:100:000, U.S. Forest Service contract.
- Geomorphic Setting of the Eastern Margin of the Columbia River Plateau*, by Kurt L. Othberg, Roy M. Breckenridge, and Paul A. McDaniel: Northwest Scientific Association Annual Meeting, March.
- Gold Production in Idaho in 1996*, by Earl H. Bennett, 1997, press release.
- Ground Water Quality in Idaho*, by John A. Welhan: Earth Day Festival panel speaker, Pocatello, April.
- Guide to the Geology and History of Hells Canyon*, by Earl H. Bennett: Field trip for Walla Walla Community College, Clarkston, Washington, May.
- History and Current Condition of the Mining Industry in Idaho*, by Virginia S. Gillerman: Idaho County Tax Assessor's Conference (IAAP), Soda Springs, November.
- History of Selected Mines in the Pine Creek Area, Shoshone County, Idaho*, by Victoria E. Mitchell: Idaho Geological Survey unpublished report, 1996, 309 p.
- The History of the Blackbird Mine*, by Earl H. Bennett: segment in a videotape program, "The Blackbird Mine, A Status Report," produced for the Noranda Mining Company, March.
- History of the Jack Waite Mine, Shoshone County, Idaho*, by Victoria E. Mitchell: Idaho Geological Survey unpublished report, 1997, 73 p.
- Hot Rocks From the Hot Spot: Geologic Evolution of Idaho's Snake River Plain*, by Bill Bonnicksen: Graduate School of Oceanography, University of Rhode Island, Narragansett, Rhode Island, April (B. Bonnicksen).
- Idaho Earthquake Education Workshop*, by R.M. Breckenridge: Poster session, Western States Seismic Policy Council Annual Meeting, Polson, Montana, September.
- Idaho Mining and Exploration in 1996*, by Virginia S. Gillerman: Northwest Mining Association Convention, Spokane, Washington, December.
- Implications of Proposed Idaho Ground Water Quality Rule for Northern Bannock County and Municipalities*, by John A. Welhan: Bannock County Commissioners' Chambers, Pocatello, July.
- The Importance of Mining to Idaho*, by Earl H. Bennett: North Idaho Chamber of Commerce's State Legislature Tour, November.
- Landslides Near Bonners Ferry, Kootenai County, Idaho*, by E.H. Bennett and R.M. Breckenridge: Prepared for Idaho Bureau of Disaster Services Mission Number 97-079-001, Idaho Geological

- Survey unpublished report, 1997, 10 p.
- Landslides in Boundary County, Idaho*, by Earl H. Bennett and Roy M. Breckenridge: Idaho Geological Survey unpublished Report, 10 p.
- Lower Portneuf River Valley Aquifer, The: A Geologic and Hydrologic Model, and Implications for Wellhead Protection Strategies*, by J.A. Welhan, C. Meehan, and T.V. Reid: Final report, EPA Wellhead Protection Demonstration Project and City of Pocatello aquifer geologic characterization project, 1996, 131 p.
- Mining Activity Roundup*, by Virginia S. Gillerman: 1997 Idaho minerals workshop, Boise, April.
- Mining and the Environment in Idaho*, by Virginia S. Gillerman: Upward Bound workshop, Boise, June.
- Mining, Minerals, and the Environment in Idaho, 1995*, by Earl H. Bennett and Virginia S. Gillerman: Idaho Geological Survey unpublished report, October, 72 p.
- Miocene and Younger Faults in Idaho*, by R.M. Breckenridge, R.S. Lewis, G.W. Adema, and K.F. Sprenke: Idaho Geological Survey unpublished report, 1997, 188 p. and 1:500,000-scale map.
- Partnerships for the Enhancement of Earth Science Education in Idaho*, by Jo A. Dodds, Terry G. Kuroda, Kurt L. Othberg, H. Randy Powell, and Judy A. Walling: National Earth Science Teachers Association Share-a-thon, National Science Teachers Association Meeting, New Orleans, Louisiana, March.
- Pocatello Aquifer and Our Ground Water, The*, by John A. Welhan: Earth science classes, Hawthorne Jr. High School, Pocatello, December.
- Preliminary Geologic Map and Cross-Section of the Clover and Southern Part of the Niagara Springs 7.5-Minute Quadrangles, Twin Falls and Gooding Counties, Idaho*, by Bill Bonnicksen and M.M. Godchaux: Idaho Geological Survey unpublished report, scale 1:24,000.
- Preliminary Geologic Map and Cross-Section of the Filer 7.5-Minute Quadrangle, Twin Falls and Jerome Counties, Idaho*, by Bill Bonnicksen and M.M. Godchaux: Idaho Geological Survey unpublished report, scale 1:24,000.
- Preliminary Geologic Map and Cross-Section of the Twin Falls 7.5-Minute Quadrangle, Twin Falls and Jerome Counties, Idaho*, by Bill Bonnicksen and M.M. Godchaux: Idaho Geological Survey unpublished report, scale 1:24,000.
- Recommendations for Idaho Communities, Infrastructure, and Resources at Risk From Landslides and Related Events*, by Governor's Landslide Task Force (others and V.S. Gillerman): Bureau of Disaster Services unpublished report, May, 1997, 75 p.
- Recommendations of the Portneuf Ground Water Forum for a Course of Action Toward a Ground Water Resource Master Plan*, by John A. Welhan: Joint Cities-County meeting, Pocatello, April.
- Rocks and Minerals*, by Virginia S. Gillerman: Nampa Boy Scouts, Nampa, May.
- Seismic Zones and Building Codes: An Exercise in Rapid Visual Screening of Buildings in the Jackson Hole Area*, by R.M. Breckenridge, Stephen Weiser and K.F. Sprenke: Idaho Geological Survey unpublished report, 1996, 30 p.
- Site Inspection Report for the Abandoned and Inactive Mines in Idaho on U.S. Forest Service Lands (Region I), Idaho Panhandle National Forest, V. II, Gold Creek Drainage*, by Earl H. Bennett and Victoria E. Mitchell: Idaho Geological Survey unpublished report, 1996, 148 p.
- Stochastic Modeling of Hydraulic Conductivity in the Snake River Plain Aquifer; 1. Hydrogeologic Constraints and Conceptual Approach; and 2. Evaluation of Lithologic Controls at the Core and Borehole Scales*, by John A. Welhan: 32nd Symposium on Engineering Geology and Geotechnical Engineering, Boise, March.
- Stratigraphy and Paleogeomorphology of Columbia River Basalt, Eastern Margin of the Columbia River Plateau*, by Roy M. Breckenridge and Kurt L. Othberg: Geological Society of America Cordilleran Section Meeting, Kona, Hawaii, May.
- Summary of Analytical Results for Hydrogeologic Studies of Wells Open Through Large Intervals of the Snake River Plain Aquifer at the Idaho National Engineering Laboratory*, by M. McCurry and J.A. Welhan: Final report, Idaho Department of Health and Welfare INEL Oversight Program, 1996, 52 p. and diskette.
- Update on the Coeur d'Alene Mining District*, by Earl H. Bennett: Pacific N.W. Metals Conference, Spokane, Washington, April.

## Professional Activities

50th anniversary open house of the David Taylor

- United States Navy Research Center, Bayview, September (R.M. Breckenridge).
- Admissions Secretary, Society of Economic Geologists (V.S. Gillerman).
- Advisory committee meeting, Idaho Geographic Information, Boise, November (L.R. Stanford).
- Advisory board meeting, Idaho Geological Survey, Boise, December (E.H. Bennett, R.M. Breckenridge, V.S. Gillerman).
- Advisory board meeting, National Cooperative Geologic Mapping Act, April (E.H. Bennett).
- Advisory board meetings, College of Mines and Earth Resources, November, April (E.H. Bennett).
- Basin and Range earthquake hazard summit, Western States Seismic Policy Council, Reno, Nevada, May (R.M. Breckenridge).
- Chair, Portneuf Ground Water Forum, Pocatello (J.A. Welhan).
- Co-leader, Geology 504, fourth annual Idaho Earthquake Education Field Workshop, Victor, July (R.M. Breckenridge).
- Co-leader (with Mike McCurry and Scott Hughes), field trip on silicic volcanism in the central Snake River Plain, Tobacco Root Geological Society meeting, Twin Falls, July (B. Bonnichsen).
- Co-leaders, geology field trip in the lower Portneuf River valley, Idaho Earth Science Teachers Association annual meeting, Pocatello, October (K.L. Othberg and J.A. Welhan).
- Director and co-instructor, Fourth Annual Idaho Earthquake Education Workshop, Teton Valley, July (K.L. Othberg).
- Director, paleomagnetism laboratory, Idaho Geological Survey/College of Mines and Earth Resources (K.L. Othberg).
- Disaster coordinator, Idaho Bureau of Disaster Services (R.M. Breckenridge).
- Division of Environmental Quality nonpoint source pollution workshop, Boise, January (V.S. Gillerman).
- Environmental Protection Agency, Region 10, Inactive and Abandoned Mine Workshop, Seattle, May (V.E. Mitchell).
- FedMap Planning Workshop, U.S. Geological Survey, Reston, Virginia, March (E.H. Bennett).
- Fellow, Geological Society of America (B. Bonnichsen).
- Fellows, Society of Economic Geologists (B. Bonnichsen, V.S. Gillerman).
- Fields trips to Ceboruco volcano in the trans-Mexican volcanic belt and to the Sierra Madre volcanic fields, January (B. Bonnichsen).
- Geological Society of America annual meeting, Denver, Colorado, October (E.H. Bennett, V.S. Gillerman).
- Geological Society of America 93rd Annual Cordilleran Section, Kailua-Kona, Hawaii, May (R.M. Breckenridge, K.L. Othberg).
- Ice Age Floods Task Force, Spokane, Washington, April (R.M. Breckenridge).
- Idaho County Tax Assessors Conference, Soda Springs, November (V.S. Gillerman).
- Idaho Department of Lands 1997 minerals workshop, Boise, April (V.S. Gillerman).
- Idaho Department of Lands, reclamation awards lunch, Boise, November (V.S. Gillerman).
- Idaho Earth Science Teachers Association annual conference business meeting, Boise, October (K.L. Othberg).
- Idaho Earth Science Teachers Association business meeting, McCall, November (K.L. Othberg).
- Idaho Earth Science Teachers Association winter meeting, Hagerman, March (K.L. Othberg).
- Idaho Geological Survey's urban geologic mapping program, Powerpoint presentation for the University of Idaho, Office of the President, February (R.M. Breckenridge).
- Idaho Science Teachers Association and Idaho Earth Science Teachers Association annual conferences, Pocatello, October (K.L. Othberg).
- Idaho State contact person, National Earth Science Teachers Association, 1988-present (K.L. Othberg).
- Instructor, Geology 405, earth science education issues and activities, University of Idaho, spring semester (K.L. Othberg).
- Instructor, Geology 408, field methods for earth science education majors, University of Idaho, fall semester (K.L. Othberg).
- Instructor, Geology 520, Advanced fault mapping, University of Idaho, spring semester (R.M. Breckenridge).
- Instructor, Geosciences 497/597, mineral resources, geology and the environment, Boise State University, spring semester (V.S. Gillerman).
- Instructor, team taught, Geology 360, geologic hazards, University of Idaho, spring semester (R.M. Breckenridge).
- Leader, field trip on the geology of Boise Valley,

- 32nd Symposium on Engineering Geology and Geotechnical Engineering, Boise, March (V.S. Gillerman).
- Leader, field trip to southwest Idaho and DeLamar Mine, Out of the Rock Minerals education teacher workshop, Boise, June (V.S. Gillerman).
- Leader, two field trips on the effusive and phreatomagmatic basalt volcanism of the western Snake River Plain, July (B. Bonnicksen).
- Liaison committee meetings, Association of American State Geologists, Washington, D.C., September, March (E.H. Bennett).
- Meetings on 8th Street fire and landslide hazards, U.S. Geological Survey and Bureau of Disaster Services, Boise, September and October (V.S. Gillerman).
- Member, advisory board, College of Mines and Earth Resources, University of Idaho (E.H. Bennett).
- Member, advisory board, National Geologic Mapping Act (E.H. Bennett).
- Member, American Geophysical Union (J.A. Welhan).
- Member, Association of Earth Science Editors (R.C. Stewart).
- Member, Basin and Range Province Committee, Western States Seismic Policy Council (R.M. Breckenridge).
- Member, Dean search committee, College of Mines and Earth Resources, University of Idaho (R.M. Breckenridge).
- Member (ex-officio), Hazardous Waste Management Council, Idaho State University (J.A. Welhan).
- Member, Federal Emergency Management Agency, Interagency hazard mitigation team workshop on Idaho floods, Boise, February (R.M. Breckenridge).
- Member, Geological Society of Nevada (V.S. Gillerman).
- Member, Idaho Association of Professional Geologists (V.S. Gillerman).
- Member, Idaho Science Teachers Association (K.L. Othberg).
- Member, Interagency hazard mitigation team, Disaster 1154 Idaho, November-January, Boise (R.M. Breckenridge).
- Member, International Association of Volcanology and Chemistry of the Earth's Interior (IAVCEI), and member of commission on explosive volcanism of IAVCEI (B. Bonnicksen).
- Member, National Association of Geology Teachers (K.L. Othberg).
- Member, National Earth Science Teachers Association (K.L. Othberg).
- Member, Northwest Scientific Association (K.L. Othberg).
- Member, Society for Mining, Metallurgy, and Exploration, Inc. (V.S. Gillerman).
- Member, State of Idaho Emergency Planning Team, Boise, December (R.M. Breckenridge).
- Member, Technical committee, Treasure Valley hydrologic modeling project (K.L. Othberg).
- Members, American Quaternary Association (R.M. Breckenridge, K.L. Othberg).
- Members, Friends of the Pleistocene, Pacific Northwest and Rocky Mountain cells (R.M. Breckenridge, K.L. Othberg).
- Members, Geological Society of America (E.H. Bennett, V.S. Gillerman, K.L. Othberg).
- Members, Idaho Earth Science Teachers Association (R.M. Breckenridge, K.L. Othberg).
- Members, Northwest Mining Association (E.H. Bennett, V.S. Gillerman).
- Midyear meeting, Association of American State Geologists, Denver, Colorado, November (E.H. Bennett).
- Moderator, Active fault characterization session, Basin and Range Seismic Summit Conference, Western States Seismic Policy Council, Reno, May (R.M. Breckenridge).
- Montana/Idaho Geographic Information System Users' Conference, Bozeman, Montana, April (J.S. Freed, J.A. Welhan).
- National meeting, Association of American State Geologists, Breckenridge, Colorado, June (E.H. Bennett).
- National Minerals Workshop, Association of American State Geologists/U.S. Geological Survey, September (E.H. Bennett).
- National Topographic Workshop, Association of American State Geologists/U.S. Geological Survey, March (E.H. Bennett).
- Northwest Mining Association Convention, 102nd annual meeting, Spokane, Washington, December (E.H. Bennett, V.S. Gillerman).
- Northwest Regional Water Conference, Spokane, Washington, April (K.L. Othberg).
- Northwest Scientific Association, 70th annual meeting, Eastern Washington University, Spokane, Washington, March (R.M. Breckenridge,

- K.L. Othberg).
- Pacific Northwest Water Resources Conference, Spokane, Washington, April (R.M. Breckenridge).
- Participant, Federal Emergency Management Agency/State Interagency Technical Team on Banks debris flow, Boise County, January and February (V.S. Gillerman).
- Participant, Field trip on basalts of western Snake River Plain, August (V.S. Gillerman).
- Participant, Field trips for Idaho Museum of Mining and Geology, August, October, May, June (V.S. Gillerman).
- Participant, Governor's Landslide Task Force, Boise, spring (V.S. Gillerman).
- Pend Oreille Anthropological Society annual meeting, Newport, Washington, March (R.M. Breckenridge).
- Poster sessions (in collaboration with M.M. Godchaux and C.M. White), International Association of Volcanology and Chemistry of the Earth's Interior meeting, Puerto Vallarta, Mexico, January (B. Bonnicksen).
- President, Association of American State Geologists (E.H. Bennett).
- President, Idaho Earth Science Teachers Association, 1995-1997 (K.L. Othberg).
- Professional facilitator and co-teacher, Project WET (Water Education for Teachers) workshops, Pocatello and Soda Springs (J.A. Welhan).
- Registered professional geologist, Oregon (R.M. Breckenridge).
- Representative, Bureau of Disaster Services flood and hazard meetings (V.S. Gillerman).
- Representative, Department of Geosciences, Boise State University (V.S. Gillerman).
- Representative, Department of Lands mining advisory committee (V.S. Gillerman).
- Representative, Earthquake Engineering Research Institute (R.M. Breckenridge).
- Representative, Idaho Department of Water Resources water planning coordination committee (V.S. Gillerman).
- Representative, Idaho State University's ad hoc committee for developing a GIS teaching facility (J.A. Welhan).
- Representative, Pocatello-Chubbuck ground-water guardian committee (J.A. Welhan).
- Representative, State Emergency Response Commission (V.S. Gillerman).
- Representative, technical advisory committee, Treasure Valley hydrologic project, Boise (V.S. Gillerman).
- Representative, Western States Seismic Policy Council, San Francisco, California (R.M. Breckenridge).
- Technical advisor and member, Ice Age Floods Institute, Spokane, Washington (R.M. Breckenridge).
- Technical advisor, planning meeting to recommend remediation actions at the Fort Hall Canyon abandoned landfill (J.A. Welhan).
- Technical advisor, coordinated meeting with Pocatello, Bannock County, Idaho Transportation Department, and Idaho Fish and Game to study the impact and protection of the Highway Pond gravel pit on the municipal aquifer and drinking water supply (J.A. Welhan).
- Technical advisor, coordinated proposal with Pocatello, Chubbuck and Bannock County officials for EPA Sustainable Development Challenge Grant program (J.A. Welhan).
- Technical advisor on bids received by the cities of Pocatello and Chubbuck and Bannock County for development of a ground-water resource master plan blueprint (J.A. Welhan).
- Technical advisor to Chubbuck and the Idaho Division of Environmental Quality on reports of ground-water contamination at the former Pocatello Naval Ordnance Plant (J.A. Welhan).
- Technical advisor to Idaho State University on design and networking requirements for a GIS teaching facility (J.A. Welhan).
- Technical advisor to Lava Hot Springs on the rehabilitation of an abandoned hot spring facility (J.A. Welhan).
- Technical advisor to Shoshone-Bannock Tribes, Fort Hall Indian Reservation, on hydrologic data acquisition and future ground-water data needs related to monitoring the pesticide contamination of reservation ground-water (J.A. Welhan).
- Technical liaison and resource person to Idaho Division of Environmental Quality, Pocatello regional office, on ground-water technical issues (J.A. Welhan).
- Technical liaison to Bannock County Commissioners on geotechnical work at Fort Hall Canyon county landfill (J.A. Welhan).
- Technical liaison to Chubbuck and Pocatello for geotechnical work in the Pocatello-Chubbuck

municipal aquifer system (J.A. Welhan).  
 Trustee, board of trustees, alumni association,  
 College of Mines and Earth Resources, University  
 of Idaho (E.H. Bennett).  
 Trustee, Northwest Scientific Association, 1997-  
 2000 (K.L. Othberg).  
 Trustees board meeting, College of Mines and  
 Resources's alumni association, University of  
 Idaho, December (E.H. Bennett).  
 Western States Seismic Policy Council, 18th  
 annual meeting, Polson, Montana, September  
 (R.M. Breckenridge).  
 Writer, Geology Graduate Record Examination,  
 National Testing Service (R.M. Breckenridge).

## Graduate Thesis Committees

Guy Adema, M.S., Geophysics, University of Idaho  
 (R.M. Breckenridge).  
 Jon Bair, M.S., Geology, University of Idaho (K.L.  
 Othberg).  
 David Bates, M.S., Geology, Idaho State University  
 (J.A. Welhan).  
 Brian Cervi, M.S., Geology, Idaho State University  
 (J.A. Welhan).  
 Thomas Dechert, Ph.D., Soils, University of Idaho  
 (R.M. Breckenridge).  
 Mason Estes, M.S., Geology, Idaho State University  
 (J.A. Welhan).  
 Marv Eveland, M.S., Geology, University of Idaho  
 (K.L. Othberg).  
 Gwen Gerber, M.S., Geology, Idaho State University  
 (J.A. Welhan).  
 John Glover, M.S., Geology, Idaho State University  
 (J.A. Welhan).  
 Chad Johanneson, M.S., Geology, Idaho State  
 University (J.A. Welhan).  
 Matthew LaForce, M.S., Geology, University of  
 Idaho (R.M. Breckenridge).  
 Chris Meehan, M.S., Geology, Idaho State University  
 (J.A. Welhan).  
 Salma B. Monani, B.A., Geology, Mt. Holyoke  
 College (B. Bonnichsen).  
 Lisa Morrow, M.S., Geology, University of Idaho  
 (B. Bonnichsen).  
 Lee Morse, M.S., Geology, Idaho State University  
 (J.A. Welhan).  
 Rob Mullener, M.S., Geology, Boise State University  
 (V.S. Gillerman).  
 Susan Nash, M.S., Geological Engineering, University

of Idaho (R.M. Breckenridge).  
 Terrance Osier, M.S., Geology, Idaho State University  
 (J.A. Welhan).  
 Brian Peterson, Ph.D., Geophysics, University of  
 Idaho (R.M. Breckenridge, K.L. Othberg).  
 Michelle Pontac, M.S., Biology, Idaho State University  
 (J.A. Welhan).  
 Kurt Priebe, M.S., Geology, University of Idaho  
 (K.L. Othberg).  
 Ted Reid, M.S., Geology, Idaho State University  
 (J.A. Welhan).  
 Chuck Unsworth, M.S., Geology, Boise State  
 University (V.S. Gillerman).  
 Scott Van Hoff, M.S., Geology, Idaho State University  
 (J.A. Welhan).  
 Judy Walling, M.S., Earth Science, Boise State  
 University (K.L. Othberg).  
 Ron Warren, M.S., Environmental Science, University  
 of Idaho (K.L. Othberg).  
 Doug Whitmire, M.S., Geology, Idaho State University  
 (J.A. Welhan).  
 Cathryn Williamson, M.A., Anthropology, University  
 of Idaho (K.L. Othberg).

## Grants and Contracts

Bibliographies of scientific studies: E.H. Bennett  
 (National Park Service and Association of  
 American State Geologists, \$29,437).  
 Earthquake and fault studies in Idaho: R.M.  
 Breckenridge and K.L. Othberg (Idaho Bureau  
 of Disaster Services, January-December 1996,  
 \$24,000).  
 Earthquake and fault studies in Idaho: R.M.  
 Breckenridge and K.L. Othberg (Idaho Bureau  
 of Disaster Services, June-September 1997,  
 \$35,846).  
 Earthquake studies of the Lewis and Clark line:  
 R.M. Breckenridge (U.S. Geological Survey,  
 National Earthquake Hazards Reduction, September,  
 1996, cooperative project with the  
 Montana Bureau of Mines and Geology,  
 \$100,000; ended March).  
 Equipment purchase for GIS research laboratory  
 expansion: P.K. Link and J.A. Welhan (Idaho  
 State University, University Research Committee,  
 \$30,080).  
 Hydrologic and geochemical evaluation of a  
 constructed wetland: J.A. Welhan (Environmental  
 Protection Agency 319 grant subcon-

tract to Pocatello, \$20,450).

Inactive and abandoned mines evaluation: E.H. Bennett (U.S. Forest Service, Region I, \$100,000).

Petrogenesis and geochemistry of basalts in the central Snake River Plain: Bill Bonnichsen (National Science Foundation subcontract, \$10,302).

Spatial correlation analysis of aquifer lithology and permeability at INEEL, and development of a stochastic ground-water flow and transport model; first year: J.A. Welhan and G. Johnson (U.S. Department of Energy, \$109,000).

Transport and dispersion of pollutants in the

subsurface environment; concluded: J.A. Welhan (National Science Foundation EPSCoR, \$54,250).

Urban geologic mapping in Idaho—Coeur d'Alene, Pocatello, and Twin Falls: K.L. Othberg, B. Bonnichsen, and R.M. Breckenridge (U.S. Geological Survey, STATEMAP project, May 1996-April 1997, \$78,555).

Urban geologic mapping of Coeur d'Alene and the quad cities (Moscow-Pullman; Lewiston-Clarkston): B. Bonnichsen, R.M. Breckenridge, and K.L. Othberg (U.S. Geological Survey, STATEMAP project, May 1997, \$106,461).

# Funding & Budget

For a second year now state agencies have had their current budgets cut within the fiscal year. Early, declining revenue projections again prompted the governor to impose a deficit correction, or "holdback," meant to curtail spending temporarily until revenues rise. Despite a quick turnabout resulting in a surplus by year's end, the governor nonetheless retained the holdback. The result amounted to a 2.5 percent permanent statewide cut in current appropriations. Combined with the permanent 2 percent holdback similarly enacted last year, the Survey's budget was significantly impacted.

These across-the-board budget reductions, authorized first as holdbacks, impose a disproportionate load on the lean backs of personnel-intensive, small agencies like the Survey. They have also weakened the integ-

rity and morale of efficiently run organizations like the Survey when, as it turns out again this fiscal year, tax revenues end in a surplus, thereby making the budget-balancing maneuver unnecessary but the loss permanent.

Currently, most research in the Survey is funded fully or partly through outside grants and contracts. Funding agencies and projects are listed below. The total amount of \$743,459 speaks well for the initiative of the staff. Despite the holdbacks, these funds have kept the agency's research efforts moving, as detailed in this annual report. The Survey's competence in successfully bidding for these funds is dependent not only on the staff's expertise and well-earned reputation but also on the agency's capacity to match funded amounts.

## Recent Budget History—Fiscal Years 1993-1997

Fiscal Year	FY-93	FY-94	FY-95	FY-96	FY-97
Personnel	\$486,000	\$505,000	\$550,400	\$560,000	\$583,200
Operating Expense	61,300	53,100	54,200	41,900	42,700
Capital Outlay	-0-	-0-	2,200	2,300	2,200
Total	\$547,300	\$558,100	\$606,800	\$604,200	\$628,100



## Overview of Grants and Contracts—Fiscal Year 1997

Funding Agency	Project	Amount
Idaho Bureau of Disaster Services	Earthquake and fault studies	\$ 24,000
Idaho Bureau of Disaster Services	Earthquake and fault studies	35,846
Idaho State University	Equipment for GIS laboratory	30,080
National Park Service/Association of American State Geologists	Bibliographies of scientific studies	29,437
National Science Foundation (EPSCoR)	Pollutants in the subsurface	54,250
National Science Foundation (subcontract)	Petrogenesis and geochemistry of basalts	10,302
U.S. Department of Energy	Analysis of aquifer lithology at Idaho National Engineering and Environmental Laboratory	109,000
U.S. Environmental Protection Agency	Hydrologic and geochemical evaluation	20,450
U.S. Forest Service, Region I	Inactive and abandoned mines evaluation	102,078
U.S. Geological Survey	Earthquake studies of the Lewis and Clark line; ended March	100,000
U.S. Geological Survey	Geological mapping in the St. Joe area	43,000
U.S. Geological Survey	STATEMAP—Coeur d' Alene and quad cities (Moscow-Pullman; Lewiston-Clarkston); started May	106,461
U.S. Geological Survey	STATEMAP—Coeur d' Alene, Pocatello, and Twin Falls; ended April	78,555
TOTAL		\$743,459

# IDAHO

## GEOLOGICAL SURVEY

Since 1919, Serving The State Through Geologic Research

Main Office at Moscow  
Morrill Hall, Third Floor  
University of Idaho  
Moscow, Idaho 83844-3014  
(208) 885-7991

Branch Office at Boise  
Math-Geology, Room 229  
Boise State University  
Boise, Idaho 83725-1535  
(208) 385-4002

Branch Office at Pocatello  
Physical Science, Room 325  
Idaho State University  
Pocatello, Idaho 83209-8071  
(208) 236-3235

1997

### Advisory Board

Office of the Governor, Philip E. Batt .....	Governor
David Hawk, representative .....	
John J. Cline .....	State Director, Bureau of Disaster Services
Paul R. Donaldson .....	Chairman, Department of Geology and Geophysics, Boise State University
Stanley Hamilton .....	Director, Idaho Department of Lands
William H. Harrison .....	Group Manager, Earth, Environmental, and Life Sciences, INEL, Idaho Falls
Paul K. Link .....	Representative, Idaho Association of Professional Geologists
Jack Lyman .....	Executive Director, Idaho Mining Association
David W. Rodgers .....	Chairman, Department of Geology, Idaho State University
Robert W. Bartlett .....	Director, <i>ex officio</i>

### Administrative and Support Staff

Robert W. Bartlett .....	Director
Earl H. Bennett .....	Associate Director and State Geologist
Charlotte D. Fullerton .....	Secretary/Account Technician
Keri Moore .....	Secretary/Program Coordinator
Nola Steuer .....	Secretary/Program Coordinator
Roger C. Stewart .....	Publications Editor
Connie Tillotson .....	Secretary-Pocatello

### Research Staff

Earl H. Bennett .....	Associate Director
Bill Bonnichsen .....	Research Geologist/Economic Geology
Roy M. Breckenridge .....	Research Geologist/Environmental Geology
Virginia S. Gillerman .....	Research Geologist/Economic Geology-Boise
Charles R. Knowles .....	Research Geologist/Analytical Services
Kurt L. Othberg .....	Research Geologist/Environmental Geology
Loudon R. Stanford .....	Coordinator, Computer-Aided Design
John A. Welhan .....	Research Hydrogeologist/Environmental Geology-Pocatello

### Project Research Staff (state or federally funded)

Guy Adema .....	Fault Studies
Blair H. Baldwin .....	Earth Science Education Workshop
Jane S. Freed .....	Digital Cartography
Tim D. Funderburg .....	Digital Cartography
Martha M. Godchaux .....	Research Geologist
John Kauffman .....	Research Geologist
Vance MacKubbin .....	Digital Cartography
Victoria E. Mitchell .....	Research Geologist
Steve F. Mulberry .....	Digital Cartography
William C. Rember .....	Research Geologist
Nola Steuer .....	Abandoned Mine Lands
Ruth E. Vance .....	Compilation Assistant/Computer Programmer
Amy M. VanHoover .....	Abandoned Mine Lands
Daniel W. Weisz .....	Paleomagnetic Laboratory