CONTENTS

INTRODUCTION ............. 1
SERVICE .................. 3
RESEARCH ................ 6
PUBLICATIONS ............ 12
PERSONNEL ............... 14
STAFF PUBLICATIONS
AND ACTIVITIES .......... 16
FUNDING & BUDGET ....... 21
ENABLING ACT ............ 22
INTRODUCTION

Natural and political incidents this past year have kindled far-reaching interest in geology. The war in the Middle East, oil fires in Kuwait, volcanic eruptions in the Philippines and Japan, and earthquakes everywhere have reawakened the public to the disastrous consequences of volatile geologic conditions. These catastrophes have understandably spread apprehension beyond national and regional borders.

Inquiries to the Idaho Geological Survey about the state’s geology reflect the global forebodings. Many new requests on the state’s oil and gas possibilities are driven by the impact of Middle East turmoil on world petroleum markets. The publications’ sales office is becoming accustomed to mail and even telephone calls on various geologic matters from places as dissimilar and distant as Austria and China. California residents in particular, looking to relocate somewhere in the Pacific Northwest, want recent data on Idaho’s faults and earthquakes. Questions on Idaho’s minerals are much more common lately from world-wise organizations like the National Geographic Society and the Wall Street Journal. The state’s hot springs once again intrigue entrepreneurs searching for alternative energy resources. Those in recreation and land development seek to understand and identify the geologic hazards in their midst. And finally, the almost daily news of ground-water contamination somewhere in the world motivates people here to question conditions in the local hydrogeologic subsurface. Recent human and natural calamities have prompted many clientele requests. Interest in Idaho’s geology is hardly confined to just the citizens of the state.

Big news for the Survey in FY-91 is that its branch office at Pocatello is now fully operational. John A. Welham, hydrogeologist, began work in July. For the first time in its history, the agency now has local offices in the southern and southeastern parts of the state. Combined with the staff and facilities of the main office at Moscow, the Survey can provide service and research statewide.

For the third year in a row, the Survey has set a record for grants and contracts. In FY-91, the agency had $653,500 in additional research money. This amount is $155,800 more than the state’s appropriation for regular operations. Two large contracts dominate this outside research. The Idaho Initiative Mapping Program, a cooperative multiyear project with the U.S. Geological Survey and the U.S. Bureau of Mines, continues to evaluate the mineral potential of areas in the state that may be considered for future wilderness. Geologists on the Bureau project, a two-year contract with the Idaho Department of Water Resources, have completed about half of the field work.

The Survey is also busy with other research. Mapping has been completed on the Boise COGEO MAP project. The staff is involved in studies covering areas in Pocatello and Bannock County, the Pearl mining district, ancient Lake Idaho, the lateral lakes of the Coeur d’Alene River, the city of Coeur d’Alene, and the western Idaho ultramafic zone. Other subjects under examination include black sand placers, in situ vitrification, lead contamination, new selenide minerals, phase relationships of sulfide systems, and seismic risk. These and other activities are discussed in the Research section.
Many of the staff's commitments are covered in the Service section. The agency has developed a sophisticated computer-aided cartographic system that has revolutionized map making beyond original expectations. By digitizing information to maps of different scales, the staff can produce maps more accurately than with traditional methods and in a fraction of the time. Of continuing interest is the agency's strong commitment to earth science education. The Survey has sponsored an annual summer workshop for earth science teachers and has representatives in the Idaho Earth Science Teachers' Association and the Idaho Science Teachers' Association. Staff members have also given well-received presentations on geology and minerals to elementary school classes. The Survey is involved in other service activities that include disaster preparedness, earthquake monitoring, the geoanalytical laboratory, and the annual mining industry review. These are explained in the Service section.

The Publications section lists for FY91 a variety of published work. Among the publications are the second editions of the Hailey and Elk City quadrangles in the Mines and Prospects Map Series and the 1:500,000-scale map, Landslides in Idaho, in the Surficial Geology Map Series. Hot off the press toward the end of the fiscal year was the Geologic Map of Idaho color poster and postcard.

Fund-raising for the University of Idaho's new Earth Resources building that will also house the Survey is complete with about $12 million on hand for the project. Ground-breaking for the facility should begin in the spring or summer of 1992. The Survey staff continues to work closely with the faculty in the geology departments at the University of Idaho, Boise State University, and Idaho State University. Several members are participating in teaching courses, and most serve on graduate committees.
The Annual Report should give a broad understanding of current operations without repeating from year to year what the reader might feel are mostly encore tributes, however laudable, to accumulating and multifarious deeds. This is especially true of those activities identified under Service. Many continuing service functions, highlighted in previous annual reports and still being conducted, are not singled out in succeeding years for this reason.

Probably a thorough understanding of the Survey’s present service role would require a review of the last several annual reports. For instance, staff members still serve on a wide range of committees connected with professional associations, university and interagency management, and other state and federal agencies. The Survey also remains committed to keeping available for future study the rock core supplied over the years by mining ventures and representing millions of dollars in irreplaceable exploratory work. Databases on subjects from seismicity to mineral locations in Idaho are as purposefully maintained today as when they were originally recounted. Furthermore, the staff continues to promote and expand geologic research by leading or participating in field trips, conferences, workshops, short courses, and other formal and informal organizational meetings so important to the Survey’s professional interest. And there are many other examples of sustained functions that a reexamination of past annual reports would favorably disclose.

This year the Survey singles out the most deserving aspects of its current work. As in past reports, this includes new items as well as updates on some regular programs like earth science education. For FY91, Service involved the following activities.

**Computer-Aided Cartographic System**

Back in 1989, the Survey began customizing a computer-aided drafting design (CADD) program to enable the agency to produce maps and illustrations digitally for publication. Using the modified CADD system, the cartographic staff drafts, plots, and edits geologic maps in-house. Recent publications in the Mines and Prospects Map Series—the Elk City and Hulley quadrangles—are examples of production from this technology. This year, the staff has digitized twenty-eight 7.5-minute maps of the Idaho City and Boise areas and nine 7.5-minute geologic maps of various areas in the state. Refinements in the system now allow the Survey to compile maps from bases of differing scales. The resulting geologic map databases can be employed later in other compilations. Planned future improvements in software and programming will allow the agency to use its system for geologic research as well as publication.

**Disaster Preparedness**

The Survey continues its active participation in the Western States Seismic Policy Council. The annual meeting, held at Anchorage, Alaska, featured field trips to the areas affected by the major earthquake there in 1964 and a tour of the Alaska Tsunami Warning Center.

A staff geologist attended the second biennial Earthquake Program Information Exchange Workshop in Golden, Colorado. The meeting was an important element in the initial informa-
tion gathering for two earthquake projects conducted by the Survey and funded by the Idaho Bureau of Disaster Services.

Earthquake Monitoring

With the departure of the director of the North Idaho Seismic Network, the daily operation and data collecting have been taken over by the Survey. The network has four seismograph stations in northern Idaho. A temporary station has been established near St. Maries on Lindstrom Peak.

Earth Science Education

The Survey conducted its fifth geology workshop for teachers this summer in the Moscow area. Participants studied rocks of Precambrian to Quaternary age in this diverse geologic setting. The 10-day session examined in detail the Columbia River basalt flows, the Clarkia fossils, and the Palouse loess. The educators also enjoyed a float trip on the Salmon River, an early morning flight over the Channeled Scabland of eastern Washington, and a field trip to the Wallowa Lake moraines of eastern Oregon.

The Survey is represented on the boards of the Idaho Science Teachers Association and the Idaho Earth Science Teachers Association (UESTA). The agency is working with UESTA to develop photographic slide sets of the state's geology for classroom use. Two UESTA newsletters were distributed by the Survey during the year. A staff geologist led an UESTA-sponsored field trip for teachers to view the geology of the Boise Valley and also worked with the Lewiston and St. Maries school districts to provide training in Idaho's geology for many of their science teachers.

A staff representative met with officials from public agencies, industry, and education to form the Idaho Earth Science Education Coalition. The new organization initiated a review of the degree programs for earth science teachers at the University of Idaho. The review committee consisted of a staff geologist as well as university faculty and earth science elementary and secondary teachers.

Staff in all three Survey offices accepted invitations to talk to elementary and secondary school classes in their local areas. Topics ranged from geology and minerals to the profession itself. This public involvement has become a widely appreciated aspect of the agency's service function.

Geoanalytical Laboratory

The geoanalytical laboratory has installed two intricate software programs, Powder Data File and Minident, to assist Survey staff and university researchers in identifying minerals. The installation has also meant the purchase of a CD-ROM reader and a computer dedicated to this specific use. Between the two programs the laboratory now has the most complete mineral identification system available, with 4,600 mineral groups in Minident and 53,000 patterns in PDF. The PDF also includes alloys and organic substances as well as minerals.
Both software programs will be updated annually. The ease and speed with which minerals may now be classified can be compared with overhauling the document retrieval system of a library from card files to computer network. The old system was slow, incomplete, and tedious. The new system greatly enhances this analytical purpose. The laboratory's highly sophisticated instruments and equipment are shared between the Survey and the University of Idaho's College of Mines and Earth Resources.

Mining Industry Review

Mining and mineral exploration have been on the upswing in the state this past year. The Survey reported on nearly 100 exploration projects at the Northwest Mining Association Convention held in December at Spokane, Washington. The talk summed up operations on six new precious metal mines in the development and permitting stages. This exploration activity is the most seen in the state since the last gold rush of the 1950s. The agency monitors for the state the mining and exploration of both metallic and industrial minerals.

Oil and Gas

Even though no new exploration holes were drilled in Idaho during the past year, the Survey fielded an increased number of requests for information from the petroleum industry and others. Rising oil prices, the political tension in the Middle East and the Gulf War, and the nation's unsettling dependence on foreign oil have renewed federal interest in incentives for domestic production.

Western Snake River Plain

The final version of the manuscript, "Volcanic Crescent," has been accepted as the chapter on geology in the forthcoming book, Volcanic Lands: The Snake River Plain and Its People. The scholarly study is a multidisciplinary effort covering much of southern Idaho's natural history, anthropology, history, economics, and politics. The book will be published by Boise State University in its Hemingway Western Studies program.

Wilderness Issue

Idaho is still seeking a wilderness bill for the federal lands within its borders. The State Legislature appropriated funds for hiring a mediator to bring the interested parties together to draft final wilderness boundaries. This action followed the failures last year on the national level of the McClure-Andrus and Kostmayer bills to designate these boundaries for the state. The Survey is providing the mediator with information on the mineral potential of about 6 million acres that cover almost all of the roadless areas in the state. The mineral information should help all sides—environmental groups and those in mining, timber, recreation, agriculture, and ranching—to successfully settle this aspect of the wilderness debate.
RESEARCH

The Survey's research effort has been visibly enhanced in eastern Idaho by the new hydrogeologist at the Pocatello branch office. The scientist has already undertaken hydrogeologic studies in Bannock County and Pocatello and at the Idaho Nuclear Engineering Laboratory near Idaho Falls. The addition of a hydrogeologist to the staff gives the agency a full range of expertise to meet its mandate.

A record amount of $633,300 in outside funding for FY-91 is more than 152 percent of the agency's state appropriation. Prominent among this contract research are the Idaho Initiative Mapping Program ($450,000) and the Bruneau project ($105,000). This large amount of research money provides the agency with the means to complete significant geologic mapping over large areas. By employing additional researchers on these projects, the agency can compress in a short time of two or three years a workload that would take the existing staff many more years to complete. And, as is also the case with these jumbo projects, the agency is able to undertake important work that it would otherwise have to forego. For FY-91, research involved the following activities.

Bannock County Landfill

The Survey has started a hydrogeologic study of the Bannock County landfill. The landfill is being considered as a possible regional waste-disposal site because of some of its geotechnical attributes (for example, depth of water table, loess foundation). Bannock County funded a preliminary hydrogeologic evaluation, including the installation of three monitoring wells and water sampling and analysis.

Black Sand Placers

The heavy mineral component (black sand fraction) of two samples of granitic rock from central Idaho were chemically analyzed with the electron microprobe to determine the composition of radioactive minerals. These analyses are part of the black sand placer study begun in 1989 with the U.S. Geological Survey. A USGS open file report is being prepared using previous data and more recent information.

Boise 1° x 2° Quadrangle

FY-91 was the culminating year for research in the south half of the Boise quadrangle, an area that includes the major population center of the state. In a cooperative agreement with the U.S. Geological Survey's COGEOGRAPH program, staff geologists completed field work for a geologic map of this important area. Scientists analyzed several basalt samples for potassium-argon dates and measured dozens of rock cores for paleomagnetic data. Researchers compiled both a geologic and a geomorphic map of the area, using computer-assisted drafting techniques, and began preparing a companion report.
Bruneau Hot Springs Area

The Bruneau project, funded at $105,000 for two years by the Idaho Department of Water Resources, is scheduled to finish geologic maps for nineteen 7.5-minute quadrangles by early 1992. During FY-91 geologists completed about half of the field work. This investigation has shown that the previous stratigraphic divisions of the Idaho Group into the Chalk Hills, Glenns Ferry, and Bruneau Formations cannot be followed for field mapping in the Bruneau-Grand View region. Instead, researchers have found that using the concept of key marker beds works quite well. Once the contract with the Department of Water Resources is completed, the Survey will publish all of the 7.5-minute quadrangles. Eventually, the agency plans to produce a 1:100,000-scale map of the west half of the Glenns Ferry quadrangle.

Geochemistry Maps

The Survey has analyzed numerous samples of volcanic rocks and sediments from the Snake River Plain geologic province in southwestern Idaho. The analyses are being compiled for publication as tables accompanying 1:100,000-scale location maps.

Idaho Initiative Mapping Program

With an annual budget of $450,000, the Idaho Initiative Mapping Program has concluded the second year of a three-year mapping and compilation project. The Idaho Initiative, a cooperative research effort between the Idaho Geological Survey, the U.S. Geological Survey, and the U.S. Bureau of Mines, is gathering information on the mineral potential of areas in the state that may be considered in future wilderness legislation. The Survey is preparing geologic maps for large areas that have had little or no mapping available. In addition, the project is compiling statewide databases that can be accessed quickly for geologic and mineral information.

During the field season, four three-person crews mapped about 1,200 square miles in the upper part of the North Fork of the Clearwater River drainage. Geologists correlated sedimentary units with those of the Belt Supergroup and subdivided a complex series of intrusive rocks. The researchers located numerous faults and determined the relationship of these faults to geochemical anomalies. The geologic map was compiled on the Survey’s computer-aided cartographic system (see Service section) during the fall and presented in December at the Northwest Mining Association Convention in Spokane, Washington.

The mapping by a three-person crew from the Department of Geology and Geophysics at Boise State University continues in the Albion Range in Cassia County. Another three-person crew from the Department of Geology at Idaho State University is mapping in central Idaho.

Work continues on the collection of reports covering the geology and ore deposits of the Elk City region, which was mapped in FY-90. The collection will be published as a Survey Bulletin.
The compilation staff on the Idaho Initiative has been revising the Survey’s Geologic Map Series and the Mines and Prospects Map Series and accompanying database. In addition, the staff is within a few months of finishing its work on the bibliography of Idaho’s geology.

In the Geologic Map Series, the digital cartography is complete on the Hailey 1° x 2° sheet. Most of the geology has been compiled on the Elk City and Hamilton 1° x 2° sheets. Both maps are waiting for additional information from the FY-92 summer field season.

Mineral information for all twenty 1° x 2° quadrangles in the Mines and Prospects Map Series is now in dBase III PLUS files. Data in these files are being revised to include new properties and production figures from the U.S. Bureau of Mines’ records. The second editions of the Elk City and Hailey Mines and Prospects Maps published this year incorporate the new information that has been added to the database. Revisions on the Dubois, Dillon, and Hamilton databases are complete, and work is proceeding on other 1° x 2° quadrangles.

The extensive bibliography of Idaho’s geology now contains over 9,500 references, and the compilation staff keeps finding more. By June, the staff had edited eighty-five percent of the citations. The editing of the database should be substantially complete by August, 1991, at which time work will begin on producing separate bibliographies for each of the twenty 1° x 2° quadrangles covering the state.

**INEL Oversight Program**

The Survey contributed its expertise to the state’s Idaho National Engineering Laboratory (INEL) Oversight Program for the design and fabrication of a sophisticated borehole straddle-pack tool to be used in groundwater sampling and hydrogeologic research. The finished tool will provide state of the art capability for obtaining water samples from discrete zones in the multilayered Snake River Plain aquifer. A staff member, in collaboration with researchers at the University of Idaho and Idaho State University, will employ the tool to map the subsurface distribution and movement of ground water beneath INEL. Geochemical analyses of these water samples will delineate the first three-dimensional model of the ground water flow systems down to 800-1000 feet below the surface. The analyses will also permit researchers to map more rigorously the ground water systems and to predict more closely the movement of contaminants than had been possible before.

**In Situ Vitrification**

The Idaho Nuclear Engineering Laboratory (INEL) and EG&G, Idaho, awarded a contract to the Survey to characterize the products from an in situ vitrification experiment. Using high voltage electrical resistance, INEL researchers at Idaho Falls melted all material in a small area of ground, producing a pod of fused earth about 3 meters long and 38,000 pounds in mass. The glass products of this melted material were studied by the Survey with the electron microprobe. All elements and their distribution were analyzed in the in situ glass. In situ vitrification is being studied as a possible way to encapsulate nuclear or other hazardous waste stored underground and to prevent further underground contamination.
Lake Idaho and Basaltic Volcanism

Recent geologic mapping in southwestern Idaho has revealed several ways in which basaltic volcanism interacted with Lake Idaho, an ancient body of water that covered a large part of the region from Miocene to Pleistocene time. Important interactions include the following: (1) abundant phreatomagmatic volcanism when volcanism occurred in the lake or through nearby water-saturated sediments; (2) the formation of abundant pillow basalt, commonly with foreset beds of pillows, when the basalt lava ran into standing water; and (3) the formation of hydrothermally altered appearing basalt, which has been referred to as water-affected basalt (WAB), where basalt flows ran into and underneath the lake on shallower slopes than needed to form pillow deltas.

Lateral Lakes

Work continues with faculty at the University of Idaho on the stratigraphy of the sediments in the lateral lakes of the Coeur d'Alene River. Funding for a waste disposal project provided by the Institute for Molecular and Agricultural Genetic Engineering enabled the researchers to collect sediment samples from the lakes this winter. Scientists are already conducting geochemical and biological analyses of the samples. They plan to take geophysical profiles of the lake bottoms and sediment thicknesses next summer.

Lead Contamination

The Survey is contributing its expertise to a feasibility study with the University of Idaho's College of Engineering on lead contamination in carpets and upholstery. Part of the project includes using a portable X-ray fluorescence instrument to develop a method for examining lead contaminants that have been shown to be toxic in children.

New Minerals

It is rare this day and age to happen upon a new mineral. Prospectors and mining companies have picked the planet over pretty carefully. Nevertheless, the Survey is attempting to characterize and name not just one but two selenide minerals found in a rock sample sent to the agency from the DeLamar Mine in southwestern Idaho. The minerals were discovered after routine identification in the Survey's laboratory indicated they were an unknown species.

Pearl Quadrangle

A staff geologist began mapping the geology of the Pearl 7.5-minute quadrangle located east of Emmett. This research is part of the Survey's project on the Boise 1° × 2° quadrangle. The mapping will focus on the timing and structural controls of sedimentation, volcanic activity, and local mineralization.
Phase Equilibrium of Bi-Pb-Se-Te System

For several years, the phase relationships of sulfide systems have been studied at the Survey. With the discovery of two new selenide minerals from the DeLamar Mine in southwestern Idaho, the agency began further research into the phase relationships of selenides and tellurides. The chemistry and structure of the synthesized minerals will be determined using the electron microprobe and X-ray diffraction. Results of this study may help in understanding how the minerals formed and perhaps lead to discoveries of other minerals.

Pocatello Aquifer

A hydrogeologic database is being assembled by the Survey on the aquifer that supplies 80 percent of Pocatello's water. Typical of many of the state's medium to large valley-fill aquifers, little information exists on its hydrogeology and flow system configuration.

Quaternary Maps

The Survey has digitized three 1° x 2° maps, including unit descriptions and labels, into computer data files for an eventual statewide Quaternary map. The new map is based on the 1:250,000-scale surficial maps compiled several years ago in cooperation with the U.S. Geological Survey. Work has begun on the urban geology in the vicinity of Coeur d'Alene. This project is bringing together information on the geology, hydrology, and engineering geology in map and graphic form for this rapidly developing area of the state. Geologists from the Survey, the U.S. Geological Survey, and Eastern Washington University have combined research on revised limits of the late Pleistocene Cordilleran ice sheets, glacial lakes, and repeated floods in northeastern Washington and northern Idaho.

Seismic Risk Analysis

The Survey is evaluating local seismic characteristics and siting regulations for the state and from this study will produce a guide for the siting of commercial and governmental facilities. The siting manual will be an important technical aid not only for the commercial, industrial, and financial sectors but also for state agencies and local government. The project is sponsored by the Idaho Bureau of Disaster Services under the Federal Emergency Management Agency's (FEMA) National Earthquake Hazards Reduction Program (NEHRP).

With funding from the same NEHRP program, the agency is preparing a brochure on earthquake awareness directed at the general public. The document will assess the risk from earthquakes and the safety measures involved.

The Survey is interpreting the geology of the seismic setting along the Lewis and Clark line in Idaho. The study is part of cooperative research between the agency, geophysicists from the University of Idaho, and geologists with the Montana Bureau of Mines and Geology. Staff researchers are analyzing seismic data for location and wave form measurements collected by a portable array last summer.
Sheep Creek and Murphy 1:100,000 Quadrangles

The U.S. Geological Survey has published the long-awaited geologic maps of the U.S. Bureau of Land Management’s wilderness study areas in the Sheep Creek and Murphy quadrangles. Survey geologists completed the field work for these maps several years ago.

Stream Ecology

The Survey staff has contributed descriptions of stream morphology to a field handbook used in a University of Idaho summer course on stream ecology. The course is taught by experts in the U.S. Forest Service and in the biology department at the university. The Survey will also participate in field instruction this summer.

Sunstone—Its Mystery Revealed

Oregon’s state gemstone, the brilliantly translucent sunstone, has been under study the past year at the Survey’s geoanalytical laboratory. This colorful semiprecious gem is a variety of feldspar and comes from a locality in southeastern Oregon. The unique character of the gem is caused by the “schiller” phenomenon. The stone gives beautiful internal reflections when turned at various angles. It was originally thought that this effect was caused by the very fine grains of iron oxide (hematite) in the stone. The Survey’s study—using scanning electron microscopy, electron microprobe analysis, and Auger surface analysis—found that extremely fine exsolved inclusions of very pure copper caused part of the reflections.

Western Idaho Ultramafic Zone

The Survey continues to study the types and mineral potential of ultramafic rocks concentrated along the boundary zone between the Mesozoic accreted terranes and the earlier-formed North American continent. During FY 91, field work was conducted in the area between Riggins and Grangeville. Important findings include the observation that several types of ultramafic rocks, including dunites, peridotites, and pyroxenites, were originally present before they were deformed and metamorphosed. In addition, the research has confirmed that massive chromitites exist in the New Meadows region.
The work of the Publications Department covers both producing and selling books and maps. Past annual reports have spotlighted the activities of editorial production. The release of new books and maps has, in their novelty, gotten the lion's share of attention. Sales, on the other hand, have been summed up with much less fanfare, as in the bottom line, sales for FY-91 were $56,785.53. This figure gives the total for the year to the penny, but it is digits and decimals short in explaining the operation involved in generating those sales.

The sales office markets over 440 of the agency's own titles along with other reports relevant to Idaho's geology primarily from the U.S. Geological Survey. In addition, the Survey carries USGS topographical maps for the entire state, which means maintaining an inventory of over 2,500 different maps in a half-dozen scales. The office also handles maps by the Idaho Department of Transportation and the American Association of Petroleum Geologists. Since 1980 the Publications section has made over $460,000. This money has in turn supported the agency in producing new books and maps. The sales office provides an essential function for the Survey not only in disseminating important information but also in sustaining an indispensable source of funds for printing future publications.

The sales office is always a busy place. For many customers it may be the only contact they have with the agency. Orders by mail account for nearly ninety percent of business. Many publications are now out-of-print, and photocopies of these must be provided upon request. To improve bookkeeping, the Survey has installed a publishers' software program. While there may be many benefits with advanced software, immediate fulfillment in this case has certainly not been one of them. To get the sales/inventory program working has taken monumental patience and perseverance. The advantage of a sophisticated program, though, is the accuracy and control it offers. With only finger strokes, the sales staff can process timely transactions such as low-stock reports, mailing lists, and sales analyses. Gone are the old days of faulty spot inventories, tedious list sorting, and lengthy journal entries. Gone too is a great part of the time it took to do those tasks. However, whether the world of the sales office is a saner place after this sometimes exasperating transformation remains for the courageous inmates to say.

On the editorial side of Publications, the move to desktop publishing, which was underway in earnest in FY-89, has been successfully productive. Its significant contribution has been the increased speed with which projects are finished. But its reliance on computer technology, too, tests the staff's practical accommodation to change. Already in this short time there have been software upgrades and new equipment. These modifications create their own problems, but so far slowdowns have been minimal. This year the editorial staff has produced an extensive list of publications and promotional literature.

In addition to publishing new material, the Survey has also begun to archive its publications. Archiving has two purposes: to store all Survey publications in permanent computer files and to furnish clean, reproducible copies of those deteriorating out-of-print editions. Current publications are archived when they are first published.

The agency started archiving the earliest reports from the 1920s because over the decades many had not survived well. Most original copies were in some form of severe decay that
made them marginally readable and in spots illegible. Photocopies of these were only as good as the original. The poor reproducible quality of the aged documents was recognized several years ago; however, efforts then on producing "new" originals from which to photocopy were stymied by competing priorities and a small staff. This year the agency resolved to get the worthy enterprise going again. Four university students were hired part-time to work on the project during the academic year. To guarantee an accurate transcription, the students typed documents and, working in pairs, proofread them. The retyped versions were read thoroughly by the editor and formatted, page by page, as in the originals. To ensure the reliability of past and future citations from the documents, almost everything in the originals was preserved, including grammar, usage, and typographical errors. Steady work on these documents has finally yielded tangible results. Seven in the Pamphlet series are archived, and several others are in various stages of preparation.

In FY-91 the following reports were produced:


Geologic Map of Idaho, color poster (14 5/8 x 20 1/2 inches) and postcard.

Archived out-of-print publications. Pamphlets 5, 6, 14, 17, 24, 28, and 29.

All of Idaho Centennial Poster. Distribution and sales arranged with the Idaho Heritage Foundation.

In July, John Welhan took up the position of hydrogeologist at the Survey’s new branch office in Pocatello. John is a transplanted Canadian who has lived and worked in the western U.S. for more than a decade. He began his geological career at the University of Manitoba where he was awarded a B.S. degree in geology in 1972. As a student, he worked summers on the Precambrian terrains of northern Canada for the Provincial Mines Branch and various exploration companies. Later, he received an M.S. from the University of Washington with interests in geochemistry and hydrology and a Ph.D. from the University of California, San Diego, in ground water and hydrothermal geochemistry. Much of his doctoral research was conducted in the Yellowstone-eastern Snake River Plain region. John also spent several years in submarine hydrothermal research and deep-marine submersible diving, first under a two-year postdoctoral fellowship and then on research faculty status at the Scripps Institute of Oceanography. In 1994, John returned to Canada to accept a tenured faculty position at Memorial University in Newfoundland, where he helped establish a stable-isotope laboratory for environmental studies and a ground-water research and teaching program. During his career, John has also consulted for industry and governmental agencies in geochemistry, hydrogeology, and nuclear waste-related problems in the western U.S., Canada, and Sweden.

Now with the Survey, John is introducing and directing the service and research functions for the Pocatello office housed at Idaho State University. He is presently involved in developing a research program in ground-water geochemistry. A current research aim is defining the vertical structure of contaminants chemistry in the Snake River Plain aquifer beneath the Idaho National Engineering Laboratory near Idaho Falls and interpreting the aquifer’s ground-water flow history from the hydrochemistry.
Publications


Geologic Map of the Jarrah Ridge Wilderness Study Area, Owyhee County, Idaho; by Bill Bonnichsen and Margaret D. Jenks; U.S. Geological Survey Map MF-2127, 1990, scale 1:50,000.

Geologic Map of the Little Jacks Creek, Big Jacks Creek, and Duncan Creek Wilderness Study Areas, Owyhee County, Idaho, by Daniel F. Kaufman and Bill Bonnichsen; U.S. Geological Survey Map MF-2125, 1990, scale 1:50,000.


Geology and Mineral Resources of the Taylor Creek Bombing Range and Eastern Owyhee County, by Virginia S. Gillerman and Bill Bonnichsen; Idaho Geological Survey GeoNote 12, 1990, 2 p.


Abstracts


Presentations

100 Years of Mining in the Fabulous Cœur d’Alene, by Earl H. Bennett: National Society of Professional Engineers, Cœur d’Alene, October; North Idaho Chamber of Commerce Legislative Tour, Wallace, November.


1990 Developments in Idaho Mining, by Virginia S. Gillerman: Mineral economics class, Boise State University, Boise, March.

1990 Developments in Mining in Idaho, by Virginia S. Gillerman: Boise Section meeting; Society of Mining Engineers, American Institute of Mining, Metallurgical and Petroleum Engineers (AIME), Boise, December.

Earthquake Hazard in Idaho, by Roy M. Breckenridge: Geology class, University of Idaho, November.

Earthquake Research in Idaho, by Roy M. Breckenridge: XIII Annual Western States Seismic Council, Anchorage, Alaska, November.

Earthquakes and Seismographs, by Roy M. Breckenridge: Sixth grade class, Genesee Public School, Genesee, March.


Environmental Geology Mapping, Puger Leland, Washington, by Kurt L. Othberg: Geologic hazards class, University of Idaho, October.

Flying Boulders, Flowing Muck, Pillow Deltas, WAB, and Other Sneaky Basalt Tricks, by Bill Bonnichsen: Geology graduate seminar, University of Idaho, March.


Geologic History of Southeast Idaho, by Margaret D. Jenks: Kiwanis International Club, Moscow, March.


Geology of the Earth and Moon, by Virginia S. Gillerman: Activity for Girl Scout ScienceTech camp, Discovery Center, Boise, May.

Geology of the Elk City Area, by Reed S. Lewis: Geology seminar, University of Idaho, February.

Glaciers and Glaciations, by Kurt L. Othberg: Idaho Geology Field Workshop, August.

Ground Failure Hazards in Southeastern Idaho, by Kurt L. Othberg: Geologic hazards class, University of Idaho, November.


Lake Idaho, by Margaret D. Jenks: Idaho Science Teachers Association Convention, Nampa, October; Geology graduate seminar, University of Idaho, February.


Meet Lake Idaho: A Classic Rift Lake in Our Own Backyard, by Margaret D. Jenks: Geological Society of America’s Penrose Conference on Large Lake Systems and Their Stratigraphic Record, Lake Tahoe, California, September.

Mineral Resources and Idaho Mining, by Virginia S. Gillerman: Physical geology class, Boise State University, Boise, April.


Petriified Wood and Fossil Forests, by Roy M. Breckenridge: Third grade class, Genesee Public School, Genesee, May.

Physiographic Development of the Palouse, by Kurt L. Othberg: Idaho Geology Field Workshop, August.


Proterozoic and Cretaceous Plutons in the Elk City Area, Idaho, and Their Relationship to Cretaceous Deformation, by Reed S. Lewis, Russell P. Burnmester, and Joe D. Dragovich: Geologic Society of America Rocky Mountain and South-Central Section Meeting, Albuquerque, New Mexico, April.
Rapid Visual Screening of Buildings for Potential Seismic Hazards: Use of Applied Technology Council Publication 21, by Roy M. Breckenridge: Geology class, University of Idaho, November.


Rocks and Minerals and Idaho Mining, by Virginia S. Gillerman: talks to eight classes in various Boise area schools, February-April.


Structures in the Elk City, Idaho Region and Their Relationship to the Tresta-Challis Fault System, by Reed S. Lewis and Earl H. Bennett: Poster session at Tobacco Root Geology Society field conference, Salmon, August.


Professional Activities

15th International Geochemical Exploration Symposium, Reno, Nevada, April (V.S. Gillerman).

27th Engineering Geology and Geotechnical Engineering Symposium, Logan, Utah, April (J.A. Welhan).

Advisory Board meeting, Idaho Geological Survey, November (staff).

Awarded Ph.D. in geology, University of Idaho, May (K.L. Othberg).

Board meeting, Idaho Science Teachers Association, Boise, August (K.L. Othberg).

Board meeting, Idaho Earth Science Teachers Association, Nampa, October (K.L. Othberg).

Chair, American Institute of Mining, Metallurgical and Petroleum Engineers' Krumbl Committee (R.W. Bartlett).

Chair, College of Mines and Earth Resources/Idaho Geological Survey Instruments committee (C.R. Knowles).

Co-chair, ad hoc steering committee to develop a proposal for a sample preparation laboratory, Idaho State University (I.A. Welhan).


Co-leaders, 1-day field trip in the Bruneau Hot Springs area for personnel from the Idaho Department of Water Resources, May (B. Bonnichsen, M.D. Jenks).
tober (M.D. Jenks).

Leader, geology and soils of Boise Valley terraces field trip, Boise Valley, Idaho Science Teachers Association, October (K.L. Othberg).

Leader, Idaho Geology Field Workshop, Moscow, July and August (K.L. Othberg).

Member, American Geophysical Union (J.A. Welhan).

Member, American Institute of Mining, Metallurgical and Petroleum Engineers (AIME), Boise Section (V.S. Gillerman).

Member, Board of Directors, The Metallurgical Society (immediate past president; chair of nominating committee) (R.W. Bartlett).

Member, College of Mines and Earth Resources’ advisory board, University of Idaho (E.H. Bennett).

Member, committee for undergraduate and graduate degree programs in earth science, University of Idaho (K.L. Othberg).

Member, Idaho Association of Professional Geologists, Boise Chapter (V.S. Gillerman).

Member, Idaho Science Teachers Association (M.D. Jenks).

Member, Northwest Mining Association’s centennial planning committee (E.H. Bennett).

Member, Representative Larry LaRocca’s silver advisory committee (E.H. Bennett).

Member, search committee for the surficial processes/environmental geology faculty position, University of Idaho (R.M. Breckenridge).

Member, Society of Economic Paleontologists and Mineralogists (V.E. Mitchell).

Members, Association of Earth Science Editors (M.D. Jenks, R.C. Stewart).


Members, Geological Society of America (E.H. Bennett, B. Bonnichsen, V.S. Gillerman, R.S. Lewis, V.E. Mitchell).

Members, Northwest Mining Association (E.H. Bennett, R.S. Lewis).

Members, Society of Economic Geologists (B. Bonnichsen, V.S. Gillerman).

Non-Point Source Pollution Conference, Tacoma, Washington, March (J.A. Welhan).


Northwest Science Symposium, Boise, March (V.S. Gillerman).

Officer, Belt Association (E.H. Bennett).


Penrose Conference on Large Lake Systems and Their Stratigraphic Record, Lake Tahoe, California, September (M.D. Jenks).

Representative, Boise State University’s Department of Geology and Geophysics (V.S. Gillerman).

Representative, Earthquake Engineering Research Institute (R.M. Breckenridge).

Representative for state on the radon committee of the Association of American State Geologists (C.R. Knowles).

Representative, Idaho Geographic Information Advisory Committee meeting, Boise, November (V.S. Gillerman).

Representative, Idaho Natural Resources Roundtable, Boise (V.S. Gillerman).

Representative, Pocatello city geographical information systems planning meetings, Idaho State University Geology Department (J.A. Welhan).

Representative, University of Idaho’s Department of Geology and Geological Engineering (R.M. Breckenridge).

Review panel on accreditation of asbestos laboratories, National Institute of Standards and Technology, Long Beach, California (C.R. Knowles).

Session co-chair, American Geophysical Union, Annual Northwest Section Meeting, Richland, Washington, September (R.M. Breckenridge).

Short course on copper heap leach, Society of Metallurgical Engineers, Tucson, Arizona, December (R.W. Bartlett).


Steering committee, National Earthquake Hazard Reduction Program school project Idaho (R.M. Breckenridge).


Technical expert for asbestos accreditation, National Institute of Standards and Technology (C.R. Knowles).

Trustee, American Institute of Mining, Metallurgical and Petroleum Engineers (AIME) (R.W. Bartlett).


Tobacco Root Geological Society, 15th Annual Field Conference, Geology and Ore Deposits of the Trans-Challis Fault System, Salmon, August (V.S. Gillerman, R.S. Lewis).


U.S. Forest Service Validity Exams, Gospel Hump Wilderness, July (V.S. Gillerman).


Wetlands Conference, Boise, February (V.S. Gillerman).

XIII Annual Western States Seismic Policy Council Meeting, Anchorage, Alaska, November (R.M. Breckenridge).

Graduate Thesis Committees

Troy Buenneke, M.A., History, University of Idaho (E.H. Bennett).
Ray Cheff, M.S. Geology, University of Idaho (R.M. Breckenridge).
Andrew Hilt, M.S., Geophysics, University of Idaho (R.M. Breckenridge).
Douglas Jones, M.S., Geological Engineering, University of Idaho (R.M. Breckenridge).
Jon Kaminsky, M.S., Geology, Idaho State University (J.A. Welhan).
Gary Kindel, M.S., Geology, Idaho State University (J.A. Welhan).
Tim Mihuc, Ph.D., Biology, Idaho State University (J.A. Welhan).
Victoria E. Mitchell, Ph.D., Geology, University of Idaho (E.H. Bennett).
Wayne Pudney, M.S., Geology, Idaho State University (J.A. Welhan).

Grants and Contracts

Earthquake information brochure: K.L. Othberg and R.M. Breckenridge (National Earthquake Hazard Reduction Program, Idaho Bureau of Disaster Services, $4,000).

Geologic mapping of nineteen 7.5-minute quadrangles in the Bannack Hot Springs area, Owyhee County: B. Bonnichsen (Idaho Department of Water Resources, $405,000).


In situ vitrification, product characterization analysis: C.R. Knowles (Idaho National Engineering Laboratory, $20,500).


FUNDING AND BUDGET

State funding for the Survey rose from $445,600 last year to $477,500 in FY-91. The Legislature had rejected in FY-90 the agency's salary parity request which sought to bring the professional salaries in line with the University of Idaho's faculty salaries. The 7 percent increase in the budget was, however, adequate for sustaining the existing programs.

Funds obtained from grants and contracts totaled $633,300. This amount breaks the record set last year of $567,000. In the last three years the Survey has brought to the state over $1.7 million. For the time this substantial funding has been available, the Survey has undertaken significant research in the state's interest. The FY-91 amount is $155,800 more than the general state appropriation and puts the agency in the ranks of the top ten state surveys nationwide in obtaining outside funds. The Idaho Initiative Mapping Project ($450,000) finished its second year, and the two-year contract ($103,000) with the Idaho Department of Water Resources completed its first year. Smaller contracts with the Idaho National Engineering Laboratory, the U.S. Geological Survey (COGEO Map), and the Bureau of Disaster Services (NEHRP) also contributed to the total.

Recent Budget History — Fiscal Years 1987-1991

<table>
<thead>
<tr>
<th>FISCAL YEAR</th>
<th>FY-87</th>
<th>FY-88</th>
<th>FY-89</th>
<th>FY-90</th>
<th>FY-91</th>
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<tr>
<td>Personnel</td>
<td>$250,300</td>
<td>$275,500</td>
<td>$350,400</td>
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<td>Operating Expenses</td>
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<td>Capital Outlay</td>
<td>—</td>
<td>8,000</td>
<td>8,000</td>
<td>*</td>
<td>*</td>
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<tr>
<td>TOTAL</td>
<td>$307,400</td>
<td>$333,600</td>
<td>$417,300</td>
<td>$445,600</td>
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* $10,000 in Capital Outlay authorized from sales savings.

Overview of Grants and Contracts — Fiscal Year 1991

<table>
<thead>
<tr>
<th>FUNDING AGENCY</th>
<th>PROJECT/ITEM</th>
<th>AMOUNT</th>
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</thead>
<tbody>
<tr>
<td>Bureau of Disaster Services</td>
<td>National Earthquake Hazards Reduction Program (NEHRP)</td>
<td>$33,500</td>
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<tr>
<td>Idaho Department of Water Resources</td>
<td>Geologic mapping</td>
<td>$103,000</td>
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<td>Idaho National Engineering Laboratory</td>
<td>In situ verifications</td>
<td>$20,300</td>
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<td></td>
<td>glass analysis</td>
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<td>Lynn Research and Consulting, Inc.</td>
<td>Plasma-sputtered coatings on alloys</td>
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<td>U.S. Geological Survey</td>
<td>Idaho Initiative Geologic Mapping Project</td>
<td>$450,000</td>
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<tr>
<td></td>
<td>Boise, COGEO Map</td>
<td>$25,000</td>
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<tr>
<td>TOTAL</td>
<td></td>
<td>$633,300</td>
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</table>
IDAHO GEOLOGICAL SURVEY ENABLING ACT
SENATE BILL 1269—47th IDAHO LEGISLATURE, 2nd REGULAR SESSION—1984

47-201. GEOLOGICAL SURVEY CREATED—PURPOSE—ADVISORY BOARD. There is hereby created the Idaho geological survey, to be administered as a special program at the university of Idaho under the authority of the board of regents of the university of Idaho. This survey will conduct business hereof carried out by the Idaho bureau of mines and geology. The survey shall be the lead state agency for the collection, interpretation, and dissemination of geologic and mineral data for Idaho. Such information is to be acquired through field and laboratory investigations by the staff of the survey and through cooperative programs with other governmental and private agencies. There is hereby established an advisory board for the survey, consisting of the following members: The dean of the college of mines and earth resources of the university of Idaho, who shall be director of the survey and board chairperson (nonvoting); the chairman of the department of geology at Boise state university; the chairman of the department of geology at Idaho state university; the president of the Idaho mining association, or long as said association continues to exist and elect a president; the governor of the state of Idaho or his designated representative; a member of the board of land commissioners designated by the state land board; the president or his designee of the Idaho association or professional geologists; and two (2) members at large selected by the director from other state or federal organizations, or from the private sector with a direct interest in the survey's programs, both serving two (2) year staggered terms; all of whom shall serve as members of the said board and shall be compensated as provided by section 59-509(3), Idaho Code.

47-202. MEETINGS—OFFICE—STATE GEOLOGIST. The advisory board shall hold annual meetings at the university of Idaho, Boise state university or Idaho state university on the first Monday of June of each year and such other meetings as it may determine. The chief office of said survey and the office of its secretary shall be maintained at the university of Idaho. The director of the survey, or a professional geologist in the survey if so appointed by the director, is designated state geologist.

47-203. DUTIES—PUBLICATIONS—COOPERATION WITH OTHER AGENCIES—SATELLITE OFFICES. It shall be the duty of the said state survey to conduct statewide studies in the field, laboratory studies; prepare and publish reports on the geology and mineral resources of the state; maintain laboratory facilities to perform noncommercial mineral and chemical analyses; fix a price upon printed reports not used in exchange with other state boards or surveys, universities or public libraries, and deposit receipts from sales in a printing fund to be used for the preparation and publication of reports of the survey, and for no other purpose. The survey shall be allowed to seek and accept funded projects from and cooperate programs with other agencies for support of the survey's research and service activities as authorized by the board of regents. All funds received from these projects shall be used for said projects and services. The survey shall be allowed to have satellite offices at the geology departments of Boise state university and Idaho state university.

47-204. REPORTS. The state geological survey shall annually, on or before the first day of January, make to the governor of the state and to the president of the university of Idaho a report detailing major events during the previous year concerning the geology and mineral resources of the state, a report of its expenditures and of the work of said survey during the preceding year, and budget requests for the following year, and it shall make a similar report of its doings and its expenditures to the state legislature through the legislative council.
Advisory Board
Office of the Governor, Cecil D. Andrus .............................................. Governor
                                   David Hawk, representative
Stanley Hamilton ............................................................... Director, Idaho Department of Lands
Paul Karl Link ................................................................. Chairman, Department of Geology, Idaho State University
Jack Lyman ................................................................. President, Idaho Mining Association
L. Leroy Mink ................................................................. Representative, Idaho Association of Professional Geologists
Clayton R. Nichols ............................................................ Idaho National Engineering Laboratory
Darrell G. Waller ............................................................... State Coordinator, Bureau of Disaster Services
Monte Wilson ................................................................. Chairman, Department of Geology and Geophysics, Boise State University
Robert W. Bartlett .......................................................... Director, ex officio

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Earl H. Bennett ............................................................... Associate Director and State Geologist
Roger C. Stewart .......................................................... Editor
Ann G. Killen ............................................................... Publications Assistant
Charlotte D. Fullerton .................................................. Secretary/Account Technician
Dreaucine C. Bonner ..................................................... Secretary/Program Coordinator
Cindy L. Bogar ................................................................. Receptionist/Technical Assistant
Pam Sinclair ................................................................. 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
John A. Welhan ............................................................. Research Hydrogeologist/Environmental Geology-Pocatello

Project Research Staff (State or Federally Funded)
Cindy L. Bogar ................................................................. Pam Sinclair
Daryle R. Fairclough ..................................................... Mary E. Huett
Craig D. Hall ................................................................. Margaret D. Jenks
Andrew P. Hilt ............................................................... Reed S. Lewis
William H. Hilt ............................................................... JoAnn Long
               ................................................................. Victoria E. Mitchell
               ................................................................. Lori D. Snyder
               ................................................................. Loudon R. Stanford
               ................................................................. Ruth E. Vance

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Design, Illustration, Layout, and Typography ............................................ Ann G. Killen
Photography ............................................................. University of Idaho Photographic Services
Printer ................................................................. University of Idaho Printing and Design Services