

OF THE
ARIZONA
GEOLOGICAL SURVEY

Fiscal Year 1990-91

(July 1, 1990 - June 30, 1991)

ARIZONA GEOLOGICAL SURVEY
OPEN-FILE REPORT

91 - 12

Prepared by

Larry D. Fellows

Director and State Geologist

and the staff of the Arizona Geological Survey

This report is preliminary and has not been edited or reviewed for conformity with Arizona Geological Survey standards

Cover illustration: Detailed map of flow patterns and water depths during a recent, large, alluvial-fan flood near the Tortolita Mountains in southern Arizona. The direction of water flow is indicated by arrows. Water depths ranging from less than 10 centimeters (4 inches) to greater than 1 meter (3.2 feet) are depicted by increasingly darker shades; the deepest floodwaters recorded in this area were approximately 1.5 meters (5 feet) deep. Geologists from the Arizona Geological Survey are analyzing this flood to increase the understanding of alluvial-fan flooding processes and to improve the assessment of flood hazards in piedmont areas of Arizona.



Fife Symington
Governor

State of Arizona
Arizona Geological Survey

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Larry D. Fellows
Director and State Geologist

August 18, 1991

The Honorable Fife Symington
Governor
State Capitol, West Wing
1700 West Washington
Phoenix, AZ 85007

Dear Governor Symington:

I submit this annual report of the Arizona Geological Survey for FY 1990-91 with pride. Projects and activities summarized within represent our efforts to achieve the following objectives:

1. To describe and map the character and distribution of rocks and rock-derived materials, with emphasis on urban and developing areas;
2. To identify and assess potential geologic hazards and limitations to development, such as land subsidence, earth fissures, earthquakes, and floods;
3. To determine the relationships between mineral and energy resources and the geologic framework;
4. To make geologic information available to users through a comprehensive computerized system; and
5. To provide objective, scientific information that will be used by the legislature, government agencies, industry, and the public in making prudent land- and resource-management decisions.

Rapid population growth and greater competition for land, water, mineral, and energy resources make attainment of these objectives increasingly important. We are committed to making additional progress in fulfilling these objectives and serving Arizonans more effectively during your tenure as Governor.

Sincerely yours,

Larry D. Fellows, Ph.D.
Director and State Geologist

EXECUTIVE SUMMARY

Information requested. Information and assistance were provided to more than 3,900 persons who wrote, telephoned, or visited the Arizona Geological Survey (AZGS) to buy publications, use the library, or confer with geologists. Information was requested by 68 government agencies, 67 universities, 36 elementary and secondary schools, more than 150 companies, and many individuals. Publication sales totaled \$34,485.

Publications released. Two reports, 2 geologic maps, and 4 12-page issues of *Arizona Geology* were published; 8 open-file reports and 10 contributed reports and maps were released; and 9 reports and maps were completed and submitted for review prior to release. In addition, other professional groups published 10 articles that were written by AZGS geologists.

Cooperative projects. Cooperative projects were undertaken with the Arizona Department of Commerce (Energy Office), Arizona Department of Environmental Quality, Arizona Geological Society, Arizona Radiation Regulatory Agency, Flood Control District of Maricopa County, U.S. Bureau of Land Management, U.S. Bureau of Reclamation, U.S. Environmental Protection Agency, and U.S. Geological Survey. Funding or material support was received for most of these projects. A total of \$109,741 was spent on contracted projects.

Geologic mapping. Geologic mapping projects were completed in the Gila Bend, Huachuca, Little Horn, Tortolita, and White Tank Mountains and the Bouse Hills.

Geologic hazards assessment. Staff geologists investigated potential flood hazards in piedmont areas of the Tortolita and White Tank Mountains, subsidence and earth fissures near Eloy, debris flows along the east side of the Huachuca Mountains, and potential radon hazards in portions of northern Arizona.

Mineral- and energy-resource studies. A report and map describing energy resources of Arizona were released. The mineral resources of the Bouse Hills were documented and described. Work began on a report that will focus on many of the mineral deposits in west-central Arizona.

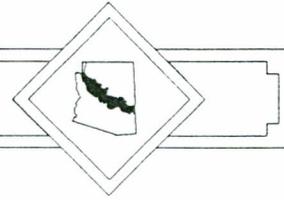
Total expenditures. Expenditures totalled \$705,961, with 80 percent coming from General Revenue, 15.5 percent from contracted projects, and 4.5 percent from the printing revolving fund. The projects and activities described in this report were done with 13.25 full-time-equivalent State-funded employees and 10 part-time, temporary employees paid with external funding.

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Overview



The AZGS has two major responsibilities: to **conduct investigations** and to **provide information and assistance**. Studies of the geologic framework, geologic hazards and limitations, and mineral and energy resources are conducted and data are compiled. Major projects and activities undertaken during Fiscal Year 1990-91 are described below. An itemized list of completed reports and maps is given on pages 8 and 9.

GEOLOGIC FRAMEWORK, MAPPING, AND DATABASE

AZGS geologists study Arizona's geologic setting or framework, including the age, origin, distribution, and character of rocks and rock-derived materials, such as gravel, sand, and clay. Information derived from these studies is added to the Arizona Geologic Information System and is made available to government agencies, industry, and the public on request. This information is used by those who manage State Trust and Public lands; site, plan, construct, operate, and maintain major water-supply, waste-disposal, residential, industrial, transportation, and other facilities; and explore for and extract metallic, nonmetallic, and energy resources.



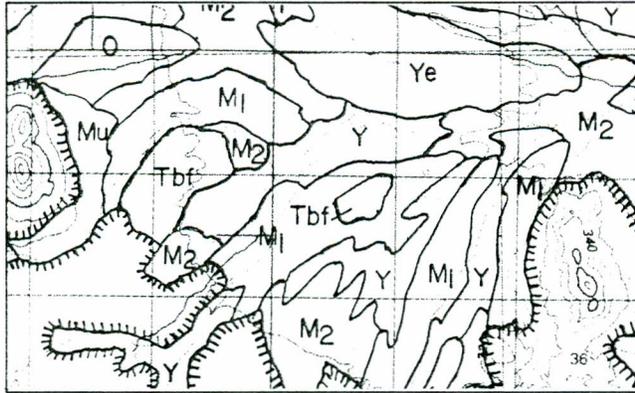
West-central Arizona. Detailed geologic mapping continued in the Phoenix 1° x 2° quadrangle, which extends west from Phoenix almost to Quartzsite and south from Wickenburg to Gila Bend. For the seventh consecutive year, mapping was done as part of the Cooperative Geologic Mapping Program, a 50-50 matched-funding program between the U.S. Geological Survey and individual State geological surveys.

The U.S. Bureau of Land Management provided color aerial photographs that were used to prepare the maps.

Maps of the bedrock and surficial geology of the Little Horn 15' quadrangle (1:62,500 scale) and surficial geology of the Little Horn Mountains 30' x 60' quadrangle (1:100,000 scale) were released. A bedrock geologic map of the Bouse Hills (1:24,000 scale) was also completed and released. The 1:24,000-scale open-file map of the Granite Wash Mountains was prepared for publication in color and is in press. A compilation of the Phoenix North quadrangle (1:100,000 scale), which incorporates mapping from the last four field seasons, is in preparation. New mapping was completed in the eastern and central Gila Bend Mountains. Preliminary maps are being prepared for release.

Surficial geologic mapping. Surficial geologic maps show potential geologic hazards and limitations, give information about the character of the substrate, and depict the recent geologic history within the area. These maps are used by land-management agencies, private consultants, and the public to evaluate potential hazards and limitations to development.

Urban and developing areas are being mapped at large scale (1:24,000) and less populated areas at intermediate scale (1:100,000). Large-scale



Surficial geologic map of part of the Little Horn 30' x 60' quadrangle in southwestern Arizona. Maps such as these allow geologists to interpret landforms and evaluate geologic hazards, such as flooding, debris flows, and soil-related problems. From AZGS Open-File Report 90-8.

mapping is being conducted in the Sierra Vista area, with the support of the Cochise County Flood Control District and the U.S. Forest Service. Similar large-scale mapping of the area around the White Tank Mountains west of Phoenix, partially funded by the U.S. Geological Survey, is nearly completed. Intermediate-scale mapping of the Phoenix 1° x 2° quadrangle has been completed.

Bibliography of the geology and mineral resources of Arizona. A database containing nearly 12,000 entries is in advanced stages of completion. An alphabetical list of references, by author, will be released soon. This list will replace the current list that contains about 4,500 references. Another 10,000 references have been entered into the system, but have not yet been formatted properly.

Carefree Basin report. A report on the geology of the Carefree Basin was published. The project incorporated the work of Peter Doorn, a graduate student at Arizona State University (ASU); Dr. Troy L. Péwé, his faculty advisor, who had previously mapped the geology of much of the area; and other ASU graduate students. Funding was provided by the State Land Department, Arizona Department of Environmental Quality, ASU, the city of Scottsdale, the towns of Carefree and Cave Creek, Desert Mountain Properties, and the Foothills Community Foundation.

GEOLOGIC HAZARDS AND LIMITATIONS

AZGS geologists investigate geologic processes and materials that are either potentially hazardous or that may limit the use of land, water, mineral, and energy resources. Flooding, earthquakes, land subsidence and fissuring, caliche, thin soil cover, and some clay soils are included in this category. If the distribution and character of geologic materials and processes are known, potentially adverse impacts may be considered during the early stages of planning.

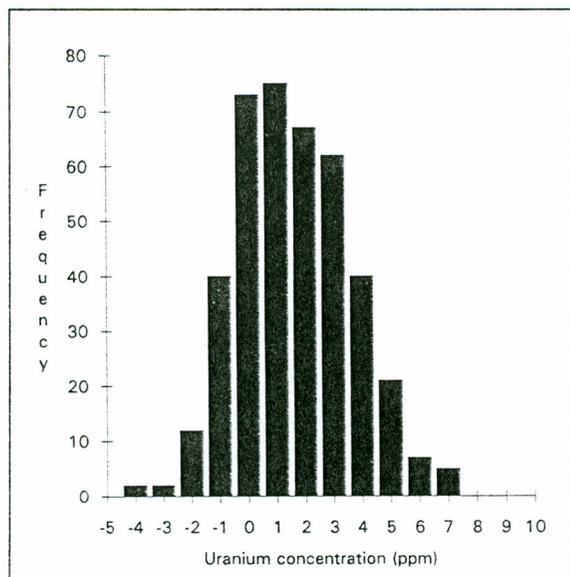
Analysis of flood hazards in piedmont areas. Potential flood hazards in piedmont areas may be identified and analyzed by using geologic data. Areas with significant flood hazards on the piedmont of the Tortolita Mountains (northwest side of Tucson, Pima County) were delineated, with close cooperation and funding from the Pima County Flood Control District. A similar project was undertaken around the White Tank Mountains (on the west side of Phoenix, Maricopa County) with the support of the Flood Control District of Maricopa County and the Arizona Department of Water Resources. AZGS staff are continuing a detailed analysis of water depths and velocities during a recent alluvial-fan flood on the Tortolita piedmont to learn more about the nature of flood hazards on piedmonts. Open-file reports summarizing studies of the Tortolita and White Tank piedmonts are nearing completion, and an AZGS bulletin detailing studies on the Tortolita Mountains is planned for the coming year.



Piedmont southwest of the Tortolita Mountains in southern Arizona. The light-colored area in the center of the photo is the path followed by runoff from the mountains during a recent, large, alluvial-fan flood. The cover illustration of this report is a detailed map of a small section of this flood.

Subsidence and earth fissures. The AZGS has a program to map and analyze earth fissures, which form as a result of ground-water withdrawal and subsidence and pose a significant hazard to buildings, highways, canals, and other structures. Fissures also provide possible avenues for pollutants to reach ground-water supplies. A comprehensive bibliography of earth fissures and subsidence in Arizona was completed, for which the U.S. Bureau of Reclamation provided partial funding. The AZGS also completed detailed mapping of earth fissures and assessment of the potential for damage to the Central Arizona Project canal and related canals near the Picacho Mountains in south-central Arizona.

Potential for ground-water contamination. A project to compile maps that will be used to assess the potential for ground-water contamination in Pinal County was initiated. It is funded by the U.S. Environmental Protection Agency through the Arizona Department of Environmental Quality.



Histogram of gamma-ray spectrometer uranium assays of nonanomalous rocks in Arizona. These data, compiled from several hundred measurements, reveal the typical range of uranium concentrations in most populated areas of Arizona. Based on these data, AZGS geologists inferred that geologic materials with uranium concentrations above 6 ppm were anomalous. Buildings in areas with anomalous concentrations of uranium are more likely to contain hazardous concentrations of radon. From AZGS Open-File Report 91-2.

Uranium concentrations. Rocks in small areas of the State contain natural uranium concentrations that are higher than normal. Because radon gas is generated by the natural decay of uranium, it is more likely that indoor radon concentrations will be elevated in some buildings that have been constructed within those areas. A project to identify the areas in which rocks have higher-than-normal concentrations of uranium is being done in cooperation with the Arizona Radiation Regulatory Agency and U.S. Environmental Protection Agency.

Advisory committee recommendations. The Environmental and Engineering Geology Advisory Committee was asked to recommend which types of projects and activities should, in their judgment, be given highest priority by the AZGS. Their recommendations are as follows: assess-

ment of Arizona's natural hazards, earth science education, computerized geologic database, and well cores and cuttings repository. These recommendations, published in the Winter 1990 issue of *Arizona Geology*, will serve as guides in choosing future projects and in setting priorities.

MINERAL AND ENERGY RESOURCES

AZGS geologists prepare geologic maps and undertake field studies to determine the relationships between mineral deposits and the geologic framework. The information that is obtained is used by the stewards of State Trust, Public, and private lands to assess mineral-resource potential and by mineral-exploration geologists and prospectors to identify potential exploration target areas. Mineral- and energy-resource data are incorporated into the Arizona Geologic Information System.

Mineral deposits of west-central Arizona. Reports on the geology and mineral resources of the northern Plomosa mineral district and the Bouse Hills were completed and placed on open file. Investigations of mineral deposits in the Harcuvar, Little Harquahala, and Vulture Mountains were also completed. Work began on a bulletin that will contain a collection of technical articles on many of the mineral deposits of west-central Arizona, including those mentioned above.

More than 1.3 million ounces of gold, with a total value at today's prices of more than \$500 million, were mined from west-central Arizona prior to 1980. In 1987 the Copperstone mine (La Paz County) began production. It will eventually yield more than 400,000 ounces of gold worth nearly \$150 million. The Copperstone deposit was only recently discovered because it is largely concealed beneath young surficial deposits.

During the past 10 years, the AZGS has focused its studies of bedrock geology and metallic mineral resources on west-central Arizona. Many new detailed geologic maps of parts of that area, which had not been previously studied in detail, have been published or placed on open file. It is now possible to interpret more accurately how alteration zones, mineralization, and mineral deposits are related to the geologic framework. On the basis of past mineral production, the newly completed geologic maps, and an improved understanding of the relationships between mineralization and the geologic framework, AZGS geologists believe that west-central Arizona has significant mineral-resource potential. The bulletin being prepared will address this potential.

Energy resources of Arizona. *Energy Resources of Arizona* was completed and released. This report is the first in the new Down-to-Earth Series, in which geologic concepts and information will be presented to nontechnical audiences. The project was done cooperatively with the Energy Office of the Arizona Department of Commerce, which provided partial funding.

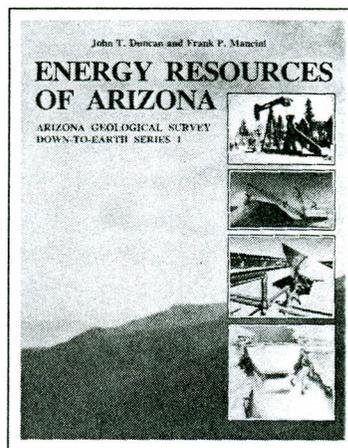
Advisory committee recommendations. The Mineral Resources Advisory Committee was asked to specify the types of projects and activities that should be given highest priority by the AZGS to remain consistent with the enabling legislation. They recommended the following: detailed geologic mapping, the computerized geologic database and library, urban-area and remote-subdivision studies and mapping, earth-science education, mineral-district studies, and repository for rock cuttings and cores. Their recommendations, published in the Spring 1991 issue of *Arizona Geology*, will be used to assist the AZGS in selecting future projects and in setting priorities.

INFORMATION AND ASSISTANCE

Information derived from original investigations is added to databases, published in reports and maps, and provided to the public in talks, field trips, reviews, displays, letters, and telephone conversations and during office visits. Primary recipients of this information and assistance are employees of government agencies, mineral exploration and mining companies, and geotechnical consulting firms; members of professional societies; university faculty members and graduate students; earth science teachers and students; and the general public.

Information requested. Geologic information and assistance are requested by individuals who telephone, write, or visit the AZGS office to purchase publications, use the library and data files, and confer with geologists. More than 3,900 requests for information or assistance were recorded. Groups that requested information or assistance are listed on pages 10 to 13.

Publications released. The following publications were released by the AZGS during the year: *Energy Resources of Arizona (Down-to-Earth Series 1)*, *Energy Resources Map of Arizona (Map 28*, included in Down-to-Earth Series 1, but also sold separately), *Geologic Map of the Little Horn Mountains 15' Quadrangle (Map 29)*, *Geologic and Gravimetric Investigations of the Carefree Basin, Maricopa County, Arizona (Special Paper 8)*, eight reports and maps in the Open-File series, seven maps in the Contributed Map series, three reports in the Contributed Report series, and four 12-page issues of *Arizona Geology*. In addition, 10 articles were published in professional journals and other non-AZGS publications, and 9 reports or maps were completed and submitted for review. A complete list of items published or submitted for review is given on pages 8 and 9.



Talks, field trips, and reviews. AZGS geologists gave 13 talks, led 13 field trips, and reviewed numerous manuscripts and funding proposals. They assisted graduate students from universities in Arizona and elsewhere who were working on Arizona-related thesis projects. AZGS geologists also represented the agency as members of numerous professional organizations and committees.

REVENUE AND EXPENDITURES

State appropriation. The General Revenue appropriation was \$565,400, which was reduced to \$564,400 at midyear. A total of 13.25 full-time-equivalent positions were authorized.

To reduce expenditures from General Revenue, the legislature combined the Oil and Gas Conservation Commission (OGCC) with the AZGS, effective July 1, 1991. The OGCC (agency) was abolished, but the Commission, the five-member governing board, was continued and will set policy for oil and gas regulatory activities, as it has in the past.

An organization chart and list of employees, together with their major duties, are included on pages 14 and 15. State appropriation expenditures are summarized on page 16.

Printing and publications. Publication sales totaled \$34,485 during FY 1990-91, compared with \$37,156 in FY 1989-90 and \$35,412 in FY 1988-89. Expenditures totaled \$31,820.

Contracted projects. Statutes authorize the State Geologist to enter into cooperative agreements with Federal, State, and local agencies and groups to carry out projects that are consistent with the AZGS mission. Such projects are undertaken if the AZGS has qualified persons to direct them and if results of the projects can be made available to the public. Most of the projects are done on a matched funding or service basis.

During FY 1990-91 the AZGS conducted cooperative projects with, or received material support from, the Arizona Department of Commerce (Energy Office), Arizona Department of Environmental Quality, Arizona Geological Society, Flood Control District of Maricopa County, U.S. Bureau of Land Management, U.S. Bureau of Reclamation, U.S. Environmental Protection Agency (through the Arizona Radiation Regulatory Agency), and U.S. Geological Survey. A total of \$109,741 was spent on these projects, and nine persons were employed on a temporary or part-time basis for the duration of the project. Details of expenditures on the specific contracted projects are given on page 17.

Cathy S. Wellendorf Memorial Fund. The balance in the fund at the end of FY 1990-91 was \$9,557. Guidelines for use of the fund were established.

Rock cuttings and core repository fund. The Homestake Mining Company and Magma Copper Company each contributed \$1,000 to the AZGS for maintenance of the repository and related activities. ASARCO contributed 500 core boxes.

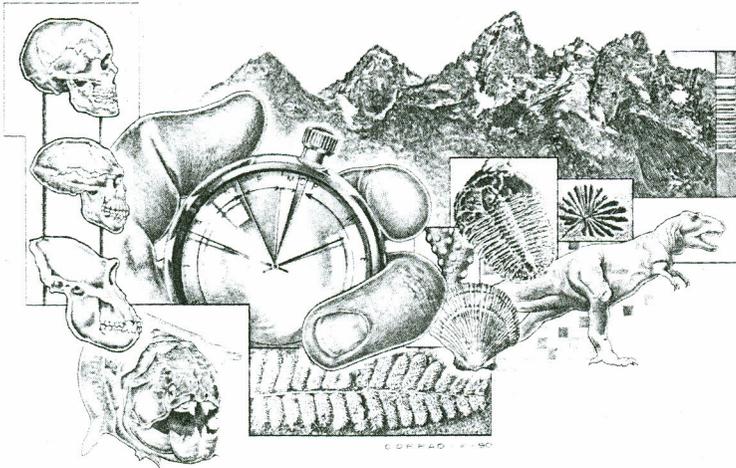
Total expenditure. Combined expenditure from General Revenue, the printing revolving fund, and contracted projects was \$708,626, of which 80 percent was from General Revenue.

Investigations Completed



ARIZONA GEOLOGICAL SURVEY PUBLICATIONS RELEASED

- Down-to-Earth Series 1: Energy resources of Arizona: **J.T. DUNCAN** and **F.P. Mancini**, 1991, 17 p.; includes Map 28.
- Map 28: Energy resources map of Arizona: **J.T. DUNCAN**, 1990, scale 1:1,000,000; included in Down-to-Earth Series 1, but also available separately.
- ___ 29: Geologic map of the Little Horn Mountains 15' quadrangle: **M.J. GRUBENSKY** and **K.A. DEMSEY**, 1991, 10 p., scale 1:62,500.
- Special Paper 8: Geologic and gravimetric investigations of the Carefree Basin, Maricopa County, Arizona: **P.L. Doorn** and **T.L. Péwé**, 1991, 187 p., scale 1:24,000 and 1:48,000, 10 plates.
- Open-File Report 90-5: Map showing areas in Arizona with elevated concentrations of uranium: **J.E. SPENCER**, **J.D. SHENK**, and **J.T. DUNCAN**, 1990, scale 1:1,000,000.
- ___ 90-6: Controls on the origin and recurrence of debris flows in the Huachuca Mountains, southeastern Arizona: **E.E. Wohl** and **P.A. PEARTHREE**, 1990, 48 p.
- ___ 90-7: Bibliography on Arizona earth fissures and related subsidence, with selected references for other areas: **S. SLAFF**, 1990, 28 p.; also available on computer disk.
- ___ 90-8: Geologic map of Quaternary and upper Tertiary alluvium in the Little Horn 30' x 60' quadrangle: **K.A. DEMSEY**, 1990, scale 1:100,000.

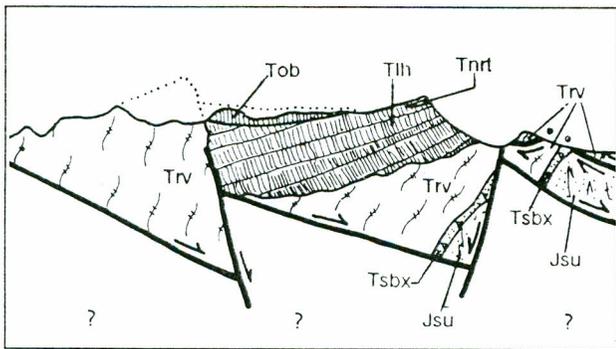


AZGS geologists rely on several relative and absolute dating techniques, such as those based on fossils, paleomagnetism, and radioactive decay, to determine the ages of rocks and the order of geologic events. From Arizona Geology (v. 20, no. 4).

- ___ 90-9: Geology and mineral resources of the Bouse Hills, La Paz County, west-central Arizona: **J.E. SPENCER** and **S.J. REYNOLDS**, 1990, 21 p., scale 1:24,000.
- ___ 90-10: The geology and mineral deposits of the northern Plomosa mineral district, La Paz County, Arizona: **J.T. DUNCAN**, 1990, 55 p., scale 1:9,318.
- ___ 91-2: A survey of uranium concentrations in rocks and soils in populated areas in Arizona -- Methods: **J.T. DUNCAN** and **J.E. SPENCER**, 1991, 9 p.
- ___ 91-3: Uranium-bearing rocks of Verde Valley, Coconino and Yavapai Counties, Arizona, and implications for indoor-radon gas: **J.T. DUNCAN** and **J.E. SPENCER**, 1991, 11 p., scale 1:32,000, 2 plates.

Articles in Arizona Geology

- Earth science education in Arizona's high schools: **L.D. FELLOWS**, 1990, v. 20, no. 3, p. 4-6.
- The Toroweap fault: One of the most active faults in Arizona: **G.W. JACKSON**, 1990, v. 20, no. 3, p. 7-10.
- How geologists tell time, part I: Introduction and relative dating techniques: **E.M. VANDENDORER**, 1990, v. 20, no. 4, p. 1-6.
- Tonto Natural Bridge, Arizona's newest State park: A 33-year effort: **C.A. Steenerson**, 1990, v. 20, no. 4, p. 7-8.
- ___: The first 1.7 billion years: **L.D. FELLOWS**, 1990, v. 20, no. 4, p. 8-10.
- Recommendations on environmental and engineering geology activities: Environmental and Engineering Geology Advisory Committee to the Arizona Geological Survey, 1990, v. 20, no. 4, p. 11.
- How geologists tell time, part II: Absolute dating techniques: **E.M. VANDENDORER**, 1990, v. 21, no. 1, p. 1, 6-11.
- Making a profession professional: **S.K. Bollin** and **L.D. FELLOWS**, 1990, v. 21, no. 1, p. 2.
- Recommendations on mineral resource activities: Mineral Resources Advisory Committee to the Arizona Geological Survey, 1990, v. 21, no. 1, p. 3-4.
- The Arizona Desert Wilderness Act of 1990: **L. Bauer**, 1990, v. 21, no. 1, p. 5.
- The nonfuel mineral industry of the Southwest: 1990 summary: **M.N. Greeley**, 1990, v. 21, no. 2, p. 1-5.
- Industrial minerals in daily life: **H. McVey**, 1990, v. 21, no. 2, p. 6-7.
- Theses and dissertations, 1990: **N. SCHMIDT**, 1990, v. 21, no. 2, p. 8-9.



Cross section of part of the Little Horn Mountains. AZGS geologists have mapped this range to understand the geologic evolution and known mineral deposits of the region. From AZGS Map 29.

OUTSIDE PUBLICATIONS RELEASED

American Society of Civil Engineers: Application of geological information to Arizona flood hazard assessment: V.R. Baker, **K.A. DEMSEY**, L.L. Ely, J.E. Fuller, **P.K. HOUSE**, J.E. O'Connor, **J.A. ONKEN**, **P.A. PEARTHREE**, and **K.R. VINCENT**, 1990, Proceedings, p. 621-626.

Arizona Geological Society: Field guide to the New Waddell Dam site, Vulture-Hieroglyphic Mountains area, and Mystic, Clementine, Newsboy, and Yarnell gold deposits, central Arizona: **S.J. REYNOLDS**, ed., 1990, 119 p.

—: Geologic highlights and route of the December 1990 Arizona Geological Society Field Trip, in **S.J. REYNOLDS**, ed., Field guide to the New Waddell Dam site, Vulture-Hieroglyphic Mountains area, and Mystic, Clementine, Newsboy, and Yarnell gold deposits, central Arizona: **S.J. REYNOLDS**, p. 1-3.

Geological Society of America: Downward steepening normal faults: S.E. Laubach, B.C. Vendeville, and **S.J. REYNOLDS**, 1990, Abstracts with Programs, v. 22, p. 272-273.

—: Deep-seated fluid involvement in ductile-brittle deformation and mineralization, South Mountains metamorphic core complex, Arizona: B.M. Smith, **S.J. REYNOLDS**, H.W. Day, and R. Bodnar, 1991, Bulletin, v. 103, p. 559-569.

Oxford University Press: Side canyons of the Colorado River, Grand Canyon, in S.S. Beus and M. Morales, eds., Grand Canyon geology: A.R. Potochnik and **S.J. REYNOLDS**, 1990, p. 461-481.

U.S. Geological Survey: Arizona radiometric ages hypercard stack: C.A. Carlson and **S.J. REYNOLDS**, 1990, Open-File Report 90-704, p. 5.

—: Mineral resources of the Gibraltar Mountain and Planet Peak Wilderness Study Areas, La Paz County, Arizona: R.C. Eppinger and others (including **J.E. SPENCER**, **S.J. REYNOLDS**, and **M.J. GRUBENSKY**), 1990, Bulletin 1704-B, 32 p.

—: Geology, in J.A. Peterson, ed., Preliminary mineral resource assessment of the Tucson and Nogales 1° by 2° quadrangles, Arizona: J.A. Peterson, J.B. Bergquist, **S.J. REYNOLDS**, and S.S. Page-Nedell, 1990, Open-File Report 90-276, 129 p., scale 1:24,000, 24 sheets.

REPORTS COMPLETED AND SUBMITTED FOR REVIEW

Arizona Geological Society: 1700 Ma Proterozoic deformation in Arizona: Evidence from high-strain zones in the Maricopa Mountains, central Arizona: E. DeWitt and **S.J. REYNOLDS**, Digest 19.

—: Proterozoic geology of the Webb Peak area, northeastern Gila Bend Mountains, southwestern Arizona: **C.J. NORTHRUP** and **S.J. REYNOLDS**, Digest 19.

—: Proterozoic geology of the Phoenix region, central Arizona: **S.J. REYNOLDS** and E. DeWitt, Digest 19.

Arizona Geological Survey: Geologic map and sections of the Granite Wash Mountains, west-central Arizona: **S.J. REYNOLDS**, **J.E. SPENCER**, S.E. Laubach, D. Cunningham, and S.M. Richard, Map 30, scale 1:24,000.

Flood Control District of Maricopa County and Arizona Department of Water Resources: Geologic mapping of flood hazards around the White Tank Mountains, Maricopa County: **J.J. FIELD** and **P.A. PEARTHREE**.

Geological Society of America: Did any synkinematic footwall tilting occur along the Miocene South Mountains metamorphic core complex of south-central Arizona?: A paleomagnetic evaluation: R.F. Livaccari, J.W. Geissman, and **S.J. REYNOLDS**.

—: Miocene base- and precious-metal mineralization associated with basin brines and detachment faults in west-central Arizona: **J.E. SPENCER**, **J.T. DUNCAN**, and **S.J. REYNOLDS**.

Pima County Flood Control District: Detailed reconstruction of a recent large alluvial-fan flood on the Tortolita piedmont: Implications for the applicability of the FEMA alluvial-fan methodology in southern Arizona: **P.A. PEARTHREE**, **P.K. HOUSE**, and **K.R. VINCENT**.

Tectonics: Tectonics of mid-Tertiary extension along a transect through west-central Arizona: **J.E. SPENCER** and **S.J. REYNOLDS**.



Massive boulder and other rock debris left by the 1988 debris flow in the Huachuca Mountains. AZGS geologists have studied the geomorphic evidence from this and previous debris flows in the area to understand better this geologic process. The study's findings are presented in AZGS Open-File Report 90-6.

Information and Assistance Provided



SERVICE TO GOVERNMENT AGENCIES

STATE OF ARIZONA

Administration, Risk Management Division
Agriculture
Attorney General's Office
Board of Technical Registration
Commerce, Arizona Energy Office
Commission on the Arizona Environment
Environmental Quality
 Office of Waste Programs
 Office of Water Quality
Game and Fish
Land Department
 Arizona Land Resources Information System
 Minerals and Nonrenewable Resources Section
Library, Archives, and Public Records
Mine Inspector's Office
Mines and Mineral Resources
Oil and Gas Conservation Commission
Radiation Regulatory Agency
State Parks
Transportation Materials Section
Water Resources
 Basic Data Section
 Hydrology Division
 Information and Education Division
 Office of Water Management

ARIZONA COUNTY, CITY, AND OTHER

Apache Junction
Clifton
Cochise County
Maricopa County Library
Mohave County Public Works Department
Phoenix Public Library
Pima County
 Board of Supervisors
 Flood Control District
 Water Department
Pinal County
 Library
 Planning Department
Salt River Project
Tucson
 Public Library
 Water Department
Yavapai County

TRIBAL GOVERNMENTS

Navajo
Tohono O'odham
White Mountain Apache

U.S. GOVERNMENT

Army, Fort Bliss, Tex.
Army Corps of Engineers, Los Angeles
Bureau of Indian Affairs, Colorado River Agency
Bureau of Land Management
 Kingman area office
 State Office
Bureau of Mines
 Intermountain Field Office, Denver
 Tucson Field Office
Bureau of Reclamation
Congress, 2d Congressional District
Congressional Research Service
Department of Justice
Environmental Protection Agency, San Francisco
Federal Emergency Management Agency
Fish and Wildlife Service
Forest Service
 Coronado Forest, Tucson
 Prescott Forest, Prescott
 Regional Office, Albuquerque
 Tonto Forest, Phoenix
Geological Survey
 Branch of Resource Analysis, Flagstaff
 Center for Inter-American Mineral Resource Investigations, Tucson
 Central Mineral Resources, Denver
 Central Regional Geology, Denver
 Minerals Information Office, Tucson
 Water Resources Division, Arizona District
 Water Resources Division, New Mexico District
 Western Mineral Resources, Menlo Park, Calif.
 Western Regional Geology, Menlo Park, Calif.
Los Alamos National Laboratory, N. Mex.
Luke Air Force Base, Phoenix
National Park Service, Tucson
Naval Academy, Annapolis, Md.
Sandia National Laboratory
Soil Conservation Service, Arizona State Office
Treasury Department, Customs Service

OTHER COUNTRIES AND STATES

Alaska Department of Natural Resources
California Division of Mines and Geology
Colorado Interstate Gas Commission
Idaho Land Department
Kansas Securities Commission
King County, Utah
Midland County Library, Tex.
National Museum of Wales
Nevada Bureau of Mines and Geology
New Mexico Bureau of Mines and Mineral Resources
North Carolina Department of Natural Resources and
 Community Development
Oklahoma Geological Survey

Pakistan Geological Survey
Rochester Museum, N.Y.
Tulsa County Library, Okla.
Utah Geological and Mineralogical Survey

SERVICE ON STATE GOVERNMENT COMMITTEES

Arizona Geographic Information Council: **L.D. FELLOWS**,
member
Arizona Rivers Assessment Committee: **L.D. FELLOWS**,
member
Commission on the Arizona Environment: **L.D. FELLOWS**,
Advisory Council, member
Environmental Education Task Force: **L.D. FELLOWS**,
member
Environmental Impact Assessment Task Force: **L.D. FEL-
LWS**, member
Interagency Committee on Environmental Education: **L.D.
FELLOWS**, member
Pima County Flood Control District: **P.A. PEARTHREE**,
Advisory Committee, member

SERVICE TO INDUSTRY

More than 150 company representatives and consultants purchased publications or conferred with staff geologists about the availability of geologic information or about the general geologic setting of areas within Arizona. Many of these individuals are geologists, hydrologists, and engineers engaged in planning, exploration, siting, construction, production, maintenance, or other activities. Some of them work on development-related activities, such as siting and construction of industrial parks, residential subdivisions, and water-supply, waste-disposal, and transportation facilities. Others concentrate on pollution mitigation. Many explore for or mine metallic and nonmetallic minerals, oil and natural gas, or other mineral resources. Others who requested information and assistance sell books and maps, real estate, or insurance or are in other businesses.

SERVICE TO EDUCATIONAL INSTITUTIONS

ARIZONA ELEMENTARY AND SECONDARY SCHOOLS

"A" Ave School, Douglas
Booth-Fickett Middle School, Tucson
Borton Magnet School, Tucson
Brichta School, Tucson
Cactus High School, Glendale
Centennial School, Tucson
Coronado Middle School, Tucson
Davis Bilingual School, Tucson
Desert View High School, Tucson
Doolan Middle School, Tucson
Elvira School, Tucson
Emily Gray Middle School, Tucson
Hebrew Academy, Tucson
Kino School, Tucson
Lincoln School, Nogales
Litchfield Elementary School District, Litchfield Park
Lulu Walker School, Tucson

Manzanita School, Tucson
Mesa Public Schools, Science Resource Center
Orange Grove Middle School, Tucson
Pueblo High School, Tucson
Safford Magnet School, Tucson
Santa Cruz Valley High School, Eloy
Sedona School, Sedona
Sunnyside High School, Tucson
Tucson Unified School District, Science Department
Utterback Middle School, Tucson
Vail Jr. High School, Vail
Van Horne School, Tucson
White School, Tucson

ARIZONA UNIVERSITIES AND COLLEGES

Arizona State University, Tempe
Arizona Western College, Yuma
Cochise Community College, Douglas
Eastern Arizona College, Thatcher
Embry-Riddle Aeronautical University, Prescott
Grand Canyon University, Phoenix
Maricopa Community College, Phoenix
Mesa Community College, Mesa
Mohave Community College, Kingman
Northern Arizona University, Flagstaff
Northland Pioneer College, Show Low
Pima Community College, Tucson
Scottsdale Community College, Scottsdale
University of Arizona, Tucson
Department of Mining and Geological Engineering
Faculty of Science
Office of Arid Lands Studies
University of Phoenix
Yavapai College, Prescott

ELEMENTARY AND SECONDARY SCHOOLS FROM OTHER STATES

Arkansas
Clarksville Junior High School
Pleasant View High School, Ozark
Scranton High School
Indiana: Wayne High School, Ft. Wayne
Maryland: Olney Elementary School, Olney

UNIVERSITIES FROM OTHER STATES

Alabama: University of Alabama
California
California State University, Northridge
California Institute of Technology
Humboldt State University
Lawrence Berkeley Laboratory
Los Angeles Harbor College
Occidental College
Orange Coast College
Stanford University
University of California
University of San Diego
University of Southern California
Colorado: Colorado State University
Florida: Palm Beach Atlantic College
Georgia: Georgia State University

Illinois

Southern Illinois University
University of Illinois

Indiana: Purdue University

Kentucky: University of Kentucky

Louisiana: University of Louisiana

Maine: University of Maine

Maryland: Johns Hopkins University

Massachusetts: Harvard University

Minnesota: University of Minnesota

Nevada: University of Nevada, Las Vegas

New Jersey: Princeton University

New Mexico

New Mexico Tech

University of New Mexico

New York

Colgate University

Columbia University

Rochester Institute of Technology

State University of New York, Binghamton

State University of New York, Stony Brook

North Carolina: University of North Carolina

Ohio

Kent State University

University of Cincinnati

Oklahoma: University of Oklahoma

Oregon: University of Oregon

Pennsylvania: Bucknell University

Tennessee: Vanderbilt University

Texas

Baylor University

Southern Methodist University

Texas A&M University

University of Houston

University of Texas, Austin

University of Texas, El Paso

Utah

University of Utah

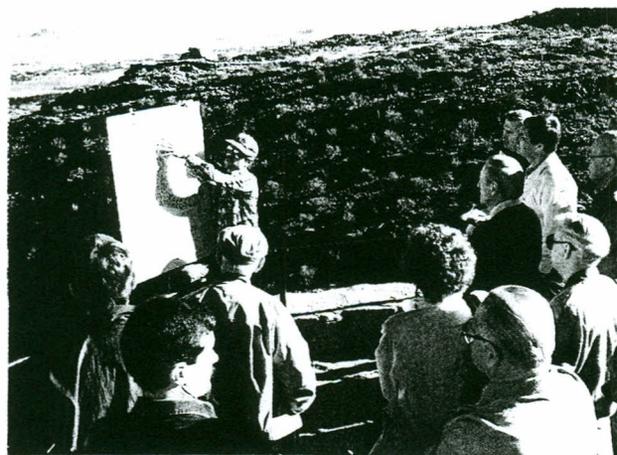
Weber State University

Washington

University of Washington

Whitman College

Wisconsin: University of Wisconsin, Madison



AZGS geologist Steve Reynolds explains the geology of the South Mountains near Phoenix to those who attended the annual meeting of the Interstate Oil Compact Commission.

UNIVERSITIES FROM OTHER COUNTRIES

Australia

James Cook University

La Trobe University

Monash University

Canada

University of British Columbia

University of Calgary

University of Guelph

University of Western Ontario

England: University of Bristol

France: University of Marseilles

SERVICE TO PROFESSIONAL ORGANIZATIONS

American Geophysical Union: **J.E. SPENCER** and **S.J. REYNOLDS** each reviewed manuscripts being considered for publication in *Journal of Geophysical Research*.

Arizona Floodplain Management Association: **P.A. PEAR-THREE**, Technical Review Committee, member

Arizona Geological Society

L.D. FELLOWS, Councilor, 1990-

S.J. REYNOLDS, President, 1990

____ Past President, 1991

____ Editor, field-trip guidebook, 1990

Association of American State Geologists

L.D. FELLOWS, Cluster Meeting Committee, Chair

____ Federal Lands Committee, member

____ Honorary Members Committee, Chair

____ Nominating Committee, member

Geological Society of America: **S.J. REYNOLDS** and **J.E. SPENCER** each reviewed manuscripts being prepared for publication in the *Bulletin* and *Geology*.

National Science Foundation: **J.E. SPENCER** and **S.J. REYNOLDS** reviewed proposals being considered for funding.

SERVICE TO OTHER GROUPS

Academy of Natural Sciences of Philadelphia

American Chemical Society

Arizona Association for Learning in and about the Environment

Arizona Conservation Projects, Inc.

Arizona Daily Wildcat

Arizona Geological Society

Arizona Great Outdoors

Arizona Republic

Arizona Science Teachers Association

Arizona - Sonora Desert Museum

Arizona Stone Products, Inc.

Chicago Tribune

Flinn Foundation

Grand Canyon Trust

Greater Tucson Economic Council

Interstate Oil Compact Commission

Mesa Tribune

Museum of Northern Arizona

National Audubon Society, Expedition Institute

Nature Conservancy

Old Pueblo Lapidary Club

Petrified Forest Museum League

Smithsonian Magazine

Tubac Center for the Arts



Teaching teachers: Earth science teachers from the Tucson area learn about the geologic history of the Tucson Mountains. Such field trips, led by AZGS geologist Tom McGarvin, provide junior high and high school teachers with concrete, close-to-home examples of geologic principles, which the teachers, in turn, bring to their students.

FIELD TRIPS LED OR ORGANIZED

Arizona Geological Society: **S.J. REYNOLDS** organized and led Fall 1990 trip to New Waddell dam site, Vulture - Hieroglyphic Mountains area, and Mystic, Clementine, Newsboy, and Yarnell gold deposits; **S.J. REYNOLDS** and **J.E. SPENCER** made oral presentation at Newsboy mine.

Arizona State University: **S.J. REYNOLDS** led trip for faculty and students to Gila Bend Mountains.

____ **S.J. REYNOLDS** led trip for faculty and students to Big Horn Mountains.

Interstate Oil Compact Commission: **S.J. REYNOLDS**, **H.W. PEIRCE**, and **L.D. FELLOWS** were leaders of trip to observe geology of Phoenix area.

James Cook University (Townsville, Australia) and Northern Arizona University: **S.J. REYNOLDS** led trip for faculty and students to Santa Catalina Mountains.

Project Help, Pinal County: Earth and space in the elementary science programs: **T.G. McGARVIN** led trip to Tucson Mountains.

Tucson-area earth science teachers: **T.G. McGARVIN** led trip to Tucson Mountains.

____ **T.G. McGARVIN** led trip to Santa Catalina and Rincon Mountains.

U.S. Forest Service, Advanced Minerals Management Course: **L.D. FELLOWS** was one of leaders of trip to observe mineral deposits in Pinal County.

____ Minerals Administration Course: **L.D. FELLOWS** was one of leaders of trip to observe mineral deposits in Pinal County.

University of Arizona and U.S. Geological Survey: **S.J. REYNOLDS** led trip for faculty, students, and U.S. Geological Survey geologists to Santa Catalina Mountains.

Victoria (Melbourne, Australia) Institute of Earth Sciences: **S.J. REYNOLDS** led trip for faculty and students to Wickenburg-Prescott area.

TALKS GIVEN

Arizona Association for Learning in and about the Environment, Prescott: Geo-literacy - Understanding Earth's secrets (a workshop on rock and mineral identification): **T.G. McGARVIN** and J. Contreras.

Arizona Mining Association and College of Engineering and Mines, University of Arizona, Minerals in Society Program, Tucson: Things geologic - Some other facts of life: **H.W. PEIRCE**.

Arizona Mining Association and Phoenix College, Minerals in Society Program, Phoenix: Things geologic - Some other facts of life: **H.W. PEIRCE**.

Arizona Science Teachers Association, Phoenix: Our movin' groovin' Earth (workshop on earthquakes and volcanoes): J. Wolfe and **T.G. McGARVIN**.

Boy Scout Camporee, Buenos Aires National Wildlife Refuge: Invisible importance - No rocks, no ice cream: **T.G. McGARVIN**.

Cactus Civitan Club, Tucson: Sand factories: **L.D. FELLOWS**.

Desert Botanical Garden, "Desert Fest," Phoenix: Geologic setting of the Phoenix region: **T.G. McGARVIN**.

Desert Gold Diggers, Tucson: Geological processes and results - Observing the obvious: **T.G. McGARVIN**.

Embry-Riddle Aeronautical University, Aerospace Education for Teachers, Prescott: Looking down before you look up - Geology and aerospace: **T.G. McGARVIN**.

Grand Canyon University, Glendale: Highlights of the geology of Arizona: **L.D. FELLOWS**.

The Society of American Military Engineers, Tucson: Sand factories: **L.D. FELLOWS**.

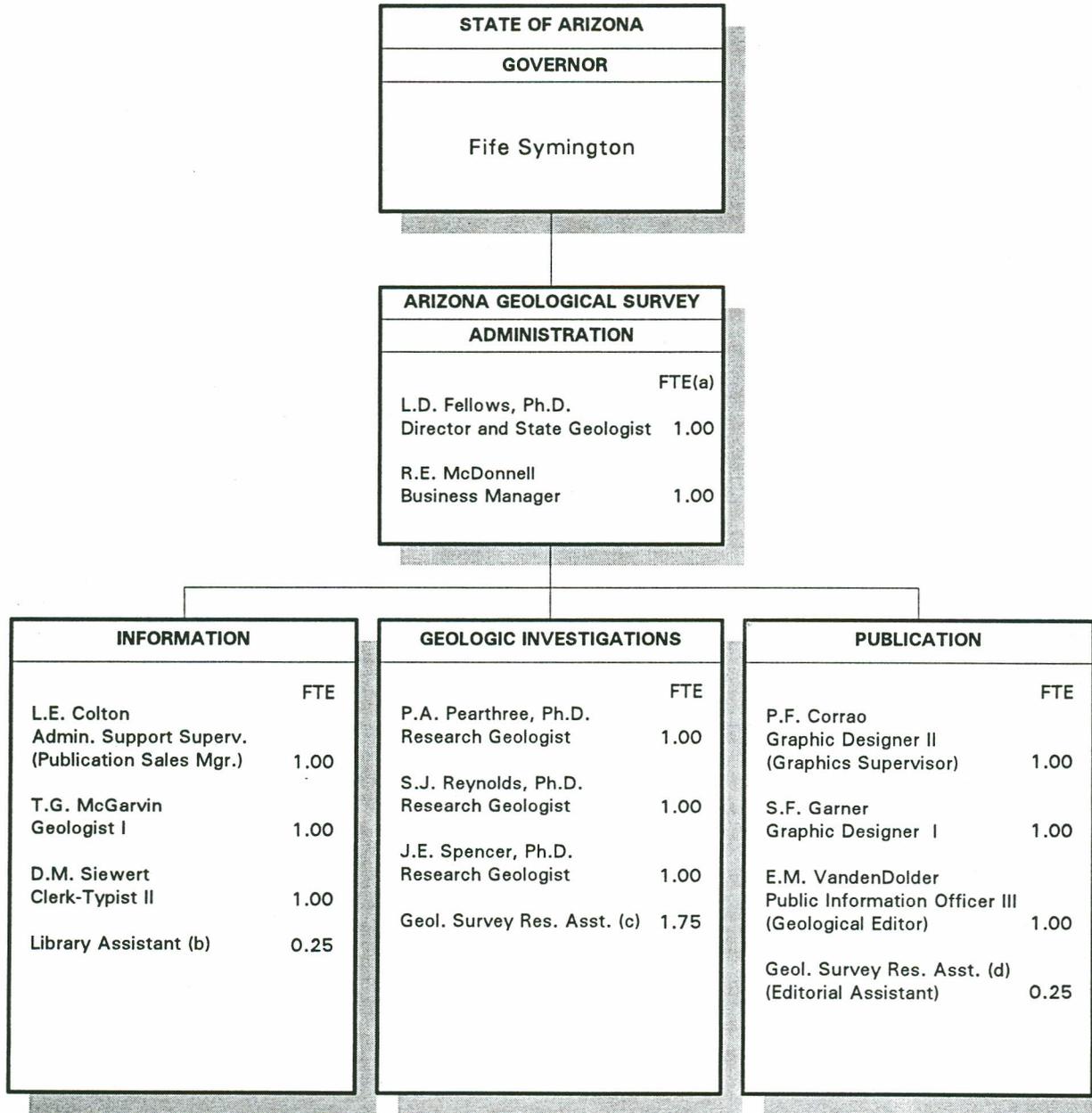
Sun City Petroleum Club, Sun City: Subsidence and earth fissures: **L.D. FELLOWS**.

Tucson Public Library Summer Program for Children, Tucson: Rock riddles and mineral mysteries: **T.G. McGARVIN**.

Organization and Personnel



ORGANIZATION CHART Arizona Geological Survey June 30, 1991



(a) Full-time equivalent

(b) Temporary
A.E. Moss
N.R. Sprague
S.L. Bundy

(c) Temporary
J.J. Field
K.C. Horstman
P.K. House
C.J. Northrup
N. Schmidt
S. Slaff
T.A. Weiskopf

(d) Temporary
N. Schmidt

GEOLOGISTS AND SPECIALTY AREAS

LARRY D. FELLOWS, Director and State Geologist; B.S., Iowa State University; M.A., University of Michigan; Ph.D., University of Wisconsin.

- administration
- geology of Arizona
- geologic hazards and limitations

PHILIP A. PEARTHREE, Research Geologist; B.A., Oberlin College; M.S., University of Arizona; Ph.D., University of Arizona.

- geology of Arizona
- Quaternary and surficial geology
- seismotectonics and seismic hazards
- late Cenozoic geology of the Basin and Range Province
- geomorphology
- subsurface geology
- geologic mapping
- environmental geology

STEPHEN J. REYNOLDS, Research Geologist; B.S., University of Texas at El Paso; M.S., University of Arizona; Ph.D., University of Arizona.

- geology of Arizona
- structural geology; analysis of rock fabric and fault movement
- State geologic mapping project
- base metals (copper, lead, zinc, molybdenum, etc.)
- computer applications
- geochemistry of granites
- Basin and Range Province

JON E. SPENCER, Research Geologist; B.S., University of California, Santa Cruz; Ph.D., Massachusetts Institute of Technology.

- geology of Arizona
- geochronology
- genesis of metallic mineral deposits
- Basin and Range Province
- Tertiary rocks, structures, and mineral deposits
- structural geology
- geologic mapping
- precious metals (gold and silver)
- geophysics

SUPPORT STAFF AND MAJOR FUNCTIONS

LAURETTE E. COLTON, Administrative Support Supervisor I (Publication Sales Manager).

- manager of publication sales office
- supervisor of clerical support staff

PETER F. CORRAO, Graphic Designer II (Graphics Supervisor); B.A., Arizona State University.

- supervise graphics section
- drafting and line drawings
- photography and darkroom
- publication layout

SHERRY F. GARNER, Graphic Designer I; B.A., University of Kentucky.

- map drafting and illustration
- graphic design
- photography and darkroom
- *Arizona Geology* illustration and layout

ROSE ELLEN McDONNELL, Business Manager; B.S., University of Arizona.

- special assistant to State Geologist
- fiscal management
- budget
- facility management
- personnel coordinator

THOMAS G. MCGARVIN, Geologist I; B.A., California Lutheran College.

- provide information to public on geology of Arizona and availability of published and unpublished maps and reports
- assist earth science teachers and teacher groups
- manage geologic library and assist users
- manage rock cuttings and core repository and assist users

DENISE M. SIEWERT, Clerk-Typist II.

- accounting assistance
- publication assistance
- typing and data entry

EVELYN M. VANDENDORER, Public Information Officer III (Geological Editor); B.S., University of Connecticut; Certificate, Publication Specialist Program, George Washington University.

- editing
- *Arizona Geology*
- manuscript flow
- liaison with typesetter and printer
- liaison with news media
- press releases

Budget and Expenditures



State Appropriation and Expenditures

Category	FY 1989-90		FY 1990-91		FY 1991-92
	Budgeted	Spent	Budgeted	Spent	Budgeted
Personal Services	\$342,635	340,337	355,500	355,495	391,700
Benefits	66,500	64,709	78,500	76,617	90,100
Operations	102,300	107,365	109,600	112,326	117,700
In-State Travel	6,100	5,228	6,700	5,633	10,900
Out-of-State Travel	4,700	1,890	3,100	2,173	4,800
Capital Equipment	13,300	10,600	12,000	12,135	8,100
TOTAL	535,535	530,129^a	565,400	564,379^b	623,300^c

^a Budget reduced \$5,400 at mid-year

^b Budget reduced \$1,000 at mid-year

^c Includes appropriation for Oil and Gas Regulatory Program, which was merged with the Arizona Geological Survey, effective July 1, 1991



AZGS staff members. Front row: S.J. Reynolds, D.M. Siewert, L.E. Colton, and J.T. Duncan; middle row: K.A. Demsey, J.E. Spencer, E.M. VandenDolder, J.R. LaVoie (retired), and T.G. McGarvin; backrow: S.F. Garner, P.F. Corrao, R.E. McDonnell, L.D. Fellows, M.E. deMartino, and P.A. Pearthree.

Contracted Projects, FY 1990-91 Expenditures

Project (Funding Source)	Principal Investigator	Personal Services	Benefits	Operations	In-State Travel	TOTAL
Geologic Mapping- Phoenix Quadrangle (U.S. Geological Survey)	Reynolds	\$28,365	3,177	3,104	4,073	38,719
Geologic Mapping- Surficial Geology (U.S. Geological Survey)	Pearthree	14,482	1,935	1,806	553	18,776
Uranium Levels (U.S. Environmental Protection Agency)	Spencer	28,097	6,265	700	0	35,062
Flood Hazards-White Tanks (Flood Control District of Maricopa County)	Pearthree	7,252	701	581	632	9,166
Land Subsidence (U.S. Bureau of Reclamation)	Pearthree	3,426	325	0	0	3,751
Energy Resources (Arizona Department of Commerce-Energy Office)	Fellows	2,956	498	0	0	3,454
Arizona Geological Society	Reynolds	0	0	813	0	813
TOTAL		84,578	12,901	7,004	5,258	109,741

Persons Employed:

Geologic Mapping-Phoenix Quadrangle: W.G. Gilbert, M.J. Grubensky, C.J. Northrup, J.A. Stimac

Geologic Mapping-Surficial Geology: K.A. Demsey, S. Slaff, J.A. Stimac

Uranium Levels: J.T. Duncan

Flood Hazards-White Tanks: J.J. Field, K.R. Vincent

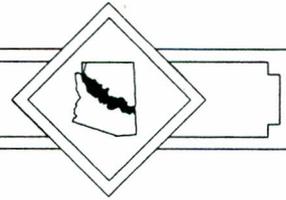
Land Subsidence: S. Slaff

Energy Resources: J.T. Duncan

Printing Revolving Fund, FY 1990-91

Revenue		\$34,485
Expenditures		
Salaries	6,104	
ERE	2,096	
Travel	463	
Operations	16,282	
Equipment	1,896	
TOTAL	26,841	34,485

Advisory Board



ENVIRONMENTAL AND ENGINEERING GEOLOGY

Kenneth M. Euge, R.G.
Geological Consultants
Phoenix

George A. Kiersch, R.G., P.E.
Kiersch Associates, Inc.
Tucson

R. Bruce Mack
Supervisor of Geohydrology
Salt River Project
Phoenix

Barbara H. Murphy
Dames & Moore
Phoenix

Stephen D. Noel, P.G.
President
Water Resources Associates, Inc.
Phoenix

Troy L. Péwé
Consulting Geologist
Tempe

Frank S. Turek
Vice President
A-N West, Inc.
Phoenix

Ralph E. Weeks, P.G.
Vice President & Chief Geologist
Sergent, Hauskins & Beckwith
Phoenix

Gary D. Weesner
Hydrogeologist
Southwest Water and Mineral
Resources
Phoenix

Wm. G. Wellendorf, P.G.
Vice President and Director
of Geosciences
Water Resources Associates, Inc.
Phoenix

MINERAL RESOURCES

Daniel M. Aiken
Geologist
Cyprus Sierrita Corporation
Green Valley

James A. Briscoe
President
JABA, Inc.
Tucson

Russell M. Corn
Consulting Geologist
Tucson

Ted H. Eyde
President
GSA Resources, Inc.
Cortaro

John D. Forrester
Chief Geologist
Phelps Dodge Corporation
Tucson

Walter E. Heinrichs
President
Heinrichs Geo-exploration Company
Tucson

Robert L. Hockett
Retired Senior Geologist
Magma Copper Company
San Manuel

James D. Loghry
Consulting Geologist
Tucson

James N. Mayor
District Manager
Newmont Exploration Ltd.
Tucson

Robert A. Metz
Senior Geologist-Evaluations
Battle Mountain Exploration
Tucson

Charles P. Miller
President
Miller Resources, Inc.
Tucson

James D. Sell
Manager
Southwestern Exploration
Department
ASARCO, Inc.
Tucson

Peter D. Tillman
Consulting Geologist
Tucson

EARTH SCIENCE EDUCATION

Carlton Ami
Navajo Community College
Tsaile

Bonnie Briscoe
Eastern Arizona College
Thatcher

Suzanne Cash
Cortez High School
Phoenix

Donald W. Clay
Arizona Western College
Yuma

Chris Cotter
Mountain View High School
Tucson

Raymond W. Grant
Mesa Community College
Mesa

Peter L. Kresan
Department of Geosciences
University of Arizona
Tucson

Michael G. Lang
School Improvement Unit
Department of Education
Phoenix

Allan Morton
Central Arizona College
Coolidge

J. Dale Nations
Northern Arizona University
Flagstaff

Beth Nichols-Boyd
Geology Department
Yavapai College
Prescott

Joseph F. Schreiber, Jr.
Department of Geosciences
University of Arizona
Tucson

Jeff Simpson
Paradise Valley High School
Phoenix

Edmund Stump
Department of Geology
Arizona State University
Tempe

J. Robert Thompson, Jr.
Glendale Community College
Glendale

Roger Weller
Cochise College
Douglas



Advisory Board Members Discuss Recommendations

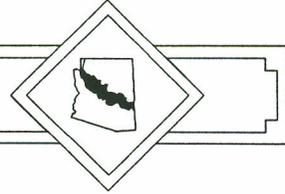
Top left: Environmental and Engineering Geology Committee: R.B. Mack and B.H. Murphy (seated); F.S. Turek and W.G. Wellendorf (standing).

Top right: Mineral Resources Committee: J.N. Mayor, T.H. Eyde, D.M. Aiken, W.E. Heinrichs, J.D. Sell, and R.A. Metz (seated); J.A. Briscoe, C.P. Miller, R.M. Corn, J.D. Loghry, and J.D. Forrester (standing).

Bottom right: Earth Science Education Committee: M.G. Lang, S. Cash, and E. Stump.

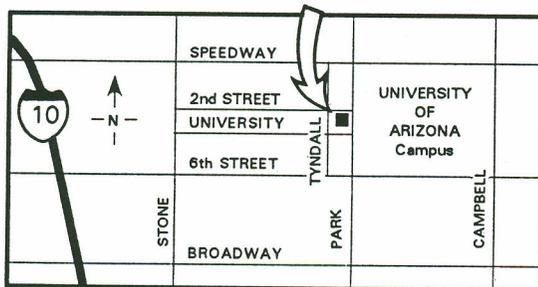


Arizona Geological Survey



INFORMATION SERVICES

- Answer requests for information and assistance
- Sell and distribute Arizona Geological Survey maps and reports
- Maintain public-access library of reports, books, maps, and other publications on the geology and mineral resources of Arizona
- Maintain public-access repository of rock cores, well cuttings, and related subsurface maps
- Educate public through lectures, displays, field trips, and quarterly publication, *Arizona Geology*
- *Arizona Geology*: Contains summaries of Arizona Geological Survey research, announcements of new publications, and articles on the geology of Arizona; free to U.S. residents



Address: 845 N. Park Ave., Suite 100,
Tucson, AZ 85719. Telephone: (602) 882-
4795. Office hours: 8:00 a.m. to 5:00 p.m.,
Monday through Friday. A commercial
parking lot is available behind the office
building via Tyndall.