Annual Report of the Arizona Geological Survey for Fiscal Year 1997 (July 1, 1996 to June 30, 1997)

by

Larry D. Fellows
Director and State Geologist

Arizona Geological Survey
Open-File Report 97-22

Arizona Geological Survey
416 W. Congress, Suite #100, Tucson, Arizona 85701

This report is preliminary and has not been edited
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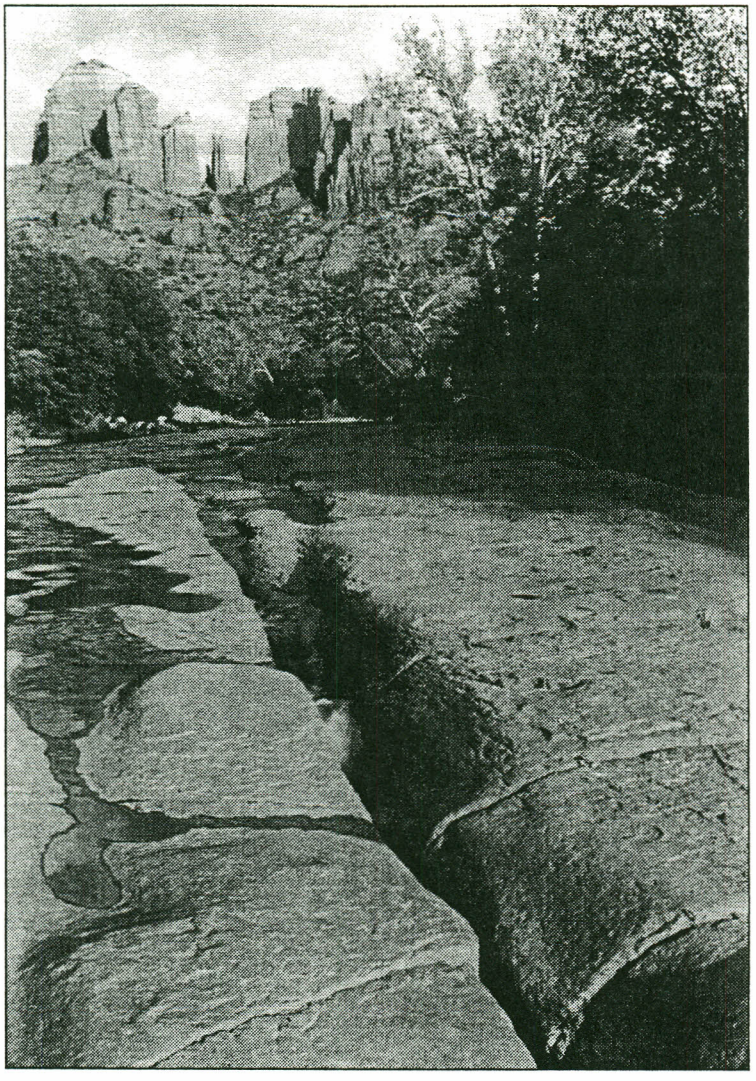

Large crack (joint) in rock points toward Cathedral Rock, a scenic feature along Oak Creek southwest of Sedona.

ANNUAL REPORT
OF THE
ARIZONA GEOLOGICAL SURVEY
FOR
FISCAL YEAR 1997
(JULY 1, 1996 TO JUNE 30, 1997)

by
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Director and State Geologist

State of Arizona
Arizona Geological Survey
416 W. Congress, Suite 100
Tucson, Arizona 85701
(520) 770-3500

Jane Dee Hull
Governor

Larry D. Fellows
Director and State Geologist

15 December 1997

The Honorable Jane Dee Hull
Governor of Arizona
Arizona State Capitol
1700 West Washington Street
Phoenix, AZ 85007

Dear Governor Hull:

It is a pleasure to submit the annual report of the Arizona Geological Survey (AZGS) for Fiscal Year 1997. The report highlights many of the ways by which our staff members enhance understanding of Arizona's geology and provide unbiased geologic information to support prudent management of land, water, mineral, and energy resources.

Because of substantial population growth, more information is needed about those aspects of Arizona's geologic setting that might impact land and resource development. This includes, but is not limited to, potentially active faults and earthquake hazards, land subsidence and earth fissures caused by overdraft of ground water, overbank and piedmont flooding, and cavernous bedrock and related problems in limestone terrain.

In addition to providing information, the AZGS provides staff support for the Arizona Oil and Gas Conservation Commission (OGCC), which is administratively attached. The OGCC regulates the drilling for and production of oil, gas, helium, and geothermal resources. We are watching, with cautious optimism, the drilling that is now being done to assess the volume of carbon dioxide in rocks near St. Johns.

AZGS staff collaborate with Federal and other State agencies on projects of mutual interest. We use State General Revenue funds to match Federal and other funds and supplement our General Fund appropriation.

I'm looking forward to working with you and your staff during FY 1998. We welcome your requests for information and assistance relative to the geologic framework and character of Arizona.

Sincerely yours,

Larry D. Fellows

Larry D. Fellows
Director and State Geologist

Arizona Geological Survey - *at a glance*

MISSION

To provide unbiased information to enhance public understanding of geologic processes, materials, and resources and to assist citizens, businesses, governmental agencies, and legislators in prudently managing Arizona's land, water, mineral, and energy resources.

GEOLOGIC DATA USERS

- Consultants
- Elementary and secondary teachers and students
- Environmental and engineering geology companies
- Governmental agencies
- Insurance companies
- Interested or concerned citizens
- Lawyers
- Legislators and legislative staff
- Libraries
- Mineral exploration and mining companies
- News media representatives
- Oil and gas exploration and development companies
- Professional societies
- Realtors
- Tourists
- University faculty and students

HOW TO CONTACT US

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http://www.azgs.state.az.us

Office hours:
Monday through Friday
8:00 a.m. to 5:00 p.m.

INFORMATION

- Inquiries about Arizona geology
- Earth Science Information Center
  - USGS topographic and other maps
  - USGS geologic maps and reports
- Arizona Geological Survey publications
- Arizona Geological Society publications
- Geology library
- Databases and files
- Rock cuttings and core repository
- *Arizona Geology* (Quarterly)
- Land-subsidence and earth-fissure information
- Earth science education activities
- Down-to-earth reports (nontechnical)
- Talks and lectures

MAPPING AND INVESTIGATIONS

- Bedrock and surficial geology
- Geologic hazards and limitations
- Mineral and energy resources
- Geologic maps and reports

OIL AND GAS

- Administrative and staff support for the Oil and Gas Conservation Commission
- Information about oil, gas, helium, and geothermal resources
- Oil and gas well inspections
- Oil and gas well files
- Subsurface geology

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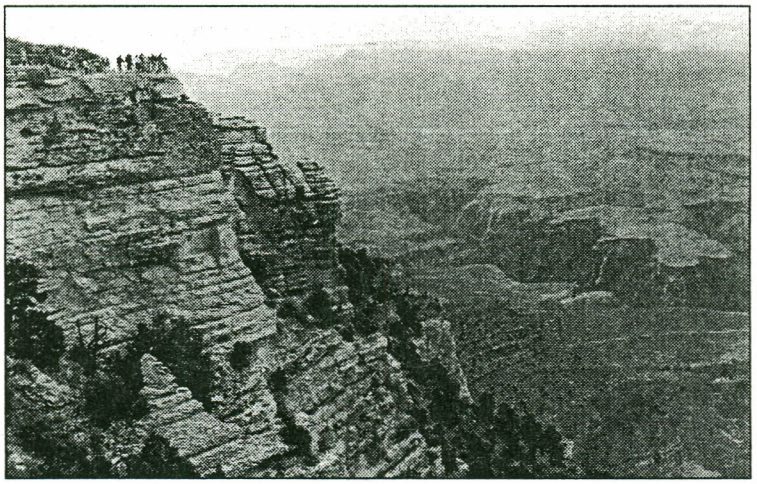


EXECUTIVE SUMMARY

Dr. Larry D. Fellows, Director and State Geologist

INFORMATION

- Answered thousands of requests for geologic information or assistance.
- Sold 11,500 maps and reports with an average turn-around time from receipt of order to mailing of less than 1.5 days.
- Relocated the Earth Science Information Center (ESIC) to the AZGS office. The ESIC is operated cooperatively by the U.S. Geological Survey and the AZGS to distribute publications and information from both agencies from a single location.
- Signed an agreement to be the distributor of Arizona Geological Society publications. The objective of the Society is to promote and encourage interest in the science of geology and in the geology of Arizona.
- Released Down-to-Earth 5, Things Geologic, a nontechnical publication that describes the impacts of "things geologic" on our daily lives.
- Received the John C. Frye Award for *Land Subsidence and Earth Fissures in Arizona* (Down-to-Earth 3). Award is given annually by the Geological Society of America and the Association of American State Geologists.
- Maintained the Center for Land-Subsidence and Earth-Fissure Information. Met with representatives of land- and water-management agencies to discuss activities related to land subsidence and the need for additional information.
- Expanded the bibliographic database, AZGEOBIB, which now has more than 12,500 entries.
- Established a speakers bureau to give nontechnical talks to adult groups. Gave 23 talks on the geology of Arizona.

MAPPING AND INVESTIGATIONS

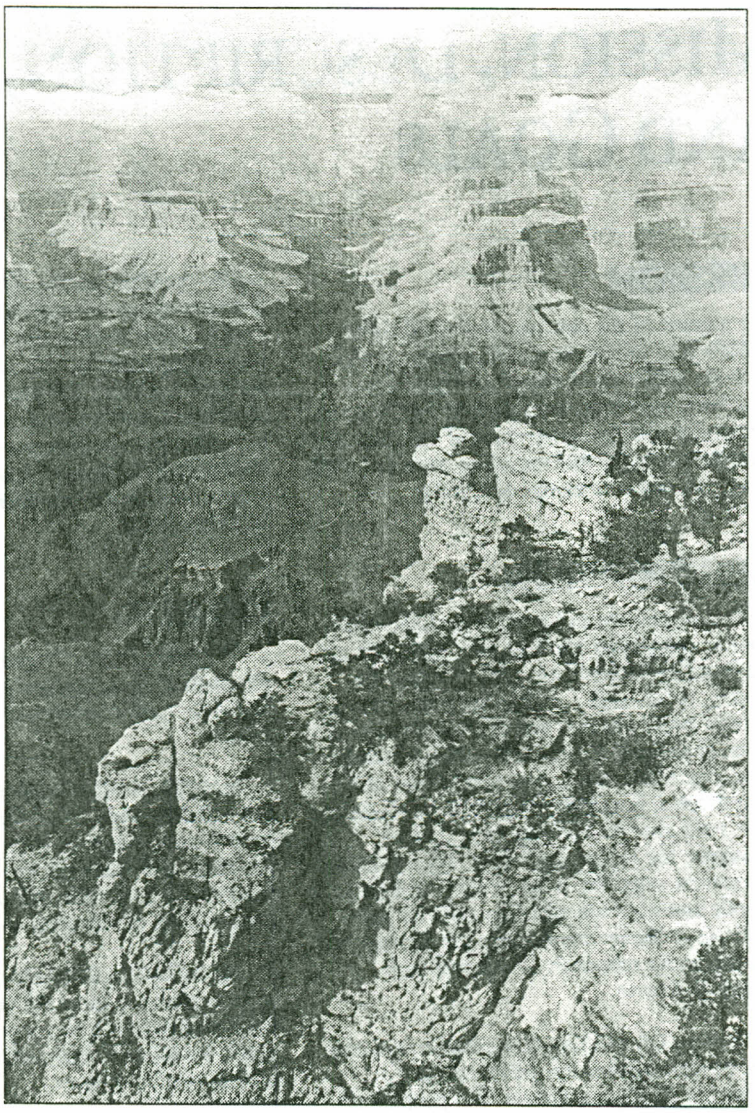
- Released 32 geologic reports and maps.
- Published report on faults and historical seismicity in the Flagstaff area as Bulletin 200.
- Completed study of the uranium content in rocks in the Cave Creek and Carefree areas in cooperation with the Arizona Radiation Regulatory Agency and U.S. Environmental Protection Agency.
- Released 7 detailed geologic maps. Mapping was funded on a 50-50 basis by the AZGS and the National Geologic Mapping Program through the U.S. Geological Survey. Map areas were determined by the Geologic Mapping Advisory Committee.
- Digitized and released geologic maps of the Phoenix North, Phoenix South, Salome, and Little Horn Quadrangles (1:100,000 scale).
- Completed geologic mapping along Highway 88 northwest of Globe in cooperation with the Arizona Department of Transportation.
- Evaluated historic river channel changes on segments of the Santa Cruz, San Pedro, and Bill Williams Rivers for a river navigability assessment.
- Spent $209,638 on externally funded projects done under contract. Employed 10 part-time and temporary employees with these funds.

OIL AND GAS

- Issued 10 permits to drill for oil, natural gas, helium, and geothermal resources.
- Inspected 39 oil and gas wells to ensure that there were no safety and environmental problems.
- Held one special meeting of the Arizona Oil and Gas Conservation Commission in St. Johns to learn about the potential carbon dioxide resource that is being evaluated there. Held two regular meetings in Phoenix.

ARIZONA GEOFACT

THE COLORADO RIVER FORMED THE GRAND CANYON IN THE LAST 6 MILLION YEARS, EXPOSING ROCKS AT THE BOTTOM OF THE CANYON NEAR THE PARK HEADQUARTERS THAT ARE 1.7 BILLION YEARS OLD.



Sedimentary rocks exposed in the walls of the Grand Canyon.

MISSION, DESCRIPTION, AND GOALS

MISSION

The mission of the Arizona Geological Survey (AZGS) is to provide unbiased information to enhance public understanding of geologic processes, materials, and resources and to assist citizens, businesses, governmental agencies, and legislators in prudently managing Arizona's land, water, mineral, and energy resources.

DESCRIPTION

AZGS staff prepare and provide geologic maps, reports, and related information. Geologists map and describe bedrock and surficial materials; metallic, nonmetallic, and energy resources; and geologic processes that may be hazardous to the public or limiting to land and resource management (e.g. earthquakes, land subsidence and earth fissures, flooding). Staff conduct investigations, write reports and prepare maps that summarize the results, and make this and related information available to the public. Staff also compile and maintain data files and computer databases, a library that features the geology of Arizona, and a repository of selected rock cuttings and cores.

The Arizona Oil and Gas Conservation Commission, which regulates the drilling for and production of oil, gas, helium, and geothermal resources, is attached administratively to the AZGS. The AZGS provides staff support. Staff issue permits to drill, monitor drilling, inspect completed wells, compile drilling and production data, and maintain files of well cuttings and related information about subsurface geology. In addition, staff prepare maps that show the distribution and thickness of bedrock formations in the subsurface, describe the character of the formations, disseminate information, and encourage the responsible exploration for and development of oil, natural gas, and related resources.

GOALS

1. INFORMATION. To provide unbiased information about Arizona's geologic processes, materials, and resources in a timely, courteous manner.

2. MAPPING AND INVESTIGATIONS. To map and describe bedrock and surficial geology, mineral and energy resources, and geologic processes and materials that can be hazardous to residents or limiting to the use of land and management of resources in Arizona.

3. OIL AND GAS CONSERVATION. To provide support to the Arizona Oil and Gas Conservation Commission, which has responsibility to protect public health and safety relative to oil and gas drilling and production.

ACCOMPLISHMENTS

ARIZONA GEOFACT

IN 1996 ARIZONA MINES YIELDED NONFUEL MINERALS VALUED AT $3.5 BILLION. THIS OUTPUT RANKED ARIZONA AS FIRST IN THE NATION.

INFORMATION

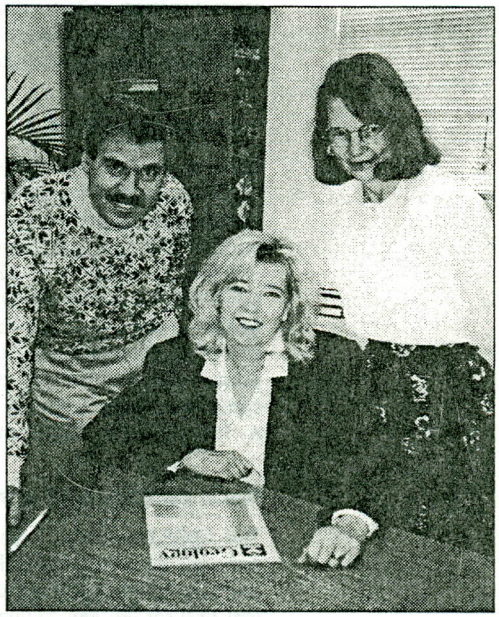
Inquiries about Arizona geology

Thousands of people requested information about the geology, mineral and energy resources, potential geologic hazards, and geology-related limitations to land use and resource management in Arizona. Many purchased maps and reports, used the library, or conferred with staff geologists. In response to public request, Arizona Geological Survey (AZGS) geologists gave talks, led field trips, served on committees, and assisted the public and profession in other ways.

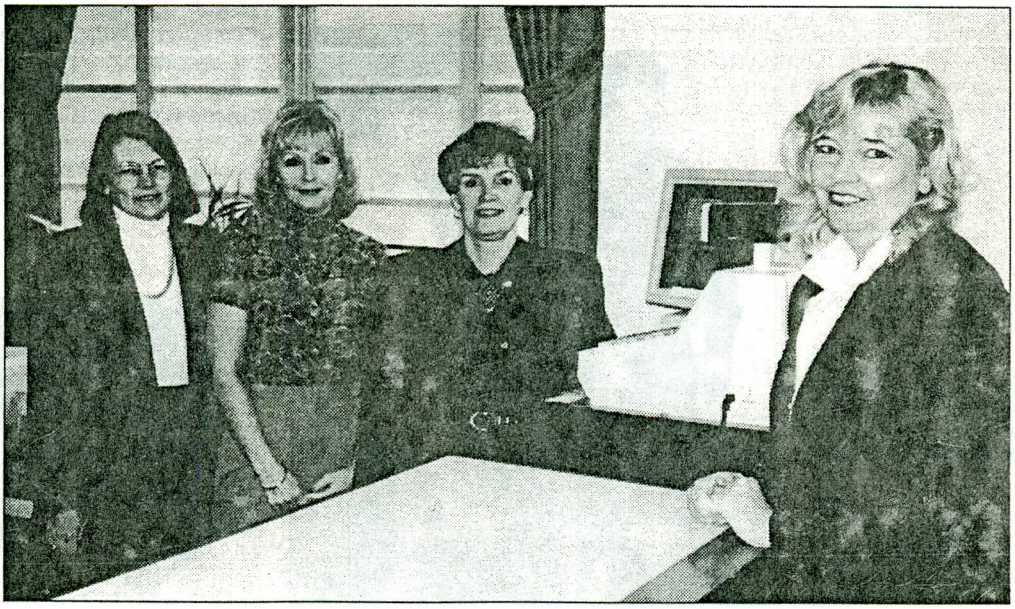
Earth Science Information Center (ESIC)

The AZGS offers for sale more than 500 published and unpublished geologic maps and reports that have been prepared by staff geologists. AZGS staff also sell U.S. Geological Survey (USGS) topographic maps and selected USGS geologic maps and reports on Arizona. In addition, AZGS staff provide access to USGS databases and distribute general-interest publications and information brochures prepared by the USGS. USGS publications are sold and distributed under terms of a cooperative agreement between the USGS and AZGS. In January 1997 the ESIC was moved to the AZGS office from another location, where it had been collocated with the USGS since 1992. Sales of AZGS reports and maps totaled $59,485. Revenue from the sale of AZGS publications is deposited in the Geological Survey Printing Revolving Fund and used for expenses to print and distribute other AZGS publications.

Sales of USGS topographic maps and other publications totaled $24,865. This revenue is used to purchase other publications for resale and for ESIC operating expenses.



Rose Ellen McDonnell (seated), Peter F. Corrao (left), and Mary E. Redmon examine latest issue of ***Arizona Geology.***



Mary E. Redmon (left), Mary E. Pasborg, Georgeanna L. Meeker, and Rose Ellen McDonnell at publication sales desk.

Geology library

The library contains publications of the AZGS, Arizona Oil and Gas Conservation Commission, Arizona Geological Society, U.S. Geological Survey, and selected publications of other governmental agencies. The library also contains theses and dissertations on Arizona geology, selected technical journal and bulletin series, textbooks, environmental impact statements and reviews, and unpublished maps and reports on the geology, water, energy, and mineral resources of Arizona. The library, supervised by T. G. McGarvin, is open to the public, but publications are not loaned. AZGS publications may also be viewed at the State Library in Phoenix and at depository libraries throughout the State.

Databases and files

The Arizona Geological Information System (AGIS) consists of computer databases that contain data compiled from published and unpublished geological investigations and maps: GENLIB is a database of AZGS library holdings; AZGEOBIB, a bibliography of Arizona geology; AZMIN, a database for metallic mineral districts and production and mine names, including primary and secondary references; and AZAGE, a compilation of radiometric age determinations. R. A. Trapp is the AGIS manager.

Rock cuttings and core repository

The AZGS has statutory responsibility to maintain a central repository for rock cuttings and cores and associated supplemental data. Companies that drill for oil, gas, helium, or geothermal resources are required by Oil and Gas Conservation statutes to save rock cuttings during drilling and submit them to the AZGS, together with logs and other pertinent information. Rock cores, taken primarily during mineral exploration, are commonly donated to the AZGS. Because of space limitations, only representative samples of cores are usually saved. Cuttings from approximately 4,000 oil and water wells, and cores from many mineral tests are in the repository, which may be used by the public.

Arizona Geology

Arizona Geology is published quarterly to summarize current events related to geology, announce and describe new geologic maps and reports that have been completed, and to publicize other activities or events that pertain to "things geologic" in Arizona. The intended audience for *Arizona Geology* is practicing geologists or others who have a special interest in Arizona geology. Three 4-page issues and one 6-page issue were published and distributed.

Center for Land-Subsidence and Earth-Fissure Information (CLASEFI)

The purpose of this undertaking, initially established in cooperation with the Arizona Department of Water Resources, is to answer requests for information, refer the public to appropriate agencies for assistance, assemble existing information at a single location, map and monitor the extent of subsidence and fissuring, and investigate subsidence areas and individual fissures. Nearly 300 reports and maps describe some aspect of land subsidence and earth fissures in Arizona.

A number of governmental agencies have responsibilities that require them to know the location of subsiding areas and the magnitude of the subsidence and fissures. Activities and priorities for CLASEFI are guided by a 13-member Steering Committee, which meets annually to provide oversight. A meeting of the Steering Committee was held in March to discuss appropriate considerations and actions at two localities within the metropolitan Phoenix area where groundwater levels are rapidly declining and subsidence and fissuring may be imminent. Geologist Robin Frisch-Gleason coordinated CLASEFI activities.

left: Thomas G. McGarvin (seated), Jon E. Spencer (left), and Richard A. Trapp search the bibliographic database.

right: Robin Frisch-Gleason (left) and Raymond C. Harris examine map showing earth fissures.

ARIZONA GEOFACT

SINCE 1945 THE LAND SURFACE HAS SUBSIDED BY MORE THAN 15 FEET IN TWO PARTS OF CENTRAL ARIZONA BECAUSE GROUND WATER HAS BEEN PUMPED FASTER THAN NATURAL RECHARGE COULD OCCUR.

Earth science education

Staff geologists, primarily T. G. McGarvin, provided information about Arizona geology to science and earth science teachers and teacher groups. Special emphasis was given to presentation of workshops and fieldtrips at the annual meetings of the Arizona Science Teachers Association and the Arizona Association for Learning in and about the Environment.

Down-to-Earth reports

Down-to-Earth 5, a collection the writings of Dr. H. Wesley Peirce, was released. Dr. Peirce, who devoted his entire professional career to the study of Arizona geology as an employee of the AZGS and its predecessors, commonly wrote about the impact of "things geologic" on our daily lives. Robin Frisch-Gleason compiled and edited the report.

Down-to-Earth 3, *Land Subsidence and Earth Fissures in Arizona*, was awarded the John C. Frye Memorial Award in Environmental Geology for 1996. The award is given annually to recognize the outstanding paper in environmental geology published by either the Geological Society of America or a State geological survey during the preceding three years. The paper must provide substantive information about a geologically based environmental problem or issue in a manner that is understandable and directly useable by geologists and other professionals. The award was presented to Steven Slaff, author of the publication, at the Annual Meeting of the Geological Society of America in Denver in October 1996.

Lectures and talks

American Emergency Services Association (24th Annual Conference, Phoenix)
L. D. Fellows: two talks on geologic hazards in Arizona.

American Institute of Mining Engineers (annual meeting of Arizona Conference, Tucson)
S. M. Richard: reconstruction of Tertiary extension in the Ray-Superior area.

American Society of Civil Engineers (Annual Meeting of Arizona Section, Tucson)
L. D. Fellows: land subsidence and earth fissures in Arizona.

Arizona Association for Learning in and about the Environment (Fall Conference, Prescott)
T. G. McGarvin, co-presenter of a talk and fieldtrip entitled "Isn't geology wonderful?"

Arizona Department of Mines and Mineral Resources (Mining Rendezvous, Phoenix)
T. G. McGarvin: information and services available at Arizona Geological Survey.

Arizona Division of Emergency Management (Seismic Sleuths Class, Prescott)
L. D. Fellows: geology of Arizona.

Arizona Geological Society
J. E. Spencer: Arizona's Cenozoic geologic history.

Desert Gold Diggers
T. G. McGarvin: geology of the Snoozer claim.

Federal Emergency Management Agency and Arizona Division of Emergency Management (State and Federal Response and Recovery Workshop, Phoenix)
P. A. Pearthree: geologic hazards in Arizona.

Geological Society of America (Annual Meeting, Denver)
J. E. Spencer: reinterpretation of the Bouse Formation as lacustrine.

Grand Canyon University (geology class, Glendale)
L. D. Fellows: geology of Arizona.

National Science Teachers Association (Regional Conference, Phoenix)
T. G. McGarvin: workshop on rock and mineral identification.

North-Central Arizona Math and Science Conference (Prescott)
T. G. McGarvin: down-to-earth geology.

Rincon Institute (docent-training program, Tucson)
T. G. McGarvin: talk and fieldtrip.

Science and Math Conference (Tucson)
T. G. McGarvin: down-to-earth geology.

Tohono Chul Park (docents-in-training class, Tucson)
T. G. McGarvin: logic in geologic processes.

Tucson High School (D. T. Smith Science Resource Center)
T. G. McGarvin: the logic in geologic processes.

University of Arizona
P. A. Pearthree: paleoseismology and earthquake hazards in the intermountain West, to Department of Geosciences.

J. E. Spencer: uplift of the Colorado Plateau and Basin and Range geology, to Department of Geosciences.

T. G. McGarvin: basic geologic concepts, to Science Concepts.

Western Association of Map Libraries
(Annual Meeting in Tempe)
L. D. Fellows: State geological surveys.

Other service to the public and profession

American Geophysical Union
J. E. Spencer: reviewed a manuscript that was submitted for publication.

Arizona Geological Society
J. E. Spencer: Secretary
Spencer, Richard, Pearthree, McGarvin worked on Arizona Geologic Highway Map.

S. M. Richard: Fieldtrip Chairman, organized trip to San Manuel and Mammoth mines and prepared trip guide; organized trip to Quitovac, Sonora and Ajo, Arizona and prepared trip guide.

Arizona Council for Earthquake Safety
L. D. Fellows: vice-chairman of the Executive Committee.

P. A. Pearthree: associate member and member of the geotechnical subcommittee.

Arizona Floodplain Management Association
P. A. Pearthree: member of the technical committee.

Arizona State Parks, Cottonwood Chamber of Commerce, and U.S. Forest Service
L. D. Fellows: co-leader of geology fieldtrip to Jerome State Park as part of the annual Verde River Day celebration.

Arizona State University
P. A. Pearthree: on thesis committee of one M.S. student in Department of Geology.

Association of American State Geologists
L. D. Fellows: member of Honorary Members, U.S. Geological Survey Strategic Plan, John C. Frye Award, and Earth Science Education Committees.

Canadian Journal of Earth Sciences
J. E. Spencer: reviewed a manuscript that was submitted for publication.

Colorado School of Mines
J. E. Spencer: led a fieldtrip to the Buckskin Mountains for geology class.

Geological Society of America
S. M. Richard: reviewed two manuscripts that were submitted for publication.

National Science Foundation
J. E. Spencer: reviewed a proposal that was submitted for funding.

Pima County Flood Control District
P. A. Pearthree: member of the Advisory Committee.

Tohono Chul Park
T. G. McGarvin: led a docent-in-training fieldtrip to observe geologic features in the Tucson area.

United States Geological Survey
P. A. Pearthree: reviewed three funding proposals for Earthquake Hazards Program; member of the young-fault mapping team.

J. E. Spencer: reviewed a proposal for mineral deposits research.

S. M. Richard: reviewed a geologic map that was being prepared for publication.

University of Arizona
P. A. Pearthree: on thesis committee of one doctoral candidate in Department of Geosciences.

J. E. Spencer: led portions of a fieldtrip to the Buckskin Mountains for a group of exploration geologists.

MAPPING AND INVESTIGATIONS

GEOLOGIC MAPPING

Mesa Quadrangle. Arizona Geological Survey (AZGS) geologists completed detailed maps of bedrock and surficial geology in the northwestern quadrant of the Mesa 1° x 2° Quadrangle, including the New River Mesa (surficial), Humboldt Mountain (surficial), Bartlett Dam, Horseshoe Dam, Cave Creek, and Wildcat Hill (7.5 minute) Quadrangles. A geologic map of the North Butte (7.5 minute) Quadrangle and a compilation map of the Mesa 30' x 60' Quadrangle (southwestern quadrant of the Mesa 1° x 2° Quadrangle) were also released. This mapping was done as part of the National Geologic Mapping Program, a cooperative effort between State geological surveys and the U.S. Geological Survey. Mapping priorities were determined by

ARIZONA GEOFACT

AT LEAST ONE EARTHQUAKE HAS OCCURRED IN 12 OF ARIZONA'S 15 COUNTIES SINCE 1960.

an advisory committee composed of representatives of land- and resource-management agencies. Mapping was done by geologists J. E. Spencer, P. A. Pearthree, S. M. Richard, C. A. Ferguson, W. G. Gilbert, R. S. Leighty, and S. J. Skotnicki.

Digital maps. Geologic maps of the Phoenix North, Phoenix South, and Salome (30' x 60') Quadrangles were digitized as part of the National Cooperative Geologic Mapping Program administered by the U.S. Geological Survey. Digitizing was done by J. T. Thieme and Kraig Korroch under the direction of S. M. Richard.

Arizona Highway 88. In anticipation of widening and straightening Highway 88 northwest of Globe, the Arizona Department of Transportation contracted with the AZGS to prepare a detailed geologic map along the highway. Mapping was done by S. J. Skotnicki.

Other areas. The AZGS released maps prepared by AZGS and other geologists of the Plomosa Pass area (La Paz County), a portion of the Rio Salado Development District (Maricopa County), Gila Bend Mountains near Woolsey Peak and Signal Mountain (Maricopa County), the Ripsey Wash area (Pinal County), House Mountain summit area (Yavapai County), and the Cholla Tank and northern Hoodoo Well Quadrangles (Yuma and La Paz Counties). Staff also updated the geologic map of the Little Horn 30' x 60' Quadrangle.

River navigability. The Arizona State Land Department was directed by the Legislature to determine which rivers were navigable at the time of Statehood (1912). The AZGS worked under subcontract to review the geomorphology, hydrology, and historical changes in the Santa Cruz and Bill Williams Rivers. P. A. Pearthree directed the project, with assistance from P. K. House and M. L. Wood.

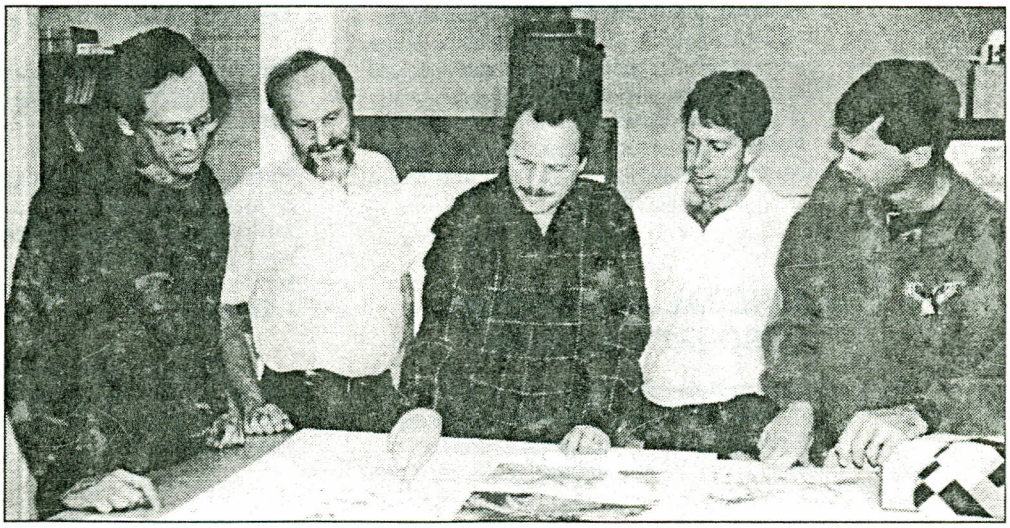
GEOLOGIC HAZARDS AND LIMITATIONS STUDIES

Earthquakes in Flagstaff area. The AZGS released Bulletin 200, which summarized the seismic hazard in the Flagstaff area. The study included a detailed investigation of the Bellemont fault on Camp Navajo, west of Flagstaff, and reconnaissance investigations of many other faults in the vicinity. About 50 faults in that area have been active in the past 5 million years and about 15 in the past several hundred thousand years. The Bellemont fault, one of the most active, has generated several large earthquakes (magnitude about 7) in the past 500,000 years. The area has many young faults, each of which generates large earthquakes very infrequently. Large earthquakes have probably occurred in the area *on average* once every few thousand years.

Several probabalistic seismic hazard scenarios were developed for the region using these fault data. Results of the scenarios are consistent with most other probabilistic assessments and indicate that seismic hazard is moderate. Although large quakes and strong ground shaking do occur in the area, their rate of occurrence is fairly low.

The project was completed by P. A. Pearthree, K. R. Vincent, R. Brazier, and D. M. Hendricks, in cooperation with the Federal Emergency Management Agency and the Arizona Division of Emergency Management.

Hurricane fault. The AZGS and the Utah Geological Survey began a cooperative research project to evaluate seismic hazards associated with the Hurricane fault in southwestern Utah and northwestern Arizona. The research is funded jointly by the two state geological surveys and the National Earthquake Hazard Reduction Program administered by the U.S. Geological Survey. This



Geologists Charles A. Ferguson (left), Stephen M. Richard, Jon E. Spencer, Steven J. Skotnicki, and Philip A. Pearthree review highway geology map.

study will significantly improve understanding of seismic hazards in this rapidly growing region so the information obtained can be incorporated into design standards and construction practices.

P. A. Pearthree is principal investigator of the Arizona portion of the study. H. D. Stenner, a graduate student at Arizona State University, began to collect field data to estimate the fault slip rate at several places along the fault, assess how much of the fault has ruptured in individual large prehistoric earthquakes, and estimate the age and size of those quakes. Stenner was assisted by K. L. Moshenberg.

Uranium content of rocks. Radon, a colorless, odorless radioactive gas, is produced by the natural radioactive decay of uranium. Radon has the potential to be hazardous if it is present in sufficient quantities and inhaled over prolonged periods. Indoor-radon levels generally correlate with the amount of uranium in underlying rocks and soil. The geology and uranium content of rocks were studied in the Cave Creek and Carefree areas on the northeastern edge of metropolitan Phoenix. Results of the study were released as Open-File Report 97-6. A similar study was done in the San Carlos, Safford, and Duncan areas. R. C. Harris measured uranium concentrations using a portable gamma-ray spectrometer. The Cave Creek-Carefree study was done in cooperation with the Arizona Radiation Regulatory Agency, with partial funding from the U.S. Environmental Protection Agency.

Water quality in San Carlos-Safford-Duncan area. The distribution and character of rock formations are being studied relative to the natural quality of surface and ground water. The study, in cooperation with the Arizona Department of Environmental Quality, is partially funded by the U.S. Environmental Protection agency. Work on the project was being done by geologist R.C. Harris.

Geologic model for lower Cienega basin. S. M. Richard and R. C. Harris prepared a series of cross sections, based on gravity and magnetic recordings, for use by hydrologists to model ground-water movement. The project, partially funded by the Arizona Department of Water Resources' Water Protection Fund, was released as Open-File Report 96-21.

MINERAL AND ENERGY RESOURCE STUDIES

Eastern Holbrook basin. Many shows of oil and gas have been recorded in the eastern Holbrook basin in east-central Arizona. S. L. Rauzi compiled well information in this 6,000-square-mile area and prepared structural sections and maps showing the thickness and distribution of sedimentary rock units. His conclusion, summarized in Open-File Report 96-25, is that pre-Permian units, especially along the unexplored southwestern margin of the Defiance positive area, have good potential for commercial accumulations of oil and gas.

MAPS AND REPORTS RELEASED BY THE ARIZONA GEOLOGICAL SURVEY

(AZGS authors are shown in bold type.)

Chenoweth, W. L., 1996, The geology and production history of the Tract 11 and Tract 17 uranium mines, Navajo County, Arizona: Arizona Geological Survey Contributed Report 96-A, 10 p.

_____, 1997, The geology and production history of the Starlight and Starlight East uranium mines, Navajo County, Arizona: Arizona Geological Survey Contributed Report 97-B, 12 p.

_____, 1997, The geology and production history of the Sunlight and South Sunlight uranium mines, Navajo County, Arizona: Arizona Geological Survey Contributed Report 97-A, 12p.

Damon, P. E., Shafiqullah, M., **Harris, R. C.**, and **Spencer, J. E.**, 1996, Compilation of unpublished Arizona K-Ar dates from the University of Arizona Laboratory of Isotope Geochemistry, 1971-1991: Arizona Geological Survey Open-File Report 96-18, 56 p.

Dickinson, W. R., 1996, Geologic map of the Ripsey Wash area, Pinal County, Arizona: Arizona Geological Survey Contributed Map 96-B, 7 p., 1 plate, scale 1:24,000.

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ARIZONA GEOFACT

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ARIZONA GEOFACT

VOLCANIC ERUPTIONS HAVE OCCURRED COMMONLY IN WHAT IS NOW ARIZONA DURING THE LAST 40 MILLION YEARS.

Spectacular columns of lithified volcanic deposits are exposed in Chiricahua National Monument.

OIL AND GAS

OIL AND GAS CONSERVATION COMMISSION

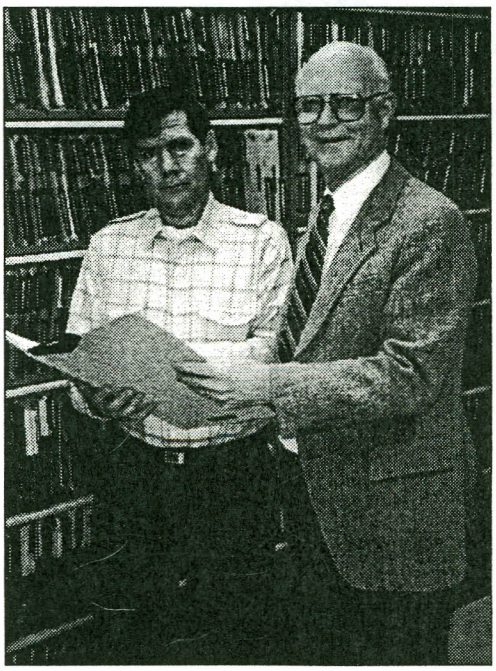
The Arizona Oil and Gas Conservation Commission (OGCC), which regulates the drilling for and production of oil, gas, helium, and geothermal resources, consists of five members appointed by the Governor and one ex-officio member, the State Land Commissioner. The AZGS provides administrative and staff support.

Commission members were J. Dale Nations, Flagstaff, Chairman; Donald C. Clay, Yuma; James C. Lanshe, Paradise Valley; Zed Veale, Flagstaff; Lisa C. Worthington, Phoenix; and J. Dennis Wells, Land Commissioner. The Commission held one special meeting in St. Johns to learn about the status of drilling for carbon dioxide there and two regular meetings.

PRODUCTION, REFINING, AND STORAGE

Oil production totaled 84,047 barrels from 22 producing wells, up from 71,067 barrels in 1995. Gas production totaled 464 million cubic feet from 7 producing wells, down from 558 million cubic feet in 1995. Thirteen oil wells, 4 gas wells, and 1 disposal well were shut-in, and 3 disposal wells were active at year-end.

The Intermountain Refinery near Fredonia delivered no product in 1996. Receipts included 2,094 barrels of #4 burner fuel and 162 barrels of red diesel, but no crude oil. The refinery was removed from active status on January 1, 1997.



Steven L. Rauzi (left), Oil and Gas Program Administrator, and Larry D. Fellows, Director and State Geologist, examine oil and gas files.

Liquified petroleum gas (LPG) transferred through storage wells near Luke Air Force Base and Adamana included 86 million gallons in receipts and 75 million gallons in deliveries, down from 88 million gallons received and 101 million gallons delivered in 1995. About 40 million gallons of LPG were in storage at year-end, up from the 30 million gallons the previous year. Fourteen storage wells constructed in subsurface salt were in operation.

LEASING

State Trust Land under lease on June 30, 1997, totaled 333,000 acres, up from 243,000 acres in June 1996. Most of this increase is due to leasing in southern Apache County where interest in the potential for CO_2 between St. Johns and Springerville remains strong. Public land under lease on June 30, 1997, totaled 78,000 acres, down from 99,000 acres in June 1996. The State Land Department administers leasing on State Trust Land. The U.S. Bureau of Land Management administers leasing on public lands.

DRILLING

Twelve wells were drilled, 1 for oil and 11 for CO_2. The oil test, drilled by PetroSun Exploration in July 1996 about 15 miles north of Concho, is currently shut-in. The CO_2 wells were drilled by Ridgeway Arizona Oil Corporation to determine the extent and amount of CO_2 between St. Johns and Springerville. Ridgeway is currently testing these wells to determine whether CO_2 can be produced commercially.

INSPECTION AND ENFORCEMENT

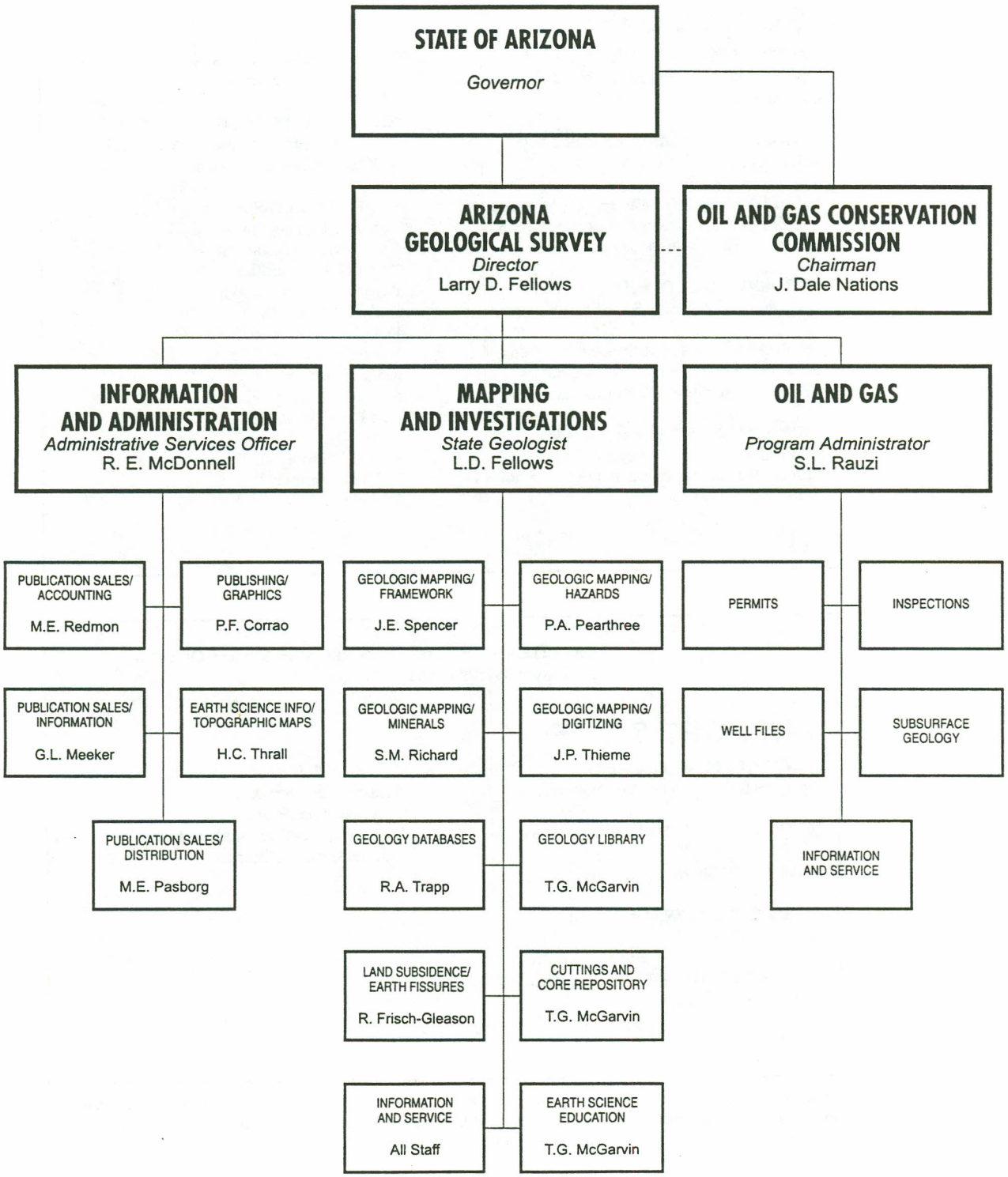
Thirty-nine well inspections were made. Semi-annual safety inspections were made of the 14 hydrocarbon-storage wells near Luke Air Base and Adamana. The wells drilled near Concho, St. Johns, and Springerville were inspected to observe the circulation of cement and to ensure that blowout-control equipment functioned properly.

SUBSURFACE DATA

The OGCC requires subsurface data, including rock samples, logs, and testing results, to be submitted for filing and archiving at the AZGS. This drilling data adds to the general understanding of Arizona's geologic framework and subsurface mineral and energy resources. The AZGS maintains a series of maps that show the locations of these wells and the types of subsurface data that are available for examination.

Samples from 10 oil and gas wells were added to the AZGS sample repository. Two well-location maps were updated.

ORGANIZATION AND FUNCTIONS, FY 1997



PERSONNEL

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

GEOLOGISTS

ROBIN FRISCH-GLEASON, Geologist II.
B.A., Oberlin College; M.S., Vanderbilt University.

THOMAS G. McGARVIN, Geologist I.
B.A., California Lutheran College.

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

STEVEN L. RAUZI, Oil and Gas Program Administrator. B.S. and M.S., Utah State University.

STEPHEN M. RICHARD, Research Geologist.
B.S. and M.S., University of Arizona; Ph.D., University of California, Santa Barbara.

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

JENNIFER P. THIEME, Geologist I.
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RICHARD A. TRAPP, Geologist II.
B.S., University of Nebraska, Omaha; M.S., University of Arizona.

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Karen A. Demsey, M.S.
Charles A. Ferguson, Ph.D.
Wyatt G. Gilbert, Ph.D.
Raymond C. Harris, M.S.
P. Kyle House, Ph.D.
Douglas A. Howard, B.S.
Jeanne E. Klawon, B.S.
Kraig M. Korroch, B.S.
Robert S. Leighty, Ph.D.
Kari L. Moshenberg
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Michelle L. Wood, B.S.

ROSE ELLEN McDONNELL, Administrative Services Officer II.
B.S., University of Arizona.

SUPPORT STAFF

PETER F. CORRAO, Program and Project Specialist II. B.A., Arizona State University.

GEORGEANNA L. MEEKER, Secretary.

MARY E. PASBORG, Secretary.

MARY E. REDMON, Administrative Assistant III.

HEATHER C. THRALL, Project Geologist.
B.A., University of Arizona

OTHERS EMPLOYED
Margaret L. Elias, Secretary
Terry A. Gilmore, Secretary
Rosemerry Koether, Student Aide
Dianne Murray, Librarian I

Persons listed above were employed June 30, 1997. The agency is authorized to employ 13.25 full-time-equivalent staff members with appropriated General Revenue funds. Some of the employees listed above were paid partly or entirely from external funds.

BUDGET

GENERAL FUND

Category	FY 1996 Expended	FY 1997 Expended	FY 1998 Budgeted
Personal Services	413,033	426,573	451,300
Benefits	82,087	81,374	82,600
Operations	179,342	183,755	186,600
In-State Travel	15,276	26,136	37,800
Out-of-State Travel	1,608	2,500	2,000
Capital Equipment	62,987	22,413	15,100
TOTAL	754,333	742,752	780,000

PRINTING REVOLVING FUND

Revenue				Total
Received during FY 1997				59,485
	Personal Services	Benefits	Operations	Total
Expenditures				
Arizona Geological Survey	3,201	2,290	26,263	31,754
Arizona Geological Society	0	0	8,547	8,547
U.S. Geological Survey	57	12	8,852	8,921
Other Publications	0	0	160	160
TOTAL EXPENDITURES	3,258	2,302	43,822	49,382

CONTRACTED PROJECTS

Project (Fund Source)	Principal Investigator	Personal Services	Benefits	Operations	In-State Travel	TOTAL
Uranium Levels in Rocks (U.S. Environmental Protection Agency)	Spencer	21,835	2,868	1,729	0	26,432
Earth Science Information Center (U.S. Geological Survey)	McDonnell	24,728	5,012	0	0	29,740
Geologic Mapping Phoenix Quadrangle (U.S. Geological Survey)	Spencer	71,223	11,534	13,269	5,664	101,690
Paleosesmicty and Seismic Hazard (U.S. Geological Survey)	Pearthree	2,842	278	48	197	3,365
Printing and Distribution (Arizona Geological Society)	McDonnell	0	0	911	0	911
Sugar Loaf Fault (AZ Dept. of Transportation)	Pearthree	0	0	0	160	160
Geologic State Highway Map (University of Arizona, School of Natural Resources)	Richard	0	0	2,943	0	2,943
Cienega Basin (AZ Water Protection Fund)	Richard	1,141	225	0	0	1,366
Geologic Mapping - Wheatfield (AZ Dept. of Transportation)	Spencer	2,305	308	248	0	2,861
River Navigability (Sabol Consulting Engineers, Inc.)	Pearthree	7,016	723	632	21	8,392
Paleoflood Study (JEF, Inc.)	Pearthree	399	40	0	0	439
Growler Wash Survey (Geraghty & Miller, Inc.)	Pearthree	5,235	527	875	221	6,858
Nonpoint Source (AZ Dept. of Evinronmental Quality)	Richard	14,768	2,295	1,089	145	18,297
New Verde River (Desert Reserarch Insitute)	Pearthree	4,487	440	0	0	4,927
San Pedro Navigability (JEF, Inc.)	Pearthree	832	80	309	36	1,257
TOTAL EXPENDITURES		156,811	24,330	22,053	6,444	209,638

Governor
Jane Dee Hull

Arizona Geological Survey Staff

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

Information
Rose Ellen McDonnell, B.S., Administrative Services Officer
Georgeanna L. Meeker, Secretary
Peter F. Corrao, B.A., Graphics Supervisor
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Mary E. Pasborg, Secretary
Mary E. Redmon, Publication Sales Manager

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Thomas G. McGarvin, B.A., Geologist I
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Stephen M. Richard, Ph.D., Research Geologist
Jon E. Spencer, Ph.D., Research Geologist
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Oil and Gas
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