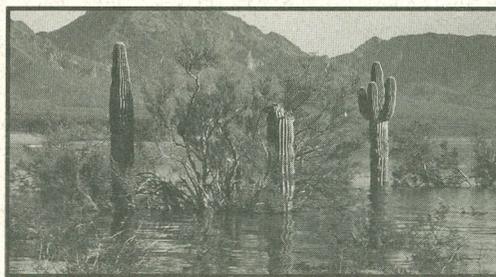


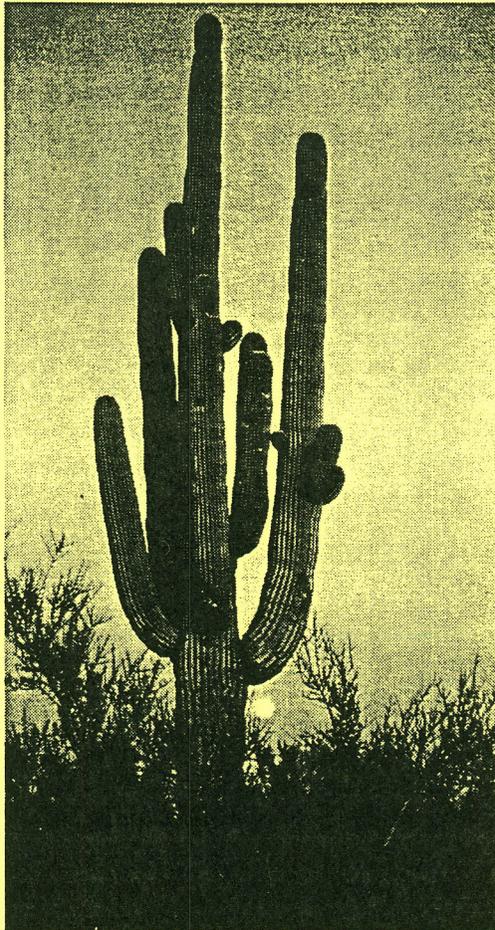
ARIZONA GEOLOGICAL SURVEY



ANNUAL REPORT FY 1992-93



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**ARIZONA GEOLOGICAL SURVEY
OPEN-FILE REPORT**

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

ANNUAL REPORT

**FY 1992-93
ARIZONA GEOLOGICAL SURVEY**



Fife Symington
Governor

State of Arizona
Arizona Geological Survey

845 North Park Avenue, #100
Tucson, Arizona 85719
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Larry D. Fellows
Director and State Geologist

September 20, 1993

The Honorable Fife Symington
Governor of Arizona
Arizona State Capitol
1700 West Washington Street
Phoenix, AZ 85007

Dear Governor Symington:

It is a pleasure to submit this Annual Report of the Arizona Geological Survey (AZGS) for Fiscal Year 1992-93.

The AZGS' mission is to encourage and assist stewardship of Arizona's land, water, mineral, and energy resources. To fulfill this mission, staff prepare geologic maps, conduct investigations, archive and maintain data, and provide information and assistance. Maps, reports, and data that are generated, together with information, interpretations, and assistance that are provided, serve as the basis for *informed* land- and resource-management decisions. On behalf of the Arizona Oil and Gas Conservation Commission, staff assist in regulating the drilling and production of oil, gas, helium, and geothermal resources.

During the year staff provided information and assistance to nearly 10,000 individuals and groups and completed and released 31 reports, maps, and abstracts in which Arizona's geology and mineral resources were described. AZGS geologists also worked on 12 cooperative investigations that were partially funded by other governmental agencies.

Subjects of the studies that were undertaken included piedmont flooding in the Phoenix area; land subsidence, earth fissures, and potential for ground-water pollution in Pinal County; radon gas potential throughout the State; and the distribution and character of bedrock, rock-derived materials, and mineral resources in west-central Arizona.

The need for better understanding of Arizona's geologic character, hazards and limitations, and water, mineral, and energy resources is increasing as the population grows, the economy expands, and competition for land and resources accelerates.

I welcome any questions you and your staff have about the AZGS' mission, activities, or plans, or about the geology and mineral resources of Arizona, in general.

Sincerely yours,

Larry D. Fellows
Director and State Geologist

ARIZONA
GEOLOGICAL
SURVEY

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EXECUTIVE SUMMARY

ANNUAL
REPORT

MAPPING AND INVESTIGATIONS

Arizona Geological Survey (AZGS) geologists completed 31 geologic maps, reports, and abstracts. The AZGS published 17 and professional societies or other groups published 14. In addition, geologists not employed by the AZGS contributed eight maps and reports that the AZGS released. These publications described the distribution and character of bedrock, rock-derived sedimentary deposits, and mineral resources in west-central Arizona; piedmont flooding in the Phoenix area; subsidence, earth fissures, and potential for groundwater pollution in Pinal County; and uranium concentrations and radon gas potential throughout the State.

AZGS geologists worked on 12 cooperative investigations under contract with other agencies and groups. Contracted work was done with the Arizona Department of Environmental Quality (3 projects), Flood Control District of Maricopa County, Arizona Department of Water Resources, U. S. Bureau of Reclamation, U. S. Environmental Protection Agency (2 projects), U. S. Geological Survey (3 projects), and the Arizona Geological Society. All of the contracts required cost sharing, with the AZGS' share provided as in-kind service. Expenditure of contract funds totaled \$178,096.

Substantial progress was made on updating the bibliography of Arizona geology. Key words are being applied to the 11,000 citations, which are also being edited to ensure accuracy and consistency in style and to eliminate duplications. Staff completed a computerized index of all rock cores in the repository and moved the cores to a new location in the State Office Building complex in downtown Tucson.

OIL AND GAS CONSERVATION COMMISSION

AZGS staff administer and enforce the rules and regulations promulgated by the Oil and Gas Conservation Commission, a 6-member governing body whose members are appointed by the Governor. Staff issued two permits to drill and conducted 69 well inspections. At year end Arizona had 22 producing oil wells, 15 producing gas wells, two refineries, and two underground LPG-storage facilities.

INFORMATION AND ASSISTANCE

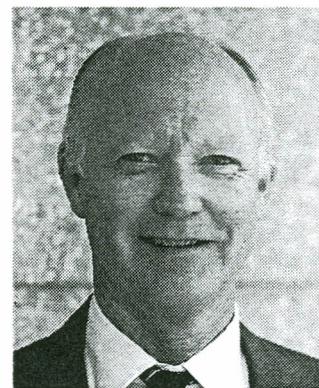
More than 9,700 persons wrote, phoned, or visited the AZGS to buy publications, use the geologic library, or confer with geologists. Requests for information were made by representatives of more than 106 governmental units, 243 companies and consultants, 13 professional societies, 93 universities and colleges, 26 elementary and secondary schools, 18 other groups, and many interested citizens. Publication sales totaled \$28,243.

AZGS staff gave 28 talks and led 8 field trips. The agency published 4 12-page issues of *Arizona Geology*, in which geologists summarized results of investigations, announced the availability of new publications, and described other aspects of the geology, mineral, and energy resources of Arizona. The AZGS and the USGS cooperatively established an Earth Science Information Office to more effectively inform constituents about geologic information available from both agencies.

BUDGET AND PERSONNEL

The AZGS' General Fund appropriation was \$623,900. Combined expenditures from the General Fund (\$622,450), contracted projects (\$178,096), and the printing revolving fund (\$27,644) totaled \$828,190.

The General Fund provided salaries for a team of 14.25 full-time-equivalent geologists and support staff. In addition, 15 part-time, temporary employees were paid from contracted projects.



Dr. Larry D. Fellows
Director and State Geologist
Arizona Geological Survey

ARIZONA GEOLOGICAL SURVEY

PURPOSE

ANNUAL REPORT

HISTORY

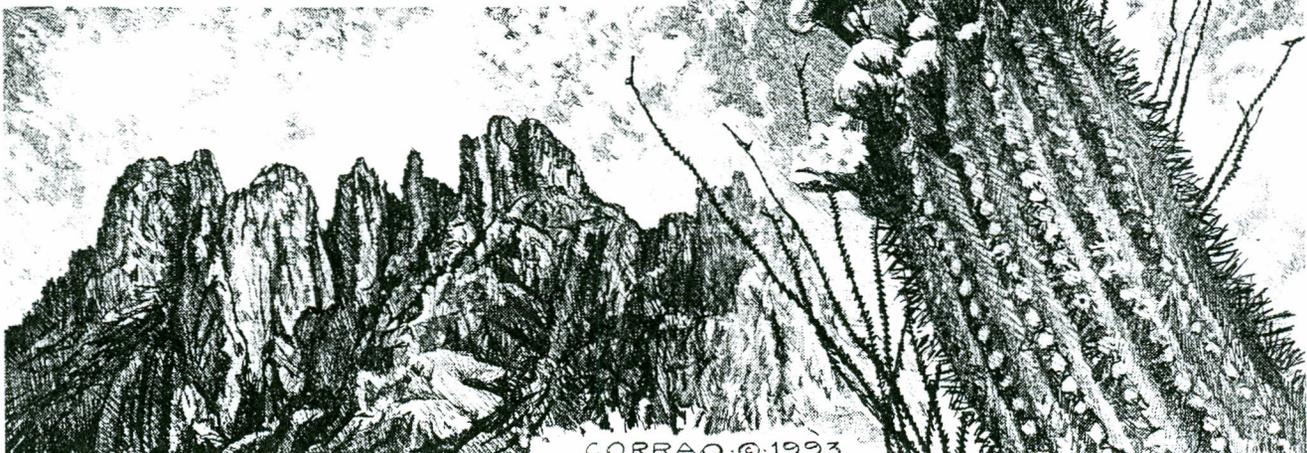
In 1881 the Territorial Legislature created the Office of the Territorial Geologist. After Statehood, functions of that office were continued within the Arizona Bureau of Mines, a State agency administered by the University of Arizona. In 1977, the name of the agency was changed to Bureau of Geology and Mineral Technology, the agency was organized into two branches, and statutory responsibility for geologic hazards and limitations was added. The Geological Survey Branch of the Bureau was redirected by the Legislature, effective July 1, 1988, to become the **Arizona Geological Survey (AZGS)**, a State agency located in Tucson in proximity to the University of Arizona. Responsibility for providing staff support needed by the Arizona Oil and Gas Conservation Commission to regulate the drilling and production of oil, gas, helium, and geothermal resources was assigned to the AZGS by the Legislature in 1991.

MISSION

The mission of the Arizona Geological Survey is to encourage and assist stewardship of Arizona's land, water, mineral, and energy resources by conducting investigations and providing geologic information that serves as the basis for informed land- and resource-management decisions.

OBJECTIVES

- Serve as a primary source of geologic information in this state.
- Inform the public in matters concerning the geological environment and the development and use of the mineral resources of this state.
- Provide technical advice and assistance in geology to other state and local governmental agencies engaged in projects which involve the geologic setting or the mineral resources of the state.
- Provide technical advice and assistance in geology to industry and other members of the public toward the wise development and use of the mineral and land resources of this state.
- Encourage the wise use of the lands and mineral resources of this state toward its development.
- On behalf of the Arizona Oil and Gas Conservation Commission, encourage development and conservation of oil, gas, helium, and geothermal resources.
- On behalf of the Arizona Oil and Gas Conservation Commission, safeguard the health, property, and public welfare of citizens of Arizona relative to the drilling and production of oil, gas, helium, and geothermal resources.



GEOLOGIC MAPPING AND FRAMEWORK

AZGS geologists investigate Arizona's geologic framework, including the age, origin, distribution, and character of rocks and rock-derived materials, such as gravel, sand, and clay. Results of these studies are made available to the public. Maps and reports that are prepared are used routinely by those who explore for and produce metallic, nonmetallic, and energy resources; manage State Trust and Public land; and site, plan, construct, operate, and maintain water-supply, waste-disposal, residential, industrial, transportation, and other facilities.

Bedrock geology. Detailed geologic mapping continued in the Phoenix 1° x 2° Quadrangle, which extends from Phoenix almost to Quartzsite and from Wickenburg to Gila Bend. For the ninth consecutive year, mapping was done as part of the Cooperative Geologic Mapping Program (COGEMAP), a 50-50 matched funding program between the U. S. Geological Survey (USGS) and State geological surveys. Bedrock geologic mapping was done under the direction of Dr. Jon E. Spencer, with substantial participation and contribution by Dr. Stephen M. Richard. Funding for cooperative geologic mapping projects with the USGS in Fiscal Year (FY) 1993-94 will be from the STATEMAP component of the National Geologic Mapping Program, which was established in 1992.

Bedrock geologic maps of the central Gila Bend Mountains, Saddle Mountain, and western Harcuvar Mountains were completed and released in the Open-File Report (OFR) Series (OFR 93-5, 93-6, and 93-8, respectively). In addition, maps of the Imperial Reservoir, Red Hill NE, and Red Hill Quadrangles were completed and released as OFR 92-11, 92-12, and 92-14, respectively.

Field work was completed in the southern Plomosa, northwestern Eagletail, and Painted Rock Mountains, and Oatman and Face Mountain. Maps of these areas are in preparation. Additional field work in the Harcuvar Mountains was directed at understanding tectonic processes associated with crustal extension. Compilation maps of the Phoenix North and Phoenix South Quadrangles are being drafted for publication at 1:100,000 scale.

Surficial geology. Surficial geologic mapping involves defining the character and mapping the distribu-

tion of surficial deposits in areas where bedrock is not exposed. Surficial deposits cover much of central, southern, and western Arizona, including nearly all of the Phoenix and Tucson metropolitan areas. The character of these deposits, such as the amount of clay, silt, sand, gravel, and calcium carbonate (caliche) in near-surface horizons, has implications for construction practices, extent of flood-prone areas, and potential for groundwater recharge. In the surficial geologic mapping program emphasis is placed on large-scale (1:24,000) mapping in urban and developing areas and intermediate-scale (1:100,000 or 1:250,000) mapping in larger regions.

AZGS geologists, under the supervision of Dr. Philip A. Pearthree, have been mapping the surficial geology of Arizona during the past four years in cooperation with the USGS COGEMAP. Federal support for surficial geologic mapping will continue in the FY 93-94 under the STATEMAP component of the National Geologic Mapping Program.

During FY 92-93, surficial geologic maps were completed along the Gila River in Pinal County and released as OFR 92-7 and 93-3. In a related effort, AZGS geologists mapped the surficial geology and the generalized bedrock geology along the Verde River upstream from Horseshoe Reservoir to define the geologic setting of riparian areas. The maps (five sheets) were released as OFR 93-4. This project was funded by the U.S. Environmental Protection Agency (EPA). Maps of the Red Rock basin and the Tortolita piedmont northwest of Tucson are being drafted for publication. Mapping is in progress in the Sierra Vista area, the Queen Creek - Apache Junction area, and in the Verde Valley in central Arizona.

GEOLOGIC HAZARDS AND LIMITATIONS

An important responsibility of the AZGS is to investigate geologic processes that may be hazardous to human life or property and geologic conditions that may limit land and resource use and development. Because cities, transportation networks, and homes are built on geologic substrates, they are affected by geologic processes and materials. By understanding the geology and geologic processes, one can make informed land-management decisions and avoid future damage and disasters. Flooding, earthquakes, land subsidence and

earth fissures caused by ground-water withdrawal, landslides, and debris flows can be hazardous or restrict usage of Arizona's land and resources. Unstable soils and indoor accumulation of radon gas are also potentially hazardous. The geologic character of Arizona strongly influences the amount of ground water that is available, the extent of flood-prone land, and the availability of essential resources. Dr. Philip A. Pearthree supervised all of the investigations described below, except for the uranium and radon studies, which were directed by Dr. Jon E. Spencer.

Piedmont floods.

The AZGS cooperated with local floodplain management agencies and the Arizona Department of Water Resources (ADWR) to define the nature and extent of flood hazards in Arizona. Emphasis was given to piedmont flooding. Piedmonts are gently-sloping aprons that ring the mountain ranges of central, southern, and western Arizona. Many cities and urban-fringe areas are built on piedmonts. Assessing flood hazards on piedmonts is challenging, primarily because floodwaters on alluvial fans may inundate broad areas or may shift dramatically from one part of the fan to another. It is essential to accurately and realistically define piedmont areas that are subject to alluvial-fan flooding prior to development so that future disasters can be avoided.

The AZGS has conducted geologic and geomorphic analyses to learn more about the character of flooding and the extent of flood-prone areas on the piedmonts of Arizona. In conjunction with local flood-control districts and communities, the AZGS studied flood hazards on piedmonts in Pima County and Maricopa County. On the basis of these studies, AZGS geologists concluded that 100-year floodplain areas outlined by the Federal Emergency Management Administration include broad areas where the risk of flooding is very low. A geomorphic analysis of flood hazards on the northern McDowell Mountains piedmont was released as OFR 92-8. The AZGS cooperated with the Flood Control District of Maricopa County to evaluate how frequently positions of channels have shifted on three active alluvial fans in Maricopa County. Studies of the character of flooding on piedmonts in southern and central Arizona are continuing.

Many Arizona rivers produced record or near-record floods during January and February of 1993. AZGS geologists began a study of the recent floods on the Verde and Salt rivers in cooperation with the Salt River Project. Geologists will estimate the peak discharges of these floods and compare them with the largest floods that have occurred on these rivers in the past.

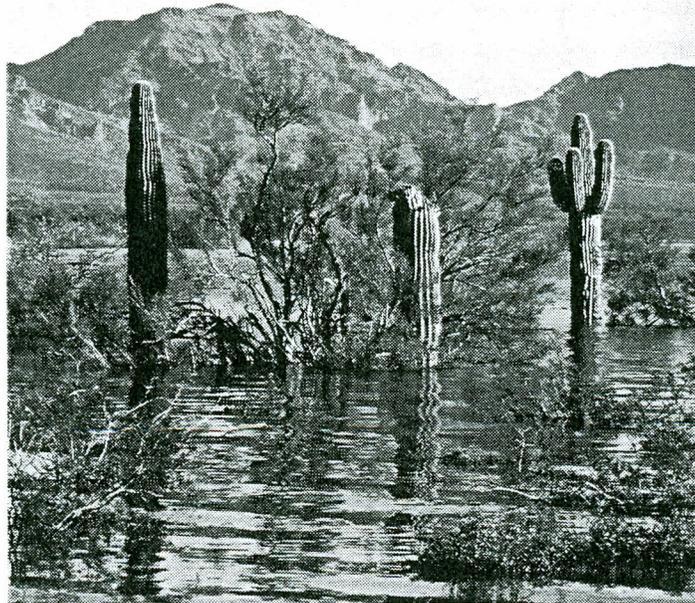
Earthquakes. The AZGS has conducted research on earthquake hazards in Arizona for many years. During the past year, AZGS geologists worked with the Arizona

Division of Emergency Management (ADEM) to develop an earthquake-preparedness program. AZGS geologists participated in the formation of the Arizona Council for Earthquake Safety, whose purpose is to increase public awareness of earthquake hazards and to facilitate earthquake preparedness. AZGS geologists gave presentations at several public forums that were held to increase awareness of seismic hazards. The AZGS, in conjunction with ADEM and the

three State universities, prepared a pamphlet in which earthquake hazards in Arizona are summarized. In addition, several articles pertaining to earthquake hazards were published in *Arizona Geology*.

The AZGS currently has two earthquake-hazards projects underway. AZGS geologists are compiling a bibliography and database of earthquake hazards in Arizona with funding from the ADEM. AZGS geologists are compiling a map of active faults in the State for inclusion in a world-wide database of active faults that is being developed by the USGS.

Subsidence and earth fissures. Land subsidence and the development of earth fissures in some of the alluvial basins in central, southern, and western Arizona have caused many structural and other problems. Because rates of ground-water withdrawal have greatly exceeded natural recharge in many basins for years, water-level declines of as much as 500 feet have been recorded locally. Declining water levels have resulted in compaction of basin sediment and subsidence of the land surface by more than 15 feet in two localities. Earth fissures have developed in many of the basins. Earth fissures, which pose a significant hazard to



buildings, highways, railroads, canals, and other structures, may provide avenues for pollutants to reach ground water.

The AZGS has cooperated with the U.S. Bureau of Reclamation for several years in investigations of earth-fissure development adjacent to the Central Arizona Project (CAP) canal in Picacho basin, in south-central Arizona. During the past year, AZGS geologists completed a detailed study of an earth-fissure area near the canal. Results of the study were described in OFR 93-1a and 93-1b. A detailed survey of earth fissures along the southern segments of the canal is in progress. A non-technical publication on subsidence and earth fissures in Arizona has been completed, and is being prepared for publication in the *Down-to-Earth* series.

Potential for ground-water contaminatin. The AZGS, under contract with the Arizona Department of Environmental Quality (ADEQ), assessed potential for groundwater contamination in Pinal County. The DRASTIC methodology, developed for the EPA, was used. Seven parameters were evaluated to determine potential for ground-water contamination. Parameter maps were digitized and integrated by the Advanced Research Technology Program of the University of Arizona. The resulting integrated DRASTIC maps show variations in the potential for ground-water contamination throughout Pinal County.

Radon. Two reports on uranium levels in rock and surficial materials in Arizona were published. Because radon gas is generated by the radioactive decay of uranium, buildings constructed on rocks with elevated uranium concentrations are more likely to have higher levels of indoor radon than those constructed on rocks containing less uranium. To address this issue, a collection of technical articles on the distribution of uranium and radon in Arizona was edited and published as Bulletin 199, *Radon in Arizona*. Most of the maps articles included in this Bulletin were released previously as open-file reports. A number of the studies were partially supported by the EPA; one was funded by the ADEQ. This Bulletin provides a firm technical foundation for a basic understanding of the geology of radon in Arizona, and assists in the recognition of potential

radon-hazard areas, especially in centers of population growth. All of the AZGS' radon investigations have been directed by Dr. Jon E. Spencer.

MINERAL AND ENERGY RESOURCES

AZGS geologists prepare geologic maps and undertake field studies to determine relationships between mineral deposits and the geologic framework. Information derived from the studies is used by 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. The AZGS' mineral resources program is directed by Dr. Stephen M. Richard.

An investigation of the geology and mineral resources of the southern Plomosa Mountains was completed and a geologic map of the district is being prepared. Preliminary results of the study were summarized in an oral presentation to the Arizona Geological Society. Field studies in the Kofa District and Little Harquahala District were completed; rock samples are being analyzed to further constrain the timing and structural setting of gold mineralization. A geochemical study of alteration processes that leached copper, manganese, and probably precious metals from volcanic rocks in the Harcuvar Mountains was completed. Results will be published in the journal, *Economic Geology*.

During the past 12 years, AZGS geologists have concentrated their studies of bedrock geology and metallic mineral resources in 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, 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. A bulletin, in which the mineral resources and potential of that area will be described, is being prepared for publication. Most of the articles that will be included have been completed and are being reviewed and edited.

Plans are being made to integrate the presently available mineralization databases, digitized geologic map data, and bibliographic data into a single, online geographic information system which will allow users to quickly obtain geologic information about any specific region of interest.

LIBRARY AND DATABASES

Geologic Library. The AZGS library contains more than 25,000 volumes, including all publications of the AZGS and its predecessors; the Oil and Gas Conservation Commission; other State agencies; state geological surveys in adjacent states; the USGS, the U.S. Bureau of Mines; and other Federal agencies. In addition, the library contains microfiche compilations of unpatented

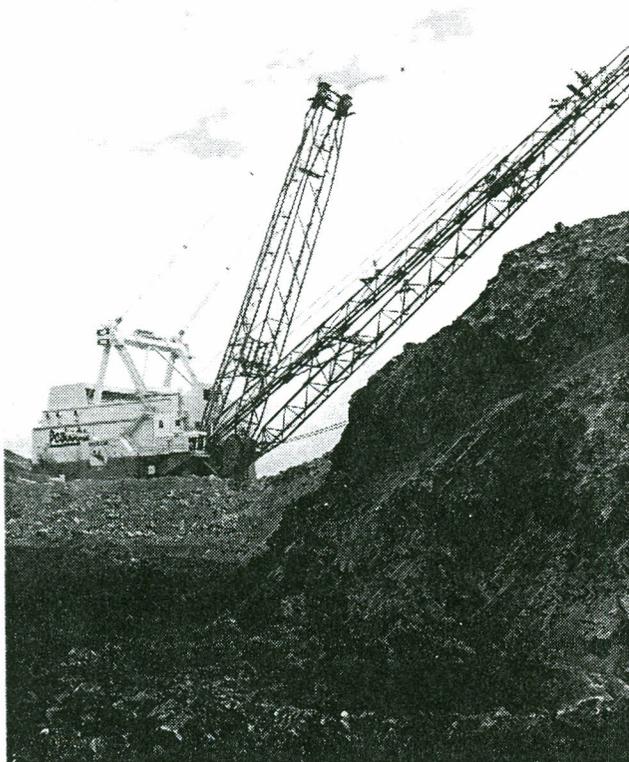
mine claims issued by the U.S. Bureau of Land Management; theses and dissertations on Arizona geology; several technical journal and bulletin series; textbooks; environmental impact statements and reviews; and many unpublished maps and reports on the geology and mineral, water, and energy resources of Arizona. The library, under the supervision of Thomas G. McGarvin, is open to the public.

Arizona Geologic Information System (AGIS). AGIS is a system of computer databases that was developed to store and provide easy access to data on Arizona geology. Data are compiled from original geological investigations and maps completed by AZGS staff and other professionals. Major components of AGIS include GENLIB, a database of AZGS library holdings; AZMIN, a database for metallic mineral districts and production, mine names, and primary and secondary bibliographic references; AZAGE, a compilation of radiometric age determinations; and AZGEOBIB, a bibliography of Arizona geology.

Richard A. Trapp, AGIS manager, continued to apply subject keywords and location information to the 11,000 citations in the AZGEOBIB bibliography. In addition, he is editing the citations to ensure consistency in style, eliminate duplicate entries, and cross-reference AZGEOBIB with AZMIN, the database on Arizona mineral deposits. Work on the bibliography is expected to be completed in a year. Other subject-specific bibliographies, such as an earthquake bibliography, are being constructed by extracting information from AZGEOBIB. A list of stratigraphic names used in Arizona is being compiled for future publication.

Well cuttings and core repository. The AZGS has statutory responsibility for maintaining a central repository for rock cores, well cuttings, and associated supplemental data. Effective July 1, 1991, responsibility for providing staff support to the Oil and Gas Conservation Commission for regulating the drilling and production of oil, gas, geothermal, and helium resources was assigned to the AZGS. Oil and gas statutes require that cuttings be saved during the drilling of these wells and that a set of the cuttings, together with logs and other pertinent information, from each well be provided to the AZGS. These data, including well cuttings, rock cores, and oil and gas production records, are on file at the AZGS and are available for examination by the public.

The repository includes cuttings from approximately 4,000 oil and water wells and mineral tests. Rock cores are available for public inspection. Donations by ASARCO, Homestake Mining Company, and Magma Copper Company were used to re-box and skeletonize cores, and prepare a computerized index of the cores in the collection. The index was released as OFR 93-2. All of the rock cores are now stored in the basement of the State Office Building at 416 West Congress Street.



**PUBLISHED BY THE ARIZONA
GEOLOGICAL SURVEY**

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Geology, radioactivity, and radon at the Cardinal
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central Tucson basin and its relationship to the
hydrogeology: B.D. Smith,* p.17-39.

Uranium and radon in southeastern Arizona:
J.T. Duncan and J.E. Spencer, p. 40-42.

Investigations of uranium and radon in the Phoenix
metropolitan area: J.T. Duncan and J.E. Spencer,
p. 43-50.

Uranium-bearing rocks in Verde Valley, Yavapai County,
and implications for indoor-radon gas: J.T. Duncan and
J.E. Spencer, p. 51-56.

Uranium and radon in the Prescott area, Yavapai
County: J.T. Duncan and J.E. Spencer, p.57-60.

Radiometric and petrochemical characteristics of the
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P. Eshragi,* and S.M. Emric,* p. 86-92.

A survey of uranium concentrations in rocks and soils in
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____ **92-8**, Geomorphic analysis of flood hazards on
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9 p., scale 1:6,000 and 1:12,000, 3 sheets.

____ **92-9**, Apatite and zircon fission-track dates from
the northern Plomosa Mountains, La Paz County, west-
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____ **92-12**, Geologic map of the Red Hill NE Quad-
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____ **92-13**, DRASTIC Analysis of the potential for
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____ **92-14**, Geologic map of Red Hill Quadrangle,
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____ **93-1a**, Gravity and magnetic surveys at Brady
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P.A. Pearthree, 1993, 25 p., scale 1:24,000, 5 sheets.

____ **93-5**, Geologic map of the west-central Gila Bend
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Contributed Map 92-D, Geologic map of the Sycamore Creek region, Maricopa County, Arizona: Steve Skotnicki, 1992, scale 1:24,000.

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Contributed Report 92-C, Geology and production history of the Firelight No.6 uranium mine, Navajo County, Arizona: W.L. Chenoweth,* 1992, 6 p.

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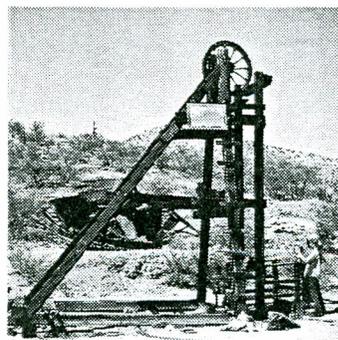
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Geological Society of America, Strength and survival of subducted lithosphere during the Laramide orogeny: J.E. Spencer, 1993, Abstracts with Programs, v. 25, no. 5, p. 149.

_____, Mesozoic pre-thrusting high-angle faults and stratigraphic variations, Plomosa Mountains, W. Arizona: S.M. Richard and J.E. Spencer, 1993, Abstracts with Programs, v. 25, no. 5, p. 138.



_____, Geological insights into deficiencies in federal procedures for flood hazard assessment on alluvial fans: P.K. House, P.A. Pearthree, and K.R. Vincent, 1992, Abstracts with Programs, v. 24, no. 5, p. A284.

_____, The longer-term context of the Nevada Seismic Belt: Patterns of Holocene-latest Pleistocene faulting in central Nevada: P.A. Pearthree, K.A. Demsey*, and S. Hecker*, 1993, Abstracts with Programs, v. 25, no. 5, p. 132.

_____, Temporal and spatial patterns of late Pleistocene-Holocene faulting in Arizona: C.M. Menges* and P.A. Pearthree, 1993, Abstracts with Programs, v. 25, no. 5, p. 119-120.

_____, Tectonostratigraphic map of the Cordilleran orogenic belt, conterminous United States:

S.J. Reynolds** and J.E. Spencer, contributors, in B.C. Burchfiel, 1993, Plate 1A, Geology of North America: DNAG v. G-3, scale 1:2,500,000.

Journal of Geophysical Research, Denudation of metamorphic core complexes and the reconstruction of the Transition Zone, west-central Arizona; Constraints from apatite fission track thermochronology: D.A. Foster,* A.J.W. Gleadow,* S.J. Reynolds,** and P.G. Fitzgerald,* 1993, v.98, p. 2167-2185.

Nature, Paleomagnetic evidence for large-magnitude, low-angle normal faulting in a metamorphic core complex: R.F. Livacari,* J.W. Geissman,* and S.J. Reynolds, 1993, v. 361, p. 56-59.

Proceedings of the Seventh International Fission-Track Dating Workshop, Philadelphia, July 1992, P.G. Fitzgerald,* S.J. Reynolds, E. Stump,* D.A. Foster,* and A.J.W. Gleadow,* in review.

Tectonics, Palinspastic reconstruction of southeastern California and southwestern Arizona: S.M. Richard, accepted for publication.

U.S. Geological Survey, Geologic map and cross section across the boundary between the Colorado Plateau Transition Zone and the Basin and Range southeast of Bagdad, Arizona: B. Bryant,* C.M. Conway,* J.E. Spencer, S.J. Reynolds, J.K. Otten,* and P.M. Blacet,* 1992, Open-File Report 92-428, 23 p., 2 plates, scale 1:100,000.

* Not an employee of the Arizona Geological Survey

** Not employed by the Arizona Geological Survey, but work on this project began while he was an employee.

OIL AND GAS
CONSERVATION COMMISSION

ANNUAL
REPORT

Oil and Gas Conservation Commission (OGCC). The OGCC has statutory responsibility to regulate drilling and production of Arizona's oil, gas, helium, and geothermal resources. The OGCC is composed of five members appointed by the Governor, and the State Land Commissioner, who is an ex-officio member. AZGS staff carry out the policies and rules established by the OGCC.

Commission members at year end were Jan C. Wilt, Tucson, chair; James E. Warne, Jr., Phoenix, vice chair; Barbara H. Murphy, Glendale; J. Dale Nations, Flagstaff; Zed Veale, Flagstaff; and M.J. Hassell, State Land Commissioner. The OGCC held three regular meetings during the fiscal year.

The OGCC, in accordance with requirements of the Governor's Regulatory Review Council, reviewed its drilling and production rules to update and clarify language, edit for consistency, and account for new technology and practices in the regulated industries. Amended rules were sent to the Attorney General for certification.

Production, refining, and liquefied-petroleum-gas (LPG) storage. Oil production in Arizona in 1992 totaled 94,428 barrels from 22 producing wells, down from 110,772 barrels in 1991. Gas production in 1992 totaled 794 million cubic feet from six producing wells, down from 1.3 billion cubic feet in 1991. Fifteen wells were idle at the end of 1992, including two shut-in helium wells at the Dineh-Bi-Keyah Field in northeastern Apache County.

Refineries produced 2.4 million barrels of products, mostly asphalt, diesel fuel, and jet fuel, in 1992. This total is down from 2.5 million barrels in 1991. The Sunbelt Refining Company near Coolidge processes heavy crude oil that comes from California and the North Slope of Alaska in the All-American Pipeline. The Intermountain Refining Company near Fredonia

processes crude oil that is shipped in trucks from the Grant Canyon and Trap Springs fields in Nevada.

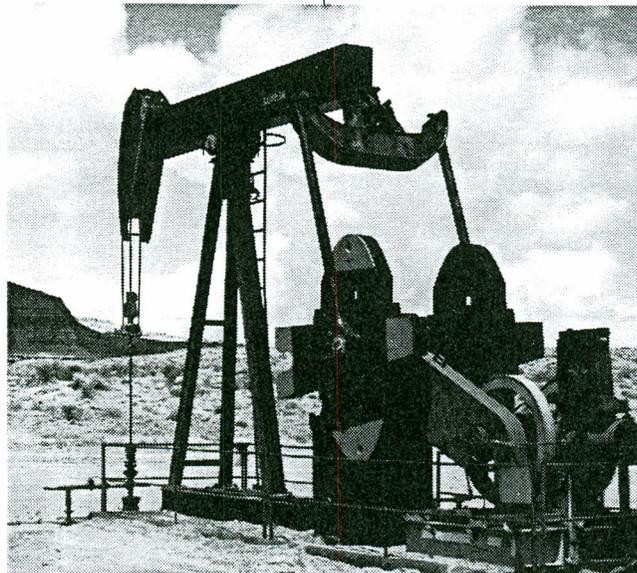
Products transferred through LPG storage-well facilities near Litchfield Park and Adamana in 1992 included about 66 million gallons in receipts and about 50 million gallons in deliveries. About 40 million gallons of propane and butane were in storage at year end.

Oil and gas leasing. Leasing decreased slightly on State Trust land and increased slightly on Federal land during the year. State Trust land under lease at the end of the fiscal year, totaled 72,593 acres, down from 81,224 in June 1992. Federal acreage under lease in June 1993 totaled 226,989, up from 217,478 in 1992. Most leasing took place in the northwestern and southeastern parts of the State.

Drilling. Two permits to drill were issued. The first was issued to Arrowhead Oil and Gas Company of Denver, Colorado, for an exploration hole near Litchfield Park, about 15 miles west of downtown Phoenix. The well was drilled to a total depth of 6,650 feet to test oil and gas potential associated with a large salt body. The well was completed as a dry hole and was abandoned in September. The second permit was issued to Tonto Drilling Services, Inc., of Salt Lake City, Utah, for a geothermal exploration hole in southernmost

Apache County, about 6 miles north of Alpine. Drilling did not begin before the end of the fiscal year.

Inspection and enforcement activity. Sixty-nine well inspections were conducted, including 26 of producing wells, 12 of shut-in and temporarily abandoned wells, 21 of LPG-storage wells, 3 of salt-water-disposal wells, and 1 drilling well. Inspection of the drilling well included observation of the cementing of the surface casing, the pressure test of the blow-out-prevention equipment, and the placement of cement plugs during final abandonment.



INFORMATION REQUESTS

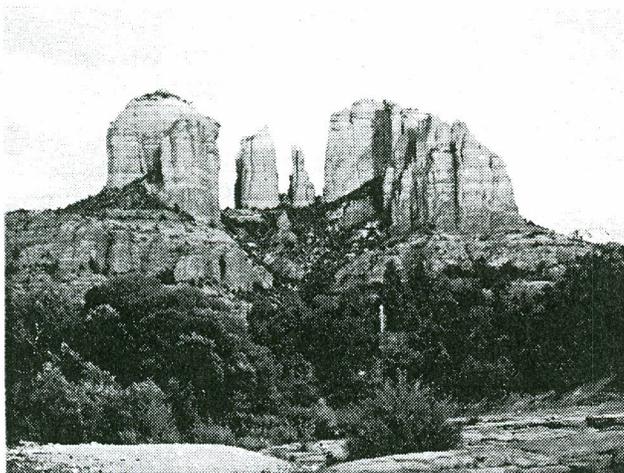
Geologic information and assistance were provided to more than 9,762 individuals who telephoned, wrote, or visited the AZGS offices. In addition to responding to routine requests for geologic information, AZGS geologists provide special assistance, including leading field trips, giving talks, assisting graduate students, serving on committees, reviewing manuscripts that have been submitted for publication, and in other ways.

Information and public service have been provided from the headquarters office, located at 845 N. Park Avenue, since 1977. Visitors can purchase publications, confer with geologists, or use the geologic library, well cuttings and core repository, and data files. Publications are also mailed from the office. Thomas G. McGarvin is the primary provider of information, but all geologists answer requests.

Almost 1,200 inquiries were answered at the Earth Science Information Center at 340 N. Sixth Avenue. At that facility, managed by Diane Murray, visitors can purchase USGS topographic maps, USGS geologic maps and reports, and AZGS publications.

Information and assistance are requested routinely by representatives of the following groups:

- governmental agencies responsible for land and resource management
- companies and consultants engaged in land development, siting, construction, waste disposal, water supply, transportation, and other businesses



- mineral exploration companies and consultants
- professional societies and groups
- university faculty members and graduate and undergraduate students
- science teachers in elementary and secondary schools
- interested and concerned citizens groups and individuals

A partial list of those who requested information and assistance during the fiscal year is given on p. 20-23.

PUBLICATION SALES

Publication sales from the headquarters office totaled \$28,243. Most items sold are maps and reports published by the AZGS. The AZGS also sells and distributes publications of the Arizona Geological Society, a professional society that was organized to promote and encourage interest in the science of geology and in the geology of Arizona. Revenues from the sale of publications are deposited in the Geological Survey Printing Revolving Fund and are used for expenses incurred for printing and distributing publications of the AZGS. Sales at the Earth Science Information Center, primarily topographic maps, totaled \$7,931.

EARTH SCIENCE INFORMATION CENTER

The Tucson Earth Science Information Center (ESIC) opened in August 1992 as a cooperative effort between the AZGS and the USGS (Geologic and National Mapping Divisions). It was established to serve the public more effectively by providing earth-science and mineral-resource information from both agencies. The ESIC is located one mile southwest of the AZGS headquarters in the Corbett Building at 340 N. Sixth Avenue. The USGS Minerals Information Office and the Center for Inter-American Mineral Resources Information are located in the same building. The ESIC is managed by Diane Murray, an AZGS employee, with support and coordination provided by the USGS and its employees.

Multipurpose cartographic, hydrologic, geologic, and mineral-resource data are available in paper (maps and books), CD-ROM, and microfiche formats. Materials

available include USGS topographic, geologic, and thematic maps for Arizona; selected USGS publications on Arizona and general geology; and AZGS reports and maps. Plans have been made to expand the inventory to include maps of border areas of Sonora, Arizona, and adjacent states.

ESIC staff members have access to information and databases that enable them to respond to a wide variety of questions. Coordination with the AZGS headquarters and the USGS Tucson Field Office ensures that information about the latest research on Arizona geology is provided. Visitors in need of more specific or detailed information are referred to the AZGS library or geologists.

ARIZONA GEOLOGY

This publication is released quarterly to inform the public about (1) the geology of Arizona, including the character of the land, mineral, water, and energy resources, and (2) the geologic materials and processes that may be hazardous or limit development and land use. Four 12-page issues were published. Articles on the following subjects were included:

Fall 1992 (v.22, no.3), The 1992 Landers earthquake sequence: T.C. Wallace.*

_____, Arizona earthquake preparedness program: R.A. Yates.*

_____, AZGS begins a new decade: L.D. Fellows.

_____, Regents approve Earth Science as a laboratory science: L.D. Fellows.

_____, Stewart Mountain dam safety modifications completed: L.D. Fellows.

_____, Theses and dissertations, 1991: E.C. DiSante.

Winter 1992 (v.22, no.4), Arizona's meteorites: Terri Haag.*

_____, The St. George earthquake of September 2, 1992: P.A. Pearthree and T.C. Wallace.*

_____, Exploration well tests salt near Phoenix: S.L. Rauzi.

_____, Tucson Earth Science Information Center opens: Diane Murray.

Spring 1993 (v.23, no.1), Geologic maps as interpretive studies: an example from the Dragoon Mountains: J.E. Spencer, G. Gehrels,* J. Bedford*, D. Hull,* K. Long,* L. Miller,* and R. Tufts.*

_____, Geologic studies related to the U.S. Geological Survey COGEMAP program: J.E. Spencer and P.A. Pearthree.

_____, Arizona develops new seismic-acceleration contour maps: K.M. Euge.*

_____, Mars observing in Arizona: Geologists continue a 100-year tradition: K.S. Edgett.*

Summer 1993 (v.23, no.2), The Arizona floods of January and February 1993: P.K. House.

_____, Summary of earthquake activity in Arizona for 1992: D. Bausch* and S. Morrison.*

_____, Seismic-hazard mapping in Arizona: D. Bausch.*

_____, Tips for earthquake preparedness.

_____, AZGS core repository reorganized.

* Not employees of the AZGS

TALKS GIVEN (TECHNICAL)

American Geophysical Union, Chapman Conference on Tectonics and Topography, Snowbird, Utah; The Laramide orogeny and uplift of the Colorado Plateau: poster session presented by J.E. Spencer.

American Institute of Mining, Metallurgical, and Petroleum Engineers, Annual Meeting of Arizona Conference, Tucson; Mineralization in western Harquahala and Little Harquahala Mountains: S.M. Richard.

Arizona Emergency Services Association, Annual Meeting, Phoenix; Late Quaternary faulting and earthquake hazards in Arizona: P.A. Pearthree.

Arizona Geological Society, Tucson; Mineralization in southern Plomosa and western Harquahala Mountains: S.M. Richard.

Arizona State University, Geology class, Tempe; Quaternary geology and geomorphology of southern and central Arizona: P.A. Pearthree.

Geological Society of America, joint meeting of Cordilleran and Rocky Mountain Sections, Reno; Temporal and spatial patterns of late Pleistocene - Holocene faulting in Arizona: poster session by C.M. Menges and P.A. Pearthree.

_____, Structure and stratigraphy, southern Plomosa Mountains: S.M. Richard.

_____, Strength and survival of subducted lithosphere during the Laramide orogeny: J.E. Spencer.

Grand Canyon University, Geology class, Phoenix; Geology of Arizona and applications to land and resource development: L.D. Fellows.

Northern Arizona University, Geology class, Flagstaff; Geologic insights into piedmont flooding in Arizona: P.A. Pearthree.

Pima Association of Governments, Water Quality Subcommittee of Environmental Planning Advisory Committee; Radon gas: A geologic hazard in Arizona: J.E. Spencer.

University of Arizona, Geology class, Tucson; Low-angle Laramide subduction and uplift of the Colorado Plateau: J.E. Spencer.

_____, Relationship between surface slope and structural style during crustal extension: seminar presentation by J.E. Spencer.

_____, Paleoseismology and fault behavior in Arizona and Nevada: P.A. Pearthree.

Yavapai Community College, Hydrology class, Prescott; Ground-water overdraft, land subsidence, and earth fissures in Arizona: S. Slaff.

TALKS GIVEN (NONTECHNICAL)

Arizona Academy for Environmental Education, Prescott; Geologic facts of life: T.G. McGarvin.

Arizona Association for Learning in and About the Environment, Fall Conference, Prescott; Looking through the windshield - it really isn't a boring drive: T.G. McGarvin.

Arizona Science Teachers Association, Fall Convention, Phoenix; California's RBO (Real Big One) - Beachfronts in Arizona?: T.G. McGarvin, featured speaker at Earth and Space Science luncheon.

Desert Gold Diggers, Tucson; Gold occurrences in Arizona: T.G. McGarvin.

Old Pueblo Rotary Club, Tucson; Time passes and things change: L.D. Fellows.

Saguaro National Monument - East, staff and docents, Tucson; Logic in the geologic processes: T.G. McGarvin.

Saguaro Rotary Club, Tucson; Time passes and things change: L.D. Fellows.

Sunset Rotary Club, Tucson; Time passes and things change: L.D. Fellows.

Tohono Chul Park docents, Tucson; Basic geologic concepts and the "geology wall:" T.G. McGarvin.

University of Arizona, Science and Mathematics Conference, Tucson; Mountain magic: T.G. McGarvin.

_____, Graduate Library class; State geological surveys: L.D. Fellows.

Verde River Day, Annual Celebration, Cottonwood; The old Verde River's not what she used to be: L.D. Fellows (2 talks).

FIELD TRIPS LED

Agua Caliente School, sixth grade classes, Tucson; northern Catalina Mountains: R.A. Trapp.

University of Arizona, introductory geology class for non-majors; Pontotoc Canyon: J.E. Spencer.

_____, advanced field mapping class; Dragoon Mountains: J.E. Spencer, participant.

_____, faculty and students; Santa Teresa Mountains: J.E. Spencer, participant.

University of Texas, Austin, advanced field mapping class; Buckskin Mountains: J.E. Spencer.

_____, graduate student; northern Dome Rock Mountains: J.E. Spencer.

U.S. Geological Survey and University of Arizona, southern Plomosa Mountains: J.E. Spencer and S.M. Richard.

Verde River Day, Annual Celebration, Cottonwood; Geology along the Verde River: L.D. Fellows.

SERVICE ON COMMITTEES

American Institute of Mining, Metallurgical, and Petroleum Engineers, Tucson Section; Diane Murray, Treasurer.

_____, Geology, Energy, and Minerals Committee; Diane Murray.

Arizona Council on Earthquake Safety, L.D. Fellows and P.A. Pearthree.

Arizona Department of Commerce, Advisory committee for geothermal project; S.L. Rauzi and L.D. Fellows.

Arizona Geographic Information Council, L.D. Fellows and R.A. Trapp.

Arizona Geological Society, Executive Council; J.E. Spencer and R.A. Trapp.

_____, Organizational committee for 1994 Porphyry Copper Symposium "Bootprints along the Cordillera:" R.A. Trapp.

Governor's Strategic Partnership for Economic Development, Mining and Minerals Cluster; L.D. Fellows.

Pima County Flood Control District, Advisory Committee; P.A. Pearthree, Vice Chairman.

State of Arizona, Interagency Committee on Environmental Education; L.D. Fellows.

Tucson Gem and Mineral Society, Editorial Committee; R.A. Trapp.

ARIZONA
GEOLOGICAL
SURVEY

ORGANIZATION
AND PERSONNEL

ANNUAL
REPORT

STATE OF ARIZONA
FIFE SYMINGTON, GOVERNOR

ARIZONA GEOLOGICAL SURVEY
L. D. FELLOWS, DIRECTOR

OIL AND GAS
CONSERVATION COMMISSION
J.C. WILT, CHAIR

INFORMATION
AND ASSISTANCE

- Information Requests
- Publication Sales
- Earth Science Information Center
- *Arizona Geology*
- Talks and Fieldtrips

GEOLOGIC MAPPING
AND INVESTIGATIONS

- Geologic Mapping
- Geologic Investigations
- Arizona Geologic Information System
- Geologic Library
- Well Cuttings and Core Repository

OIL AND GAS
REGULATION

- Permits to Drill
- Drilling Activities
- Well Inspections
- Production Statistics
- Data Files

GEOLOGIC MAPPING AND INVESTIGATIONS

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

- administration
- geologic hazards and limitations
- geology of Arizona

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

- public information
- geologic library
- well cuttings and core repository
- earth science education
- geology of Arizona

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

- Quaternary and surficial geology
- seismotectonics and seismic hazards
- piedmont flooding
- applied geology
- geologic mapping
- geology of Arizona

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

- metallic mineral deposits
- structural geology
- geologic mapping
- geology of Arizona

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

- geologic mapping
- structural geology, geophysics, and geochronology
- precious metals (gold and silver)
- geology of Arizona

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

- computer database manager
- oil and gas program
- public information
- geology of Arizona

Temporary Employees

S.A. Beyer, Geologist I
J.T. Duncan, Geologist II
J.J. Field, Geologist I
R.C. Harris, Geologist II
P.K. House, Geologist I
Steven Slaff, Geologist I
K.R. Vincent, Geologist I

OIL AND GAS REGULATION

Oil and Gas Conservation Commission⁽¹⁾

Barbara H. Murphy, Glendale (Jan. 1993)
J. Dale Nations, Flagstaff (Jan. 1996)
Zed Veale, Flagstaff (Jan. 1997)
J.E. Warne, Jr., Phoenix; Vice Chair (Jan. 1994)
Jan C. Wilt, Tucson; Chair (Jan. 1995)
M.J. Hassell, Land Commissioner, Ex officio

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

- oil and gas rules and regulations
- data files and records
- well cuttings and cores
- subsurface geology investigations

(1) Members are appointed by the Governor for 5-year terms. Expiration date of term is in parentheses. The Arizona Geological Survey provides staff support for the Commission and carries out applicable rules and regulations.

INFORMATION AND ASSISTANCE

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

- executive assistant to the Director
- operations manager
- budget officer
- personnel coordinator
- manager of editing, graphics, and publication sales

LAURETTE E. COLTON, Administrative Support Supervisor I.

- publication sales manager
- clerical support coordinator
- time and attendance records

PETER F. CORRAO, Graphic Designer II; B.S., Arizona State University.

- graphics supervisor
- chief illustrator and layout designer
- computer graphics
- cartographer
- liaison with typesetters and printers

EMILY C. DiSANTE, Administrative Assistant I⁽¹⁾; B.A., University of the Pacific; M.A., University of Arizona.

- editorial assistant
- layout and design assistant

DENISE M. INGRAM, Accounting Technician II⁽²⁾.

- accounting assistant
- administrative clerical support
- publication sales assistant
- payroll assistant

PAMELA J. LOTT, Secretary; B.S., Texas Wesleyan College.

- oil and gas program secretary
- personnel assistant
- administrative clerical support

EVELYN M. VANDENDOLDER, Public Information Officer III; B.S., University of Connecticut.

- editor
- manuscript coordinator
- news media liaison

Temporary Employees

S.M. Bundy, Library Assistant
D.N. Cuffel, Student Aide
M.E. de Martino, Clerical Assistant
C.R. Jackson, Clerical Assistant
J.S. Pigati, Student Aide
Marjorie Tiznado, Clerical Assistant

(1) Resigned May 1, 1993

(2) Resigned June 23, 1993

ARIZONA
GEOLOGICAL
SURVEY

BUDGET
AND EXPENDITURES

ANNUAL
REPORT

GENERAL FUND

Category	FY 1991-92	FY 1992-93	FY 1993-94
	Expended	Expended	Budgeted
Personnal Services	\$372,187	393,743	380,400
Benefits	80,182	91,331	89,300
Operations	128,233	125,519	126,000
In-State Travel	10,087	8,595	12,400
Out-of-State Travel	2,627	3,262	2,000
Capital Equipment	15,646	0	3,100
TOTAL	608,962^a	622,450^b	\$613,200

a) Appropriation was \$621,400. Mid-year budget reduction was \$12,400.

b) Appropriation was \$623,900.

PRINTING REVOLVING FUND

Revenue

Received during FY 1992-93 \$28,243

Expenditures

Salaries 735

Benefits 127

Travel 0

Operations 21,225

Equipment 5,557

TOTAL \$27,644

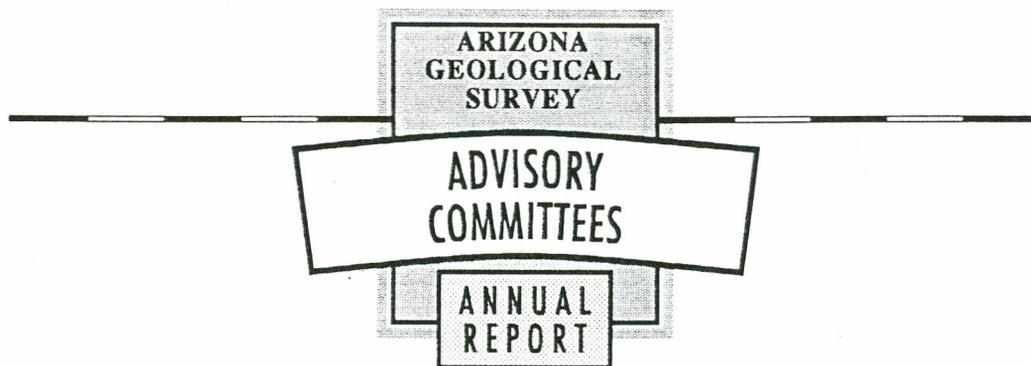
Persons Employed: M.E. deMartino, C.R. Jackson, Marjorie Tiznado

CONTRACTED PROJECTS

Project (Funding Source)	Principal Investigator	Personal Services	Benefits	Operations	In-State Travel	TOTAL
Land Subsidence (U.S. Bureau of Reclamation)	Pearthree	\$7,786	762	1,039	285	9,872
Geologic Mapping-Bedrock Phoenix Quadrangle (U.S. Geological Survey)	Spencer	40,972	4,027	2,482	5,760	53,241
Geologic Mapping-Surficial Materials (U.S. Geological Survey)	Pearthree	18,060	1,588	3,616	2,067	25,331
Alluvial Deposits Mapping- Verde River (U.S. Environmental Protection Agency)	Pearthree	9,271	2,099	6,889	1,216	19,475
Uranium Levels in Rocks (U.S. Environmental Protection Agency)	Spencer	16,764	3,409	0	0	20,172
Earth Science Information Center (U.S. Geological Survey)	McDonnell	19,993	4,133	0	0	24,126
Printing and Distribution (Arizona Geological Society)	McDonnell	0	0	707	0	707
Flood Hazards-White Tanks (Flood Control District of Maricopa County)	Pearthree	0	0	0	206	206
DRASTIC Project-Pinal County (AZ Department of Environmental Quality)	Pearthree	3,577	359	5,564	0	9,501
Geologic Information Sharing (AZ Department of Environmental Quality)	Spencer	8,827	1,173	0	0	10,000
Earthquake Bibliography (AZ Division of Emergency Management)	Pearthree	494	50	155	120	818
Geologic Data Compilation- Bradshaw Mountains (AZ Department of Environmental Quality)	Fellows	2,170	217	0	260	2,647
Subsidence and Earth Fissures (Cathy Wellendorf Memorial Fund)	Fellows	1,818	182	0	0	2,000
TOTAL EXPENDITURES			17,999	20,451	9,914	\$178,096

Persons Employed:

S.A. Beyer, D.D. Coblenz, J.T. Duncan, J.J. Field, W.G. Gilbert, P.K. House, G.A. Huckleberry, D.L. Moulton, D. Murray, M. Ort, P.S. Scott, S.J. Skotnicki, Steven Slaff, K.R. Vincent, M.L. Wells



ENGINEERING AND ENVIRONMENTAL GEOLOGY ADVISORS

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

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

R. Bruce Mack
Salt River Project
Phoenix

Barbara H. Murphy
Dames & Moore
Phoenix

Stephen D. Noel, P.G.
Southwest Ground-water Consultants, Inc.
Phoenix

Troy L. Péwé, Ph.D.
Consulting Geologist
Tempe

Frank S. Turek
Greeley and Hansen
Phoenix

Ralph E. Weeks, P.G.
SHB AGRA, INC.
Phoenix

Gary D. Weesner
Southwest Water & Mineral Resources
Phoenix

William G. Wellendorf, P.G.
Southwest Ground-water Consultants, Inc.
Prescott

Lisa C. Worthington
Paradise Valley

MINERAL RESOURCE ADVISORS

James A. Briscoe
JABA, Inc.
Tucson

Russell M. Corn
Consulting Geologist
Tucson

Ted H. Eyde
GSA Resources, Inc.
Cortaro

John D. Forrester
Phelps Dodge Corp.
Tucson

Walter Heinrichs
Heinrichs Geo-Exploration Co.
Tucson

Robert L. Hockett
Magma Copper Company
(retired)
San Manuel

James D. Loghry
Consulting Geologist
Tucson

James N. Mayor
Newmont Exploration Ltd.
Tucson

Charles P. Miller, Ph.D.
Miller Resources, Inc.
Tucson

James D. Sell
ASARCO
Tucson

EARTH SCIENCE EDUCATION ADVISORS

Carlton Ami
Navajo Community College
Tsaile

Susan Bollin
Scottsdale

Bonnie Briscoe
Eastern Arizona College
Thatcher

Suzanne Cash
Cortez High School
Phoenix

Donald W. Clay, Ph.D.
Arizona Western College
Yuma

Chris Cotter
Mountain View High School
Tucson

Raymond W. Grant, Ph.D.
Mesa Community College
Mesa

David Harbster
Chandler

Peter L. Kresan
University of Arizona
Dept. of Geosciences
Tucson

Mike Lang
Dept. of Education
School Improvement Unit
Phoenix

Allan Morton
Central Arizona College
Coolidge

J. Dale Nations, Ph.D.
Flagstaff

Beth Nichols-Boyd
Yavapai College
Geology Department
Prescott

Anthony L. Occhiuzzi
Tempe High School
Tempe

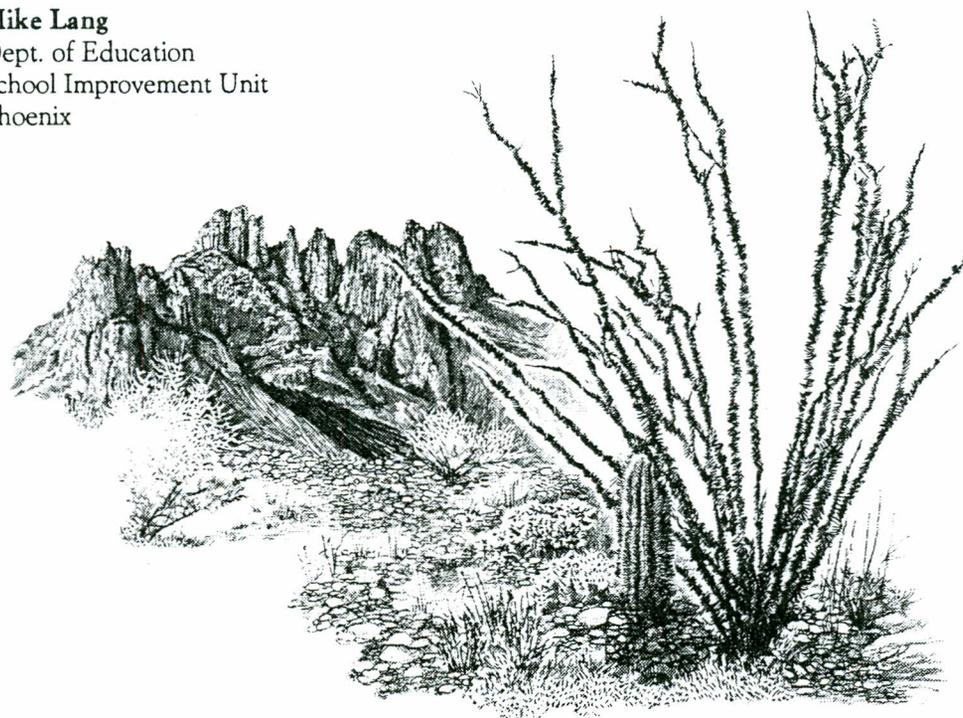
Joseph F. Jr. Schreiber, Ph.D.
University of Arizona
Tucson

Jeff Simpson
Peoria

Edmund Stump, Ph.D.
Arizona State University
Tempe

J. Robert Thompson, Jr., Ph.D.
Glendale

Roger Weller
Cochise College
Douglas



ARIZONA
GEOLOGICAL
SURVEY

CONSTITUENTS

ANNUAL
REPORT

Constituents write, phone, and visit the Arizona Geological Survey (AZGS) headquarters and the Earth Science Information Center; purchase publications; confer with geologists; and use the library, archives, and well cuttings and core repository. Staff record names of the companies, government agencies, schools and universities, and other groups, listed below, whose representatives request information and assistance. Many contact us multiple times during the year. Names of individuals who request our services are not recorded. During Fiscal Year 1992-93 staff recorded 9,762 requests for information and assistance from groups, many of which are listed below.

GOVERNMENTAL AGENCIES

STATE OF ARIZONA

Attorney General: Water Rights
Department of Commerce: Energy Office
— Corrections: Tucson
— Education
— Environmental Quality: Hydrology
— Emergency and Military Affairs:
— Division of Emergency Management
— Library, Archives, and Public Records:
— Federal Documents, Reference
— Mines and Mineral Resources
— Transportation: Arizona Highways Magazine
— Geotechnical Services
— Materials
— Water Resources: Hydrology Division
— Weights and Measures
Mine Inspector
Radiation Regulatory Agency
Residential Utility Consumer Office
State Land Department: Minerals
— Arizona Land Resource Information System
— Arizona Geographic Information Council
State Parks: State Office, Picacho, Tonto Natural Bridge

ARIZONA COUNTY, CITY, AND OTHER

City of Avondale: Public Works
— Litchfield Park
— Phoenix
— Scottsdale
Cochise County Library
LaPaz County
Maricopa County
Mohave County
Navajo County
Patagonia Public Library
Pima Association of Governments
Pima County Flood Control District
Pinal County Planning Department
Yavapai County

OTHER STATES

California: Division of Mines and Geology,
State Senate
Colorado: Geological Survey

Indiana: Geological Survey
Louisiana: Geological Survey
Montana: Bureau of Mines and Geology

Nevada: Bureau of Mines and Geology,
Las Vegas Water District
New Mexico: Bureau of Mines and Mineral Resources
Texas: Bureau of Economic Geology
Utah: Comprehensive Emergency Management Agency,
Division of Wildlife Resources, Game & Fish
Geological Survey
Washington: Department of Natural Resources
Wisconsin: Geological and Natural History Survey

U.S. GOVERNMENT

Air Force: Luke A.F.B., Phoenix
Army Corps of Engineers: Los Angeles,
San Francisco
Army: Ft. Huachuca
Department of Agriculture
— Forest Service: Regional Office, Albuquerque
— Coconino and Coronado Forests
— Soil Conservation Service: Tucson
Department of Housing and Urban Development
Department of the Interior
— Bureau of Land Management: State Office
— Phoenix and Safford District Offices
— Tucson Resource Area Office
— Bureau of Mines: Denver, Tucson, and Washington, DC
— Bureau of Reclamation: Phoenix
— Fish and Wildlife Service
— Geological Survey: Earth Science Information Offices -
— Denver, Menlo Park, Salt Lake City, and Spokane
— Minerals Information Offices - Reno, Tucson
— Office of the Director, Reston
— Oil and Gas, Denver
— Tucson Field Office
— Water Resources Division Offices - Missoula, MT;
— Tempe, Tucson
— Western Mapping Center, Menlo Park, CA
— Western Mineral Resources, Menlo Park, CA
— Western Regional Geology, Denver
National Park Service: Cooperative Park Studies Unit,
Tucson; Denver Office, Grand Canyon, Petrified Forest
Saguaro National Monument
Department of Veterans Affairs
Energy Information Administration
Environmental Protection Agency: San Francisco
Federal Emergency Management Agency
Federal Housing Administration
Federal Trade Commission
Indian Health Service: Pinetop, Sells
National Science Foundation
Occupational Safety and Health Administration
Western Archeological Center: Tucson

TRIBAL GOVERNMENTS

Hopi Indian Nation: Water Resources Program
Navajo Nation: Environmental Protection Administration
Pueblo of Zuni: Zuni Conservation Project
Tohono O'Odham Nation
White Mountain Apache: Tribal Engineer

OTHER COUNTRIES

Canada: British Columbia Geological Survey
Mexico: Consejos de Recursos Minerales, Pachuca

COMPANIES AND CONSULTANTS

ENVIRONMENTAL AND ENGINEERING

Alderman, Slothower, and Associates, San Francisco
A-N West, Inc., Phoenix
A & R Environmental
Arizona Testing Laboratories
ATEC Environmental Consulting - Phoenix, Denver
Aztec Environmental, California
BCM Engineers, Ontario, CA
Basin & Range Hydrogeologists, Phoenix
Bechtel, San Francisco
Bioremediation, Inc., Tucson
Black & Veatch, Phoenix
Call & Nicholas, Inc., Tucson
CDM Federal Programs Corporation, Albuquerque
Cella-Barr Associates, Tucson
Certified Engineering & Testing, Irvine, CA
CH2M Hill, Phoenix
Cimetta Engineering and Construction Company, Tucson
Condor Earth Technology
Converse Environmental West
Copeland Geotech
Dames & Moore - Phoenix, Tucson
Daniel B. Stephens Associates, Albuquerque
Delta Environmental, Phoenix
Earth Technology - Tempe, Tucson
EMCON Associates, Camarillo, CA
EMCON Southwest, Phoenix
Energy Engineering Corporation
Engineers International, Inc., Tucson
ENV America, Inc., Irvine, CA
Enviromed, Tucson
Enviro Engineering
Environmental Science Consultants, Denver
Environmental Science & Engineering, Inc. -
Denver; Marietta, GA
Enviroquest, Torrance, CA
Errol L. Montgomery and Associates, Tucson
GRC Consultants, Tucson
GeoMarine, Plano, TX
GeoSoils, CA
Geo Surveys Ltd.
Ground Water Resources
Ground Water Technology, Phoenix
Gulf-Pacific Environmental, Oklahoma
HTS Environmental Group
Harding, Lawson, and Associates, Phoenix
Hargis & Associates - La Jolla, CA; Tucson
Harza Northwest, Inc.
HydroAnalysis, Inc., Phoenix
HydroGeoChem, Inc., Tucson
Hydrogeophysicists, Inc.
IMDEX
ISO Commercial Risk Services, San Ramon, CA
Integrated Agri Systems, MI
JayKim Engineers, Phoenix
Kleinfelder, Phoenix
Knox-Rickson, Oakland, CA
Law Engineering
LHMN Environmental Council
Malcolm-Pirnie, Inc.
PKF Consulting, San Francisco
Poteet Engineering
PRC Environmental Company, Phoenix
Riverside Technology, Ft. Collins, CO

Rust Environmental and Consulting, TX
Saguaro Environmental Services Company
Seacor Environmental Engineering, Phoenix
SHB AGRA, INC. - Phoenix, Tucson
Southwest Ground Water Consultants, Inc. -
Phoenix, Prescott
Speedie & Associates, Phoenix
Summit Manhattan Company, Summit, NJ
Sun West Appraisal Group
SWCA Environmental Consultants, Inc., Tucson
Terracon Consultants Western
The Winters Company
TRC Environmental
Troutman Engineering
Water Resources Associates, Niagara Falls, NY
Western Technology, Phoenix
Willdan Associates
Woodward-Clyde, Phoenix
Zonge Engineering, Tucson

MINERAL RESOURCES

Adwest Minerals, Denver
Alpine Exploration Group
Altair Resources, Tucson
AMAX Minerals
American Copper Nickel, Denver
Apache Canyon Consulting
ARIMETCO, Tucson
Arizona Stone Products, Tucson
ASARCO, Tucson
Battle Mountain Exploration Company, Tucson
Bema Gold US
BHP Minerals, Tucson
Bitterroot Resources, Ltd.,
Vancouver, British Columbia, CANADA
Blackwell North America
California Portland Cement
Cambior Exploration, Reno
Canyon Resource Corporation, Golden, CO
Chemehuevi Placers, CA
Continental Lime, Inc., Salt Lake City
Corn & Ahern, Tucson
Cyprus Casa Grande
Cyprus Exploration
Cyprus Minerals, Englewood, CO
Cyprus Minerals, Guadalajara, MEXICO
Harold J. Downey and Associates, Tucson
Freeport Exploration Company
Genmin, Inc.,
Johannesburg, SOUTH AFRICA
Georgia Marble Company
Gold Fields Mining
Goldstream Prospecting,
Hope, British Columbia, CANADA
GSA Resources, Inc., Marana
Hecla Mining
Heinrichs Geoeexploration, Inc., Tucson
Homestake Minerals, Denver
JABA, Inc., Tucson
James A. Yanez Company, Tucson
Kennecott, UT
Lepley & Associates, Tucson
Magma Copper, San Manuel
MEI Exploration, CA
Miller Resources, Tucson
MIM Australia,
Brisbane, Queensland, AUSTRALIA
Minnova (US), Inc., Sparks, NV
Mission Minerals Group
Moore Minerals, Lake Jackson, TX
Newmont, Tucson
Newsboy Gold Mining Company, Morristown, AZ
Noranda, NV
North Mining Company
Orvana Resources Corporation

Pearson, Hofman, & Associates,
 Toronto, Ontario, CANADA
 Pegasus Gold Corp., Reno, NV
 Phelps Dodge Exploration East, Lakewood, CO
 _____ Morenci Mine Geology Department, Morenci, AZ
 _____ Western Exploration, Tucson
 Proffett Exploration, Inc.
 Ramon P. Shannon & Associates
 Republic Goldfields, Congress, AZ
 Rocky Mountain Geological Databases, Inc., Denver
 St. Mary's Minerals, Denver
 Santa Fe Minerals, Albuquerque
 Southwestern Stone, Inc., Taylor, AZ
 Teck Exploration,
 _____ Vancouver, British Columbia, CANADA
 TET Exploration, Sierra Vista, AZ
 U.S. Silica
 Viceroy Gold Corporation, NV
 Western States Minerals Corporation, Tempe

OIL, GAS, AND GEOTHERMAL

AmeriGas, Peoria
 Arrowhead Oil and Gas, Denver
 BHP Petroleum, Inc., Houston
 Baroid Drilling Fluid Services, Farmington, NM
 Basin Petroleum
 Bechtel Corporation, San Francisco
 Bowers Oil and Gas
 Burnett Oil Company, Fort Worth
 Champ Oil Company, Oklahoma
 Chevron Production Company, Houston
 Chuska Energy Company, Farmington, NM
 Dry Mesa Corporation, Farmington, NM
 Dwight's Energy Data, Dallas
 ENG Associates, Denver
 FerrellGas, Holbrook, AZ
 Giant Exploration Company, Farmington, NM
 Golden Storage Services, Houston
 Hunt Oil, Denver
 Kerr-McGee Corporation, Amarillo, TX
 Medallion Oil Company, Houston
 Merrion Oil and Gas Company, Farmington, NM
 Mullins Well Reporters, Casper, WY
 Munger Oil Services, Inc., Los Angeles
 New Mexico-Arizona Land Company
 Norcen Energy Resources
 Pacific Gas and Electric
 Petroleum Information Services, Inc., Farmington, NM
 PetroSun, Inc.
 Santa Fe Pacific Pipeline Company,
 Shields Exploration Company, Pacific Palisades, CA
 Southwest Technology Development Institute
 SunCor Development Corporation, Litchfield Park, AZ
 Texaco
 Tonto Drilling Services, Salt Lake City
 Total Petroleum Canada, Ltd.,
 _____ Calgary, Alberta, CANADA
 TranAm Energy Company, Tulsa
 Wellsite Engineering Company, Farmington, NM

OTHER COMPANIES

Adam Design & Construction, NETHERLANDS
 Archaeological Research Services
 Arizona Daily Star, Tucson
 Arizona Electric Power Cooperative, Benson, AZ
 Arizona Public Service Company, Phoenix
 Arizona Hiking Shack
 Bekins Van & Storage, Los Angeles
 Biosphere Press, Oracle, AZ
 British Broadcasting Corporation
 Broughton Investments, Ltd., Brownsville, TX
 Caterpillar, Inc.
 Century 21-DM Realty, Tucson
 Con-Ed Publications, NY

Cooper Aerial Survey Company, Tucson
 Desert Prospecting Outfitters, Inc., Tucson
 Environmental Science Consortium, Denver
 Esplanade Realty
 Esterson Construction Company
 The Findlay Group, Oceanside, CA
 Gersh & Danielson, P.C., Denver
 Granite Construction, Nogales, AZ
 Holland Educational Consulting,
 _____ La Ronge, Saskatchewan, CANADA
 Hughes Technology
 Iguana Archeological
 Institute for Scientific Information, Philadelphia
 Intertec, MT
 Kiewit Construction, Omaha, NB
 Llectronix, Clovis, NM
 Lowell Construction Company
 Martin-Marietta, TN
 Mesa Tribune
 Motorola Space Communications, Chandler, AZ
 National Geographic Magazine, Washington, DC
 North American Bank and Trust, Waterbury, CT
 Orbis Geographics, Inc.
 Reproductions, Inc., Tucson
 Research Associates of Wyoming
 Riverside Publishing Company, Chicago
 Salomon Brothers, Inc., New York
 Salt River Project, Phoenix
 Scottsdale Cardiovascular Center, Scottsdale, AZ
 Speciality Technical Publishers,
 _____ Vancouver, British Columbia, CANADA
 Statistical Research, Inc., Tucson
 Sunset Magazine, Inc.
 SunWest Appraisal Corporation
 Travelers Insurance Group, CA
 Tucson Electric Power Co.
 Tucson Map & Flag
 Tucson Newspapers, Inc.
 TV - Channel 4, Tucson
 Vestar Development Co., Phoenix
 Wait & Schaffer, Reno, NV

UNIVERSITIES AND COLLEGES

ARIZONA

Arizona State University: Department of Geology
 Arizona Western College: Yuma
 Cochise College: Douglas
 Eastern Arizona College: Thatcher
 Grand Canyon University: Glendale
 Mesa Community College
 Northern Arizona University: Department of Geology
 _____ Earthquake Information Center
 _____ Environmental Education Resource Center
 Northland Pioneer College: Show Low
 Phoenix College
 Pima Community College: Tucson
 University of Arizona: Arizona State Museum
 _____ College of Architecture
 _____ Ecology and Evolutionary Biology
 _____ Entomology
 _____ Geosciences
 _____ Environmental Research Laboratory
 _____ Gila County Cooperative Extension Service
 _____ Hydrology and Water Resources
 _____ Kitt Peak National Observatory
 _____ Laboratory of Tree Ring Research
 _____ Landscape Architecture
 _____ Maricopa Agriculture Center
 _____ Mining and Geological Engineering
 _____ Office of Arid Land Studies

Planetary Sciences
School of Renewable Natural Resources
Water Resources Research Center
Yavapai College: Prescott

OTHER STATES

Ambassador College
Augustana College
Stephen F. Austin State University
Brigham Young University
California Institute of Technology
Colorado School of Mines
Colorado State University
Cornell University
Colorado State University
Columbia University
Dartmouth College
Denison University
Duquesne University
Eastern Illinois University
Ft. Lewis College
George Mason University
Grossmont College, El Cajon, CA
Harvard University
Humboldt State University, CA
Indiana University
Lake Superior State University
Louisiana State University
Macalaster College
Michigan State University
Minot State University
New Mexico State University
New Mexico Tech, Socorro
Oklahoma State University
Old Dominion University, VA
Pennsylvania State University
Pomona College
Princeton University
Rutgers University
Southern Connecticut University
Southern Illinois University
Southern Methodist University
Southwest Oregon Community College
Texas Tech University
Trinity University
University of California
____ Cincinnati
____ Illinois-Chicago
____ Iowa
____ Kansas
____ Kentucky
____ Koblenz (GERMANY)
____ Massachusetts
____ Minnesota
____ Nevada, Las Vegas
____ New Brunswick (CANADA)
____ New Mexico
____ North Carolina
____ Oklahoma
____ Oregon
____ Pennsylvania
____ Saskatchewan (CANADA)
____ Texas-Austin
____ Wisconsin
____ Wyoming
Utah State University
Vanderbilt University
Western New Mexico University
Yale University

ELEMENTARY AND SECONDARY SCHOOLS

ARIZONA

Agua Caliente School, Tucson
Apache Junction High School, Apache Junction
Armstrong Academy, Tucson
Booth-Fickett Magnet Elementary School, Tucson
Borton Magnet School, Tucson
Cactus High School, Glendale
Centennial Elementary School, Tucson
Ft. Lowell Elementary, Tucson
Fountain Hills High School, Phoenix
Garden Lakes Elementary, Phoenix
Mansfield Middle School, Tucson
Mary Welty School, Nogales
McGee Middle School, Tucson
Mountain View High School, Tucson
Mountain Vista Elementary, Oracle
St. Gregory College Preparatory School, Tucson
San Simon School, Sells
Soleng Tom Elementary, Tucson
Sunrise Drive Elementary School, Tucson
Tucson Hebrew Academy
Warren Elementary School, Tucson

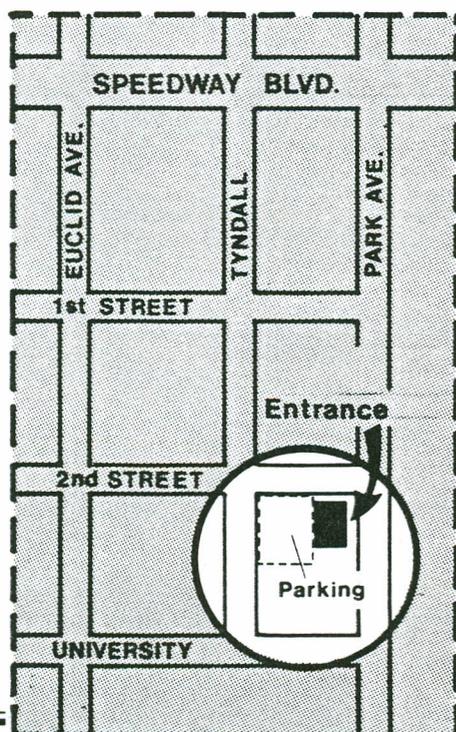
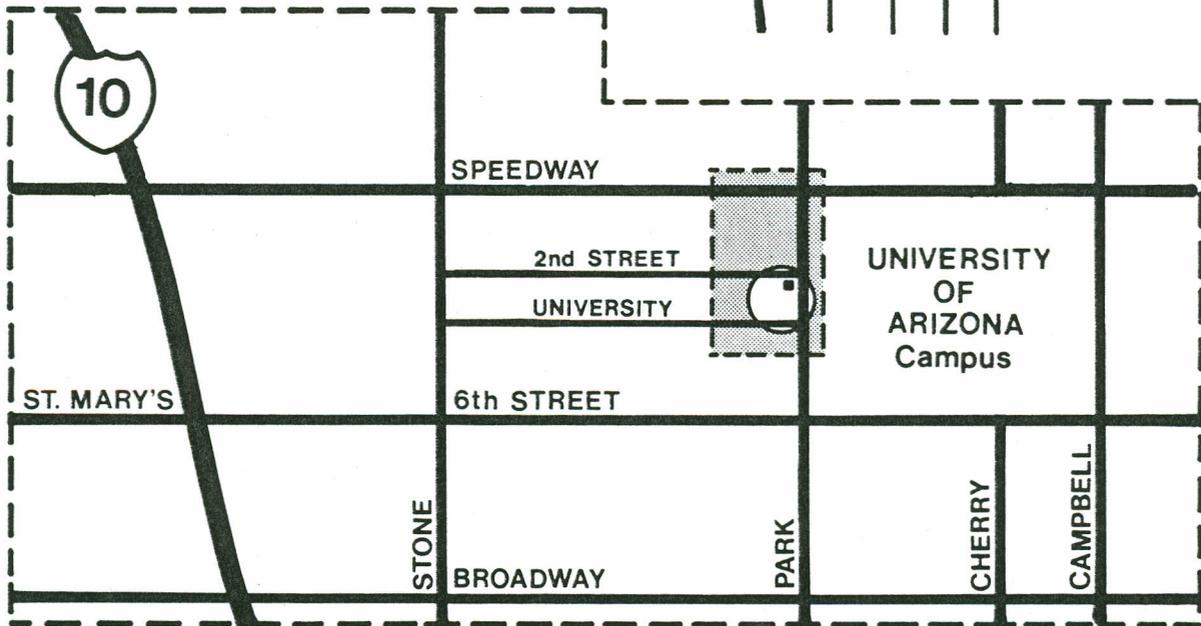
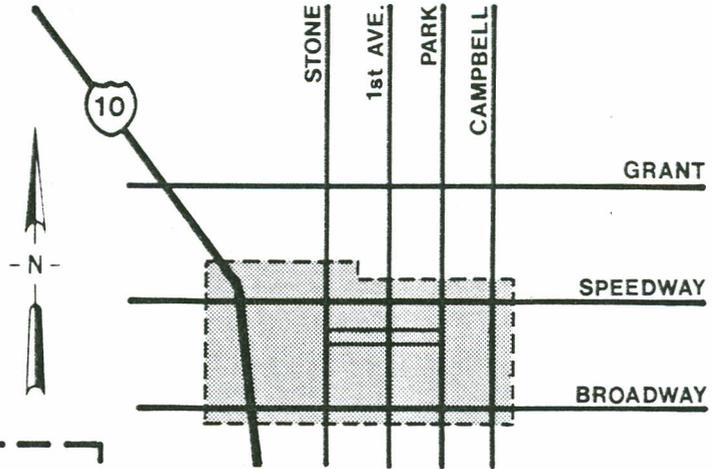
OTHER STATES

Brevard Elementary School, Tallahassee, FL
Canton High School, Canton, IL
Columbia Catholic School, Columbia, MO
Hartland Elementary, Hartland, VT
West View Elementary School, Pittsburgh, PA

OTHER GROUPS

American Association of Petroleum Geologists
American Geophysical Union
American Institute of Mining, Metallurgical, and Petroleum Engineers
American Institute of Professional Geologists
American Library Association
Arizona Association for Learning in and about the Environment
Arizona Emergency Services Association
Arizona Geological Society
Arizona Mining Association, Phoenix
Arizona Science Teachers Association
Arizona Society of Floodplain Managers
Arizona-Sonora Desert Museum, Tucson
Cub Scouts, Clarendon Hills, IL
Desert Botanical Garden, Phoenix
Desert Gold Diggers, Tucson
Geological Society of America
Girl Scouts, Sahuaros Council
Green Valley Coordinating Council
Interstate Oil Compact Commission
Mining Club of the Southwest, Tucson
Museum of Northern Arizona, Flagstaff
Nature Conservancy, Tucson
Old Pueblo Rotary Club, Tucson
Petroleum Research Fund
Pima Air and Space Museum, Tucson
Saguaro Rotary Club, Tucson
School House Inn Bed and Breakfast, Bisbee
Southwest Paleontological Society, Mesa
Sunset Rotary Club, Tucson
Tucson Gem and Mineral Society
Tohono Chul Park, Tucson
Tucson Basin Environmental Education Group
Verde Valley Chamber of Commerce
Wild Horse Ranch, Tucson
Yuma County Historical Society

**our
location...**



ARIZONA GEOLOGICAL SURVEY

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