

Annual Report 1987

Arizona
Geological
Survey

Annual Report

Arizona Geological Survey*

Fiscal Year 1986 – 1987
(July 1, 1986 – June 30, 1987)

**ARIZONA GEOLOGICAL SURVEY
OPEN-FILE REPORT**

87 - 13

Cover Illustration: earth fissures formed in response to ground-water withdrawal near Chandler Heights; artwork by Peter F. Corrao.

* The Arizona Geological Survey is the Geological Survey Branch of the Bureau of Geology and Mineral Technology, a Division of the University of Arizona, Tucson.

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

Highlights

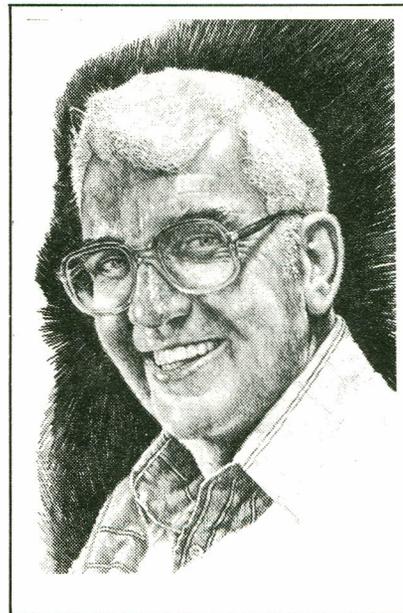
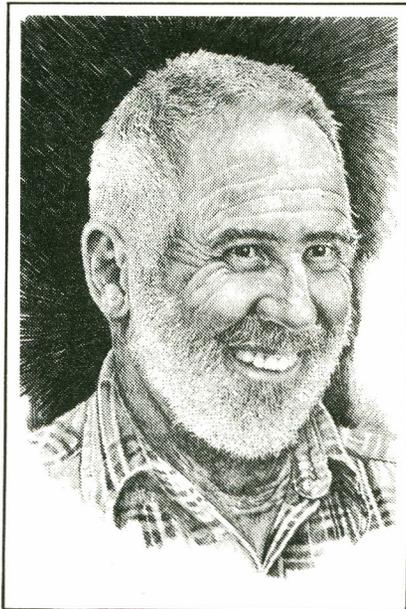
- Provided **information** or assistance to more than 3,200 persons who visited the office, telephoned, or wrote; sold **publications** totalling \$19,431.
- Completed 36 geologic **maps and reports**; presented 9 **technical papers** and talks and gave 10 non-technical talks; conducted or participated in 5 **workshops or field trips**.
- Published map showing land **subsidence and earth-fissure zones**; project was done cooperatively with the U.S. Geological Survey, U.S. Bureau of Reclamation, and the Arizona Departments of Water Resources and Transportation.
- Assisted Pima County Health Department in investigating **potential indoor radon occurrences** in southwestern Tucson by determining location and natural radioactivity levels of a uranium-bearing limestone.
- Assisted Arizona Radiation Regulatory Agency in planning a **statewide indoor radon survey** by providing information about the distribution of rocks that contain elevated uranium content.
- Assisted State Land Department in **minerals ownership exchanges** by assessing potential for mineral resources in specified areas.
- Published bibliographies of **metallic mineral districts** for Yuma, La Paz, Mohave, Pima, and Santa Cruz Counties.
- Completed detailed **geologic mapping** in the Hieroglyphic and Wickenburg Mountains in Yavapai and Maricopa Counties; partial support was provided by the U.S. Geological Survey and U.S. Bureau of Land Management.
- Completed, and submitted for publication, a report on the **geology and mineral resources** in the Buckskin Mountains and adjacent areas in La Paz and Mohave Counties.
- Co-sponsored and hosted meeting of geologists engaged in research on metallic mineral deposits in Arizona in order to discuss **future research needs**; U.S. Geological Survey and the University of Arizona Department of Geosciences were other co-sponsors of the meeting.
- Established network of **in-state library depositories** for Bureau publications, in cooperation with the Arizona Department of Library, Archives, and Public Records.

Dedication

This report is dedicated to H. Wesley Peirce and Joseph R. LaVoie, two long-term Bureau staff members who retired June 30, 1987. Both were outstanding employees whose combined service totalled 53 years. We will miss them professionally and personally.

H. WESLEY PEIRCE

Wes served continuously since July 1, 1956, a total of 31 years. For the last 8 years his title was Principal Geologist. His new title, effective July 1, 1987, is Principal Geologist, Emeritus.



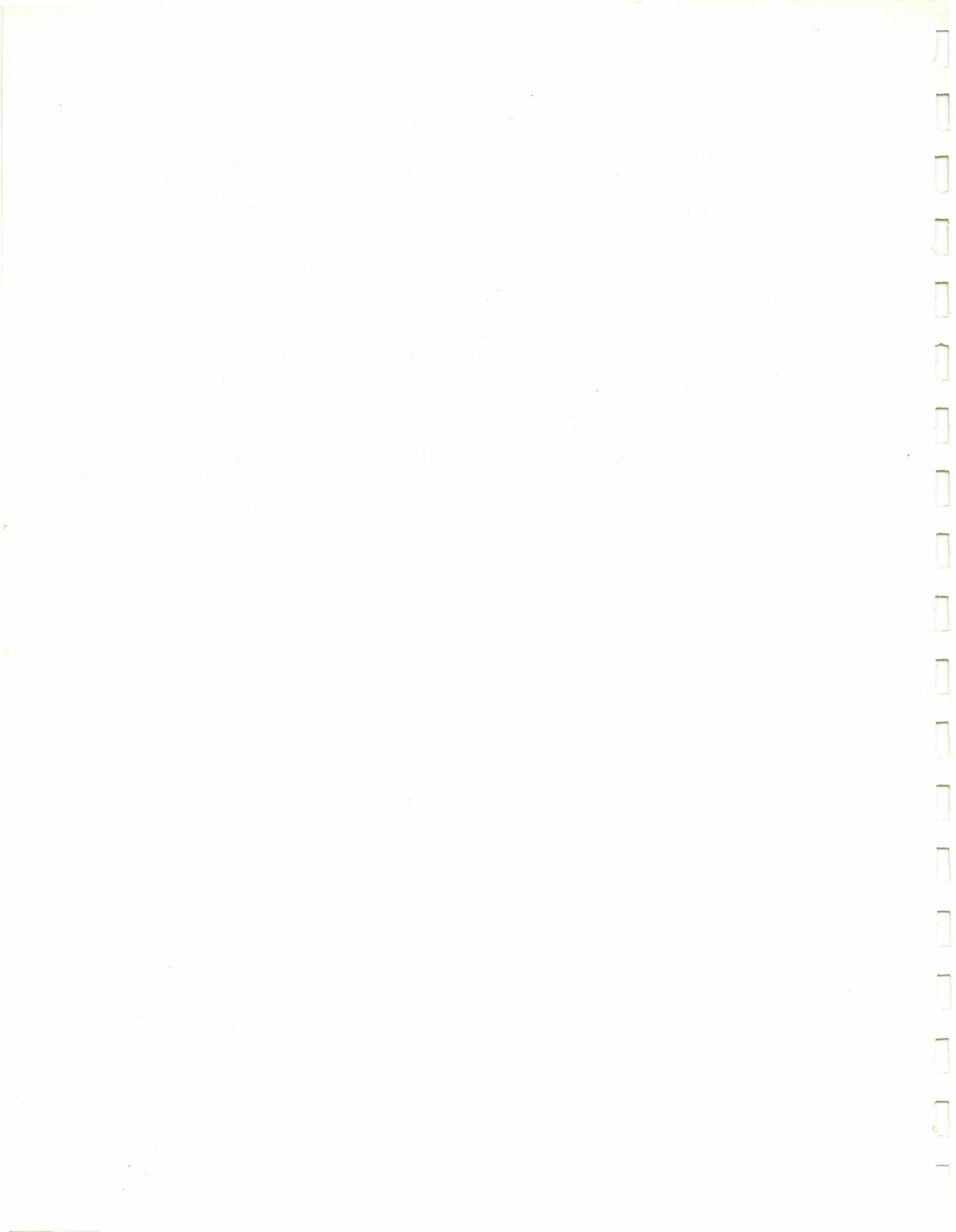
JOSEPH R. LAVOIE

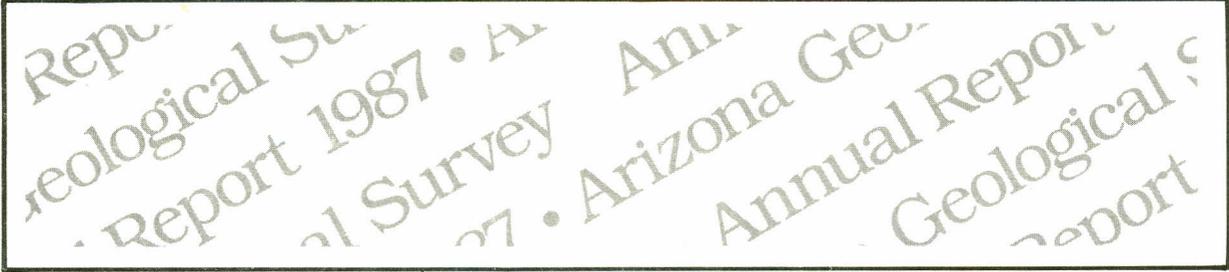
Joe began working at the Bureau March 16, 1965, 22 years ago. He was a graphic artist and supervised the graphics section.



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Objectives and Duties

The Legislature declares that the wise use of the lands and mineral resources of the state can be assisted by the establishment of a scientific, investigative and information agency whose purpose is to conduct research and provide information for use by the legislature, governmental agencies, industry and the public. (House Bill 2060, Thirty-third legislature, 1977, Section 1.)

Objectives

- **To inform the public in matters concerning the geological environment and the development and use of the mineral resources of this state.**
- **To encourage the wise use of the lands and mineral resources of this state toward its development.**
- **To provide technical advice and assistance in geology and mineral technology to other state and local governmental agencies engaged in projects in which the geologic setting or the mineral resources of the state are involved.**
- **To provide technical advice and assistance in geology and mineral technology to industry and other members of the public toward the wise development and use of the mineral and land resources of this state.**

Section 27-152,
Arizona Revised Statutes

Duties

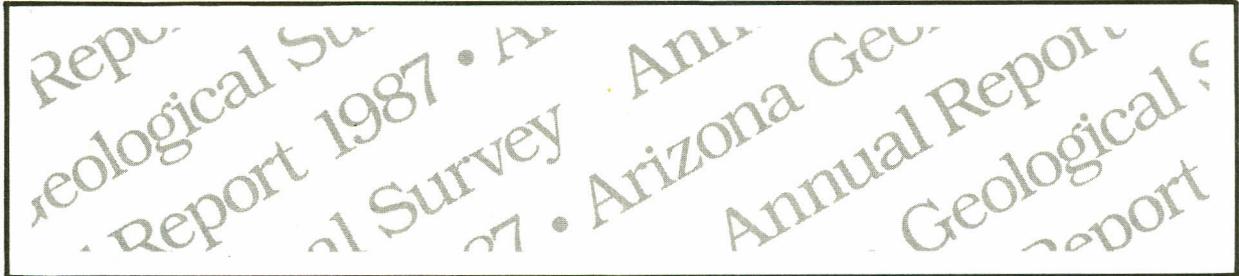
- **Investigate, describe, and interpret the geological setting of this state, including its natural hazards and limitations, its natural attributes and its mineral resources.**
- **Publish in the form of bulletins, circulars, maps and other related series or otherwise make available to state agencies, government officials, industry, and the public the results of all geological . . . and related research and investigation undertaken by the Bureau.**
- **Provide lectures, talks, displays, and exhibits for the general education of the public toward a better understanding of this state and the wise use of its land and mineral resources.**
- **Operate and maintain a central repository for reports, books, maps, and other publications regarding the geology, mineral resources, and associated technologies present or practiced in this state. Such repository shall be available for the use of the public.**
- **Operate and maintain a central repository for rock cores, well cuttings, and related subsurface samples and all associated supplemental data consistent with the laws of this state requiring the deposit of such material and information. Such repository shall be available for the use of the public.**

Section 27-152.01
Arizona Revised Statutes

Long-Term Goals

Long-term goals, developed to reflect the statutory mandate of the Arizona Geological Survey, are as follows:

- **Geologic Information.** Serve as a primary source of information on the geology of Arizona by maintaining computerized data bases (Arizona Geologic Information System), a library, and a repository of rock cuttings, cores, and other samples; publishing reports and maps; and conducting information dissemination programs.
- **Rock and Surficial Materials.** Characterize rock and surficial material units in Arizona, prepare maps showing their distribution, and provide information to those who investigate Arizona's geologic framework and manage or use land and mineral resources.
- **Mineral and Energy Resources.** Determine the types, distribution, origins, and geologic associations of Arizona's metallic, nonmetallic, and energy resources and assess potential for future discoveries.
- **Geologic Processes.** Inventory and investigate ongoing geologic processes such as subsidence, mass movement, collapse, seismicity, and others, that are, or might be, hazardous or damaging to life or property in Arizona.
- **Applied Geoscience.** Assess the potential impact of rock and surficial materials, mineral and energy resources, and geologic processes on the use and management of Arizona's lands.
- **Education.** Encourage awareness of Arizona's geologic heritage and the vital role it plays in our lives by developing earth science education materials and programs, publishing nontechnical reports, and interacting with graduate students and faculty.



Accomplishments

Investigations Completed	Page 6
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Investigations Completed

PUBLISHED BY BUREAU OF GEOLOGY
AND MINERAL TECHNOLOGY

- Special Papers, Bulletins, Circulars, Maps

PEIRCE, H. W., editor, 1987, Proceedings of the 21st Forum on the Geology of Industrial Minerals: Arizona Bureau of Geology and Mineral Technology Special Paper 4, 134 p. (The 21st Forum was hosted in Tucson by the Arizona Geological Survey in April 1985.)

-----, 1987, Industrial minerals and rocks of Arizona, in Peirce, H. W., editor, Proceedings of the 21st Forum on the Geology of Industrial Minerals: Arizona Bureau of Geology and Mineral Technology Special Paper 4, p. 17-23.

REYNOLDS, S. J., and **PEIRCE, H. W.**, 1986, Geologic setting of industrial rocks and minerals in Arizona, in Peirce, H. W., editor, Proceedings of the 21st Forum on the Geology of Industrial Minerals: Arizona Bureau of Geology and Mineral Technology Special Paper 4, p. 9-16.

Schnabel, L., and **WELTY, J. W.**, 1986, Bibliography of metallic mineral districts in La Paz, Mohave, and Yuma Counties, Arizona: Arizona Bureau of Geology and Mineral Technology Circular 25, 45 p.

Schnabel, L., **WELTY, J. W.**, **TRAPP, R. A.**, and **REYNOLDS, S. J.**, 1986, Bibliography of mineral districts in Pima and Santa Cruz Counties, Arizona: Arizona Bureau of Geology and Mineral Technology Circular 26, 44 p.

Schumann, H. H., and Genualdi, R. B., 1986, Land subsidence, earth fissures, and water level change in southern Arizona: Arizona Bureau of Geology and Mineral Technology Map 23, 1:1,000,000 scale. (See project description on page 15.)

WELTY, J. W., and **SPENCER, J. E.**, 1986, Geology and industrial uses of Arizona's volcanic rocks, in Peirce, H. W., editor, Proceedings of the 21st Forum on the Geology of Industrial Minerals: Arizona Bureau of Geology and Mineral Technology Special Paper 4, p. 106-115.

● Open-File Reports

CAPPS, R. C., REYNOLDS, S. J., KORTEMEIER, C. P., and SCOTT, E. A., 1986, Geologic map of the northeastern Hieroglyphic Mountains, central Arizona: Arizona Bureau of Geology and Mineral Technology Open-File Report 86-10, 16 p., 1:24,000 scale map. (Partial funding was provided by the U.S. Geological Survey as part of the Cooperative Geologic Mapping Program with state geological surveys. The U.S. Bureau of Land Management supplied color aerial photographs required to do the mapping.)

GRUBENSKY, M. J., and REYNOLDS, S. J., 1987, Index of unpublished (pre-1969) geologic mapping in Arizona done by the Arizona Bureau of Mines and the U.S. Geological Survey: Arizona Bureau of Geology and Mineral Technology Open-File Report 87-5, 13 maps, scale 1:250,000.

MCGARVIN, T. G., 1987, Index of published geologic maps of Arizona - 1986: Arizona Bureau of Geology and Mineral Technology Open-File Report 87-1.

PEARTHREE, P. A., and SCARBOROUGH, R. B., 1986, Reconnaissance assessment of Quaternary faulting in the Gila River region from San Carlos Reservoir to Coolidge, Arizona: Arizona Bureau of Geology and Mineral Technology Open-File Report 86-13, 15 p. (Funding provided by U.S. Bureau of Reclamation during FY 1985-86; approval to release report granted in FY 1986-87.)

Schumann, H. H., and Genualdi, R. B., 1987, Land subsidence, earth fissures, and water level change in southern Arizona: Arizona Bureau of Geology and Mineral Technology Open-File Report 86-14, scale 1:500,000. (See project description, page 15.)

SPENCER, J. E., Emer, D. F., and SHENK, J. D., 1987, Geology, radioactivity, and radon at the Cardinal Avenue uranium occurrence, southwestern Tucson: Arizona Bureau of Geology and Mineral Technology Open-File Report 87-3, 16 p. (Project done in cooperation with the Pima County Health Department; see description, page 15.)

SPENCER, J. E., and REYNOLDS, S. J., 1987, Geologic map of the Swansea-Copper Penny area, central Buckskin Mountains, west-central Arizona: Arizona Bureau of Geology and Mineral Technology Open-File Report 87-2, scale 1:12,000.

SPENCER, J. E., and REYNOLDS, S. J., and Lehman, N. E., 1986, Geologic map of the Planet-Mineral Hill area, northwestern Buckskin Mountains, western Arizona: Arizona Bureau of Geology and Mineral Technology Open-File Report 86-9, 13 p., and map, scale 1:24,000.

SPENCER, J. E., and SHENK, J. D., 1986, Map showing areas in Arizona with elevated concentrations of uranium: Arizona Bureau of Geology and Mineral Technology Open-File Report 86-11, scale 1:1,000,000. (Prepared for the Arizona Radiation Regulatory Agency; see project description, page 14.)

SPENCER, J. E., and WELTY, J. W., Mid-Tertiary ore deposits in Arizona: Arizona Bureau of Geology and Mineral Technology Open-File Report 86-12, 40 p.

• Fieldnotes

FELLOWS, L. D., 1987, Radon update: Arizona Bureau of Geology and Mineral Technology Fieldnotes, v. 17, no. 2, p. 6-7, 12.

MCGARVIN, T. G., The 1887 Sonoran earthquake: it wasn't our fault: Arizona Bureau of Geology and Mineral Technology Fieldnotes, v. 17, no. 2, p. 1-2.

REYNOLDS, S. J., and SPENCER, J. E., 1987, Cooperative geologic mapping in Arizona: COGEO MAP update: Arizona Bureau of Geology and Mineral Technology Fieldnotes, v. 17, no. 2, p. 8-11.

SPENCER, J. E., 1986, Radon gas: a geologic hazard: Arizona Bureau of Geology and Mineral Technology Fieldnotes, v. 16, no. 4, p. 1-6.

VANDEN DOLDER, E. M., The nonfuel mineral industry: 1986 summary: Arizona Bureau of Geology and Mineral Technology Fieldnotes, v. 17, no. 2, p. 3-5.

PUBLISHED EXTERNALLY

Aldrich, M. J., Laughlin, A. W., Meade, J. S., and PEIRCE, H. W., 1986, The Jemez lineament: structural boundaries and control on sedimentary facies, tectonism, and mineralization: Proceedings of the 6th International Conference on Basement Tectonics, p. 104-113.

PEIRCE, H. W., 1987, An ancestral Colorado plateau edge: Fossil Creek Canyon, Arizona, in Geological Society of America Centennial Field Guide, Cordilleran Section, p. 41-42.

-----, 1987, Hitting rock bottom, in Arizona Wildlife News: Arizona Game and Fish, v. 30, no. 6, p. 12-15.

REYNOLDS, S. J., and Lister, G. S., 1987, Structural aspects of fluid-rock interactions in detachment zones: Geology, v. 15, no. 4, p. 362-366.

TECHNICAL PAPERS PRESENTED

Lehman, N. E., SPENCER, J. E., and WELTY, J. W., 1987, Middle Tertiary mineralization related to metamorphic core complexes and detachment faults in Arizona (paper presented by N. E. Lehman at annual meeting of American Institute of Mining, Metallurgical and Petroleum Engineers, Denver, Colorado; February 1987).

REYNOLDS, S. J., and Lister, G. S., 1987, Kinematics of mylonitic rocks in metamorphic core complexes in Arizona -- origin of the mylonitic front (paper presented by S. J. Reynolds at meeting of the Cordilleran Section of the Geological Society of America; Hilo, Hawaii; May 1987): Geological Society of America Abstracts with Programs, v. 19, p. 443.

WELTY, J. W., and SPENCER, J. E., Two types of mineralization related to Tertiary detachment faults in the southwestern United States (paper presented by J. W. Welty at annual meeting of the Geological Society of America; San Antonio, TX; November 1986): Geological Society of America Abstracts with Programs, v. 18, p. 785.

TALKS GIVEN

FELLOWS, L. D., Arizona Geological Survey program and projects: talk presented to Arizona Hydrological Society, Tempe.

McGARVIN, T. G., Geologic history of southern Arizona: talk given to Ajo Chapter of American Institute of Mining, Metallurgical, and Petroleum Engineers (AIME).

PEIRCE, H. W., Thirty years of Arizona geology: talk presented to Northern Arizona University geology graduate students, Flagstaff.

-----, History and origin of the Mogollon Escarpment: talk given to Southern Arizona Paleontological Society, Tucson.

REYNOLDS, S. J., Structural evolution and fluid-rock interactions of detachment zones in Arizona: talk presented to geology faculty and students at University of Nevada-Las Vegas; Las Vegas, NV; November 1986.

SPENCER, J. E., Cenozoic extensional tectonics in the southwestern United States: talk presented to University of Nevada-Las Vegas geology faculty and students; Las Vegas, NV; April 1987.

SUBMITTED FOR PUBLICATION

Cunningham, D., DeWitt, E., Haxel, G., **REYNOLDS, S. J.**, and **SPENCER, J. E.**, Geologic map of the Maricopa Mountains, central Arizona: Arizona Bureau of Geology and Mineral Technology Open-File Report, in preparation. (Prepared in cooperation with Superconducting Super Collider Team; see description, page 15.)

Laubach, S. E., **REYNOLDS, S. J.**, and **SPENCER, J. E.**, Mesozoic stratigraphy of the Granite Wash Mountains, west-central Arizona: submitted to Arizona Geological Society for publication in Digest 18.

PEIRCE, H. W., Paleozoic history in Arizona -- a selective overview: submitted to Arizona Geological Society for publication in Digest 17.

Potochnik, A. R., and **REYNOLDS, S. J.**, Side canyons of the Colorado River, Grand Canyon: submitted to Museum of Northern Arizona for publication in Geology of the Grand Canyon volume.

REYNOLDS, S. J., and Lister, G. S., Field guide to lower- and upper-plate rocks of the South Mountains detachment zone, Arizona: to be included in Arizona Bureau of Geology and Mineral Technology Special Paper.

REYNOLDS, S. J., and Lister, G. S., Ductile-to-brittle evolution of the South Mountains detachment zone, central Arizona: submitted for publication in Journal of Structural Geology.

REYNOLDS, S. J., **SPENCER, J. E.**, and DeWitt, E., Stratigraphy and U-Th-Pb geochronology of Triassic and Jurassic rocks in west-central Arizona: submitted to Arizona Geological Society for publication in Digest 18.

REYNOLDS, S. J., and others, Geologic setting of Mesozoic and Cenozoic metamorphism in Arizona, to be published in Ernest, W. G., editor, Metamorphism and crustal evolution of the western United States: Prentice-Hall, Inc. (Reynolds presented this paper as an invited speaker at the W.W. Rubey Symposium sponsored by the Department of Geology at the University of California at Los Angeles in April 1985.)

REYNOLDS, S. J., and others, Geologic map of the Tucson 1° X 2° quadrangle, Arizona: to be published by the Arizona Bureau of Geology and Mineral Technology or the U.S. Geological Survey.

REYNOLDS, S. J., and others, Compilation of radiometric age determinations in Arizona: to be published as Arizona Bureau of Geology and Mineral Technology Bulletin 197.

Richard, S. M., **REYNOLDS, S. J.**, and **SPENCER, J. E.**, Mesozoic stratigraphy of the Little Harquahala and Harquahala Mountains, west-central Arizona: submitted to Arizona Geological Society for publication in Digest 18.

RODDY, M.S., **REYNOLDS, S. J.**, and others, Potassium metasomatism and detachment-related mineralization and fluid regimes, Harcuvar Mountains, Arizona: submitted for publication in Geological Society of America Bulletin.

SPENCER, J. E., **REYNOLDS, S. J.**, Anderson, J. L., Davis, C. A., Laubach, S. E., Richard, S. M., and Marshak, S., Field-trip guide to parts of the Harquahala, Granite Wash, Whipple, and Buckskin Mountains, west-central Arizona and southeastern California, to be published in Arizona Bureau of Geology and Mineral Technology Special Paper 5.

STIMAC, J. A., **FRYKELL, J. E.**, **REYNOLDS, S. J.**, **GRUBENSKY, M. J.**, and **SCOTT, E. A.**, Geologic map of the Wickenburg, southern Buckhorn, and northwestern Hieroglyphic Mountains, central Arizona: to be released by Arizona Bureau of Geology and Mineral Technology as an open-file report.

Young, R. A., **PEIRCE, H. W.**, and Faulds, J. E., 1987, Geology of Colorado plateau margin -- central Arizona: to be published in Arizona Bureau of Geology and Mineral Technology Special Paper 5.

Information and Assistance Provided

RESPONSE TO INQUIRIES

Inquiries. During FY 1986-87 approximately 3,200 geological inquiries were answered by AGS geologists. More than 1,228 persons visited our office to purchase reports and maps, use the geologic library, examine rock cuttings and cores, and talk with geologists.

Publications sold. The Bureau is charged by statute to publish, or otherwise make available to the public, the results of all geological investigations undertaken. The Bureau and its predecessor, the Arizona Bureau of Mines, have published geologic reports and maps since 1915. Most of the older publications have gone out-of-print and are now available only in libraries. Currently available for purchase, however, are 63 published reports and maps, 134 open-file reports, and 7 miscellaneous maps.

During FY 1986-87 publication sales totalled \$19,431, which was deposited in the publication revolving fund to print and distribute future reports and maps.

Governmental and other groups assisted. Information and assistance are provided to the public, representatives of industry, consultants, faculty and students, the Governor and his staff, legislators and legislative committee staff, and employees of local, county, state, and federal governmental agencies. The following governmental agencies requested and received information or assistance:

- **State agencies:**

- Commerce

- Emergency Services

- Health Services:

- Office of Emergency Response and Environmental Analysis

- Office of Waste and Water Quality

- Historical Society

- Land Department

- Library, Archives, and Public Records

- Mine Inspector

- Mines and Mineral Resources

- Radiation Regulatory Agency

- Transportation

- Water Resources

- County and local agencies:
 - City of Willcox
 - Cochise County Public Works Department
 - Pima Association of Governments
 - Pima County Parks Department
 - " " Health Department
 - " " Wastewater Management Office
 - Sunnyside School District
 - Tanque Verde School District
 - Tucson Convention Bureau
 - " Economic Development Board

- Federal agencies:
 - Bureau of Indian Affairs
 - Bureau of Land Management
 - Bureau of Mines
 - Bureau of Reclamation
 - Forest Service
 - Geological Survey
 - Securities and Exchange Commission

- Other groups:
 - Arizona Mining Association
 - Arizona - Sonora Desert Museum
 - Arizona State Library Association
 - Arizona State University
 - Foreign Trade Association
 - Idaho State Land Department
 - National Wildlife Federation
 - Nevada Bureau of Mines and Geology
 - New Mexico Bureau of Mines and Geology
 - New Mexico Economic Development Board
 - Northern Arizona University
 - Pima Community College
 - Salt River Project
 - Sonora Project
 - Tohono O'odham Indian Reservation, Water Division
 - University of Arizona, Department of Education
 - University of Arizona, Office of Arid Lands Studies

Examples of assistance to and cooperation with governmental agencies.

Earthquakes - Arizona Earthquake Information Center (AEIC):
 The AEIC, in operation since 1985, maintains a network of seismic stations in northern Arizona. Activities of the AEIC, including summaries of seismic events recorded, will be summarized in Fieldnotes, as was done in the Winter 1986 issue. In addition, reports of specific seismic events or of events recorded during specific periods of time will be released as part of the AGS' open-file-report series. This collaboration is being undertaken to make seismic information more accessible to the public. Director of the AEIC, which is affiliated with the Department of Geology at Northern Arizona University, is Dr. David S. Brumbaugh.

Geologic mapping - U.S. Geological Survey (USGS) and U.S. Bureau of Land Management (BLM): For the third successive year the AGS has participated in the Cooperative Geologic Mapping Program (COGEOMAP), established by the USGS to support original mapping done by the USGS and state geological surveys. COGEOMAP projects require equal funding by the state geological survey, usually as in-kind service, and the USGS. The BLM has provided color aerial photographs needed to complete the mapping. During FY 1986-87 mapping was completed in the Hieroglyphic and Wickenburg Mountains. Objective of the project is to complete and publish geologic maps in the Phoenix 1° x 2° quadrangle. COGEOMAP results have been described in the Spring, Summer, and Winter 1985 issues and the Summer 1987 issue of Fieldnotes.

Library depositories - State Library, Archives, and Public Records: In order to make AGS publications available for examination by persons throughout the state, twelve libraries have agreed to serve as depositories. Selection of these libraries was done in cooperation with Ms. Janet Fisher of the State Library, Archives, and Public Records. New publications of the AGS will be sent to the State Library, which will distribute them to the depository libraries. Open-file-reports and miscellaneous map series items will not be included.

Mineral ownership exchanges - State Land Department: Exchanges of mineral ownership between the State Land Department and the U.S. Bureau of Land Management, as well as selection of "in lieu" lands, have occurred during the past several years. AGS geologists have assisted by providing information about known and potential mineral resources to the State Land Department.

Radon - Arizona Radiation Regulatory Agency (ARRA): AGS geologists assisted the ARRA in planning a program to assess the potential for indoor radon by preparing a map (OFR 86-11) that shows areas in which rocks are known to have elevated concentrations of uranium. Uranium breaks down slowly by the radioactive decay process. Radon gas is one of the decay products. In general, the higher the uranium content in a rock, the more radon gas that will be generated in the radioactive decay process. The ARRA will use the uranium occurrence information in determining where to place charcoal canisters to detect radon.

The ARRA submitted a request to the Arizona Legislature for \$58,000 to assess the indoor radon potential during FY 1987-88. The request was approved. The AGS will receive \$8,000 of the appropriation to determine the natural radioactivity in several populated areas believed to be underlain by rocks with elevated uranium content. The results of this investigation will be provided to the ARRA.

A summary of radon and current knowledge of the distribution of rocks with elevated uranium content in Arizona was included in the Winter 1986 issue of Fieldnotes.

Radon - Pima County Health Department (PCHD): AGS geologists assisted the PCHD in assessing the potential for indoor radon in southwestern Tucson by identifying the boundaries of a limestone deposit known to contain a higher-than-normal amount of uranium. The PCHD used this information as a guide to the placement of charcoal canisters, from which radon content was determined. This activity, which occurred during April 1987, was summarized in the Summer 1987 issue of Fieldnotes. Geologic aspects of the uranium-bearing limestone, natural radioactivity levels, and radon were described in Open-File Report 87-3.

Subsidence: A group of state and federal agencies initiated a project to determine the extent to which ground-water levels have been lowered and subsidence and earth fissures have occurred. A 1:1,000,000-scale overview map was prepared by Schumann and Robert B. Genualdi (Arizona Department of Water Resources) and published by the AGS (Map 23, 1987). A 1:500,000-scale map showing the same information was placed on open file (OFR 86-14).

The U.S. Bureau of Reclamation provided the use of a helicopter to re-survey earth fissures. Fissures were mapped by Richard H. Raymond (retired, U.S. Bureau of Reclamation), Herbert H. Schumann (U.S. Geological Survey), William G. Wellendorf (consultant), and Carl C. Winikka (Arizona Department of Transportation). A 1:250,000-scale map is currently being prepared. This project was described in more detail in the Spring 1987 issue of Fieldnotes.

Superconducting Super Collider (SSC): AGS geologist Stephen J. Reynolds first suggested the Maricopa site to the SSC team, attended initial project planning sessions, provided geologic information and expertise about both the Maricopa and Sierrita sites, and reviewed the geologic reports for both sites. Reynolds and AGS geologist Jon E. Spencer participated in preparation of a reconnaissance geologic map of the Maricopa Mountains, which were previously unmapped. A summary of the SSC project was included in the Spring 1987 issue of Fieldnotes.

Other assistance provided.

A telephone request for information from Mr. Marvin Kohlman, followed by other discussions, resulted in the establishment of a new business in Arizona, the Western Clay Tennis Company. Mr. Kohlman's company builds clay tennis courts using fines from a crushed and screened decomposed granite from southern Arizona.

FIELDNOTES

Fieldnotes, published quarterly, includes articles that describe various aspects of Arizona's geologic framework, mineral and energy resources, and hazards or limitations to land and resource management that are related to geology. In addition, the availability of new publications on these subjects is announced.

Issues published during FY 1986-87 included the following items:

Fall 1986 - Volume 16, Number 3, 12 p.

A geologic surprise in the Grand Canyon: Stanley S. Beus,
Northern Arizona University
The renaissance of copper solution mining: J. Brent
Hiskey, Mineral Technology Branch
Geologic place names: Tombstone
Recent publications on the geology of Arizona
New Bureau publications

Winter 1986 - Volume 16, Number 4, 12 p.

Radon gas: a geologic hazard: Jon E. Spencer, Geological
Survey Branch
Arizona Earthquake Information Center, 1986 activity
summary: David S. Brumbaugh, Northern Arizona
University
Stewart Mountain Dam: current geologic investigations:
Cathy S. Wellendorf, U.S. Bureau of Reclamation
Geologic place names: Wickenburg
Association of American State Geologists
Recent publications on the geology of Arizona
New Bureau publications

Spring 1987 - Volume 17, Number 1, 12 p.

Arizona and the superconducting super collider: Dickson
Cunningham, University of Arizona
Mineral and oil-and-gas leasing
Subsidence areas and earth-fissure zones: Larry D.
Fellows, Geological Survey Branch
Theses and dissertations, 1986
Geologic place names: Globe
Recent publications on the geology of Arizona
New Bureau Publications

Summer 1987 - Volume 17, Number 2, 12 p.

The 1887 Sonoran earthquake: it wasn't our fault: Thomas G. McGarvin, Geological Survey Branch
The nonfuel mineral industry: 1986 summary: Evelyn M. VandenDolder, Geological Survey Branch
Radon update: Larry D. Fellows, Geological Survey Branch
Cooperative geologic mapping in Arizona: COGEOMAP update: Stephen J. Reynolds and Jon E. Spencer, Geological Survey Branch
Key Survey employees retire
Arizona Geological Survey established

GRADUATE EDUCATION

Arizona Geological Survey (AGS) geologists provide assistance to geology graduate students working on thesis and dissertation projects in Arizona that relate directly to the AGS mission. During FY 1986-87, AGS geologists served on thesis or exam committees of 11 geology graduate students and provided assistance to 11 others. Numerous maps and reports completed by AGS geologists during the year were co-authored by faculty members and students representing the Univ. of Arizona, Arizona State Univ., Univ. of California - Santa Barbara, Univ. of Illinois, Massachusetts Institute of Technology, Monash Univ. (Melbourne, Australia), Univ. of Nevada - Las Vegas, Univ. of New Mexico, State Univ. of New York - Geneseo, Northern Arizona Univ., Univ. of Southern California, and Virginia Polytechnic Institute.

FIELD TRIPS AND WORKSHOPS

Fieldtrip to Tucson Mountains led for Tucson-area earth-science teachers; T. G. McGarvin

Fieldtrip to Sonoita, Patagonia, and San Rafael Valley areas for Arizona Association for Learning In and About the Environment; T. G. McGarvin

Conducted geology portion of "Eco-Intensive" workshops for Tucson Unified School District teachers at Camp Cooper; T. G. McGarvin

Conducted geology program at Boy Scout Holiday Camp in Tucson Mountains; T. G. McGarvin

Conducted geology portion of Natural Resources Conservation Workshop for Arizona Youth sponsored by Arizona Section of the Society for Range Management; Sierra Ancha; H. W. Peirce

TALKS

Arizona State Library Association Annual Meeting, Tucson

Desert Goldiggers Association, Tucson

Desert Hills Recreation Center, Green Valley

Kiwanis Club, Tucson

Tucson Public Library - Main, Wilmot, Woods, Nanini, Valencia,
and Himmel Branches

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State Appropriation

Arizona Geological Survey⁽¹⁾

Category	FY 1985-86		FY 1986-87		FY 1987-88
	Budgeted	Spent	Budgeted	Spent	Budgeted
Personal Service	\$269,201	290,812	288,042	298,202 ⁽²⁾	323,599
ERE (Benefits)	50,836	52,317	51,258	52,991	54,782
Operations	25,000	30,062	26,100	26,554	26,100
In-state Travel	5,900	7,508	6,200	5,183	6,200
Out-of-state Travel	750	737	800	2,684 ⁽³⁾	800
Equipment	10,600	10,600	10,300	12,410	0
TOTAL	\$362,287	392,036	382,700	398,024	411,481

- (1) Budget is from "Organized Research", a special program in the University of Arizona Main Campus appropriation.
- (2) Reflects salary increases awarded January 1, 1987.
- (3) Includes \$1,205 provided by Vice President for Research.

Contracted Projects*

Arizona Geological Survey

FY 1986-87 Expenditures				
Category	Landslides	Geologic Mapping- Wickenburg area	Geologic Mapping- Hieroglyphic Mtns.	TOTAL
Personal Services	\$6,413	20,018	15,794	42,225
ERE (Benefits)	115	1,320	617	2,052
Operations	76	442	1,114	1,632
In-state Travel	34	8,936	3,420	12,390
Out-of-state Travel	0	0	542	542
Equipment	0	0	0	0
Indirect	2,921	7,525	5,264	15,710
TOTAL	\$9,559	38,241	26,751	74,551

*Occasionally opportunities arise to complete projects with federal and other state agencies on a formal contractual basis. Such projects are undertaken if they are consistent with the statutory responsibilities of the Arizona Geological Survey (AGS), if the AGS has personnel qualified to direct the project and, thus, provide a quality product, and if the results of the project can be made available to the public.

Contracted projects address specified subjects or areas and are completed within a specified time interval. Persons are employed with contract funds with the understanding that their employment is temporary and terminates when the project is completed.

The following contracted projects were in progress during FY 1986-87:

LANDSLIDES

Description: This statewide inventory of landslides will result in preparation of a 1:500,000-scale map that includes 7 selected areas done in greater detail. Project is funded by U.S. Geological Survey.

Principal Investigators: Larry D. Fellows and John W. Welty

Amount of Contract: \$10,000

Duration of contract: September 15, 1986 to September 14, 1987.

Amount spent in FY86-87: \$9,559

Persons employed in FY86-87: John W. Welty

Reports and maps completed in FY86-87: None

GEOLOGIC MAPPING - WICKENBURG AREA

Description: Geologic mapping in Phoenix Quadrangle (1° x 2°), a 50-50 matched-funding project with the U.S. Geological Survey. U.S. Bureau of Land Management provided color aerial photographs. Mapping was done in the western Hieroglyphic and the Wickenburg Mountains.

Principal Investigators: Stephen J. Reynolds and Larry D. Fellows

Amount of contract: \$60,000

Duration of contract: January 1, 1987 to December 31, 1987

Amount spent in FY86-87: \$38,241

Persons employed in FY86-87: Joan E. Fryxell, Michael J. Grubensky, Stephen M. Richard, Elizabeth A. Scott, and James A. Stimac

Reports and maps completed:

STIMAC, J. A., FRYXELL, J. E., REYNOLDS, S. J., GRUBENSKY, M. J., and SCOTT, E. A., Geologic map of the Wickenburg, southern Buckhorn, and northwestern Hieroglyphic Mountains, central Arizona: to be released by Arizona Bureau of Geology and Mineral Technology as an open-file report.

GRUBENSKY, M. J., and REYNOLDS, S. J., 1987, Index of unpublished (pre-1969) geologic mapping in Arizona done by the Arizona Bureau of Mines and the U.S. Geological Survey: Arizona Bureau of Geology and Mineral Technology Open-File Report 87-5, 13 maps, scale 1:250,000.

GEOLOGIC MAPPING - HIEROGLYPHIC MOUNTAINS

Description: Geologic mapping in Phoenix Quadrangle (1° x 2°), a 50-50 matched funding project with the U.S. Geological Survey. U.S. Bureau of Land Management provided color aerial photographs. Mapping was done in the northeastern Hieroglyphic Mountains.

Principal Investigators: Stephen J. Reynolds and Larry D. Fellows

Amount of contract: \$63,204 (dollars from U.S. Geological Survey)
18,948 (in-kind work by U.S. Geological Survey)
82,152 (in-kind work by Arizona Geological Survey)

Duration of project: January 1, 1986 to December 31, 1986

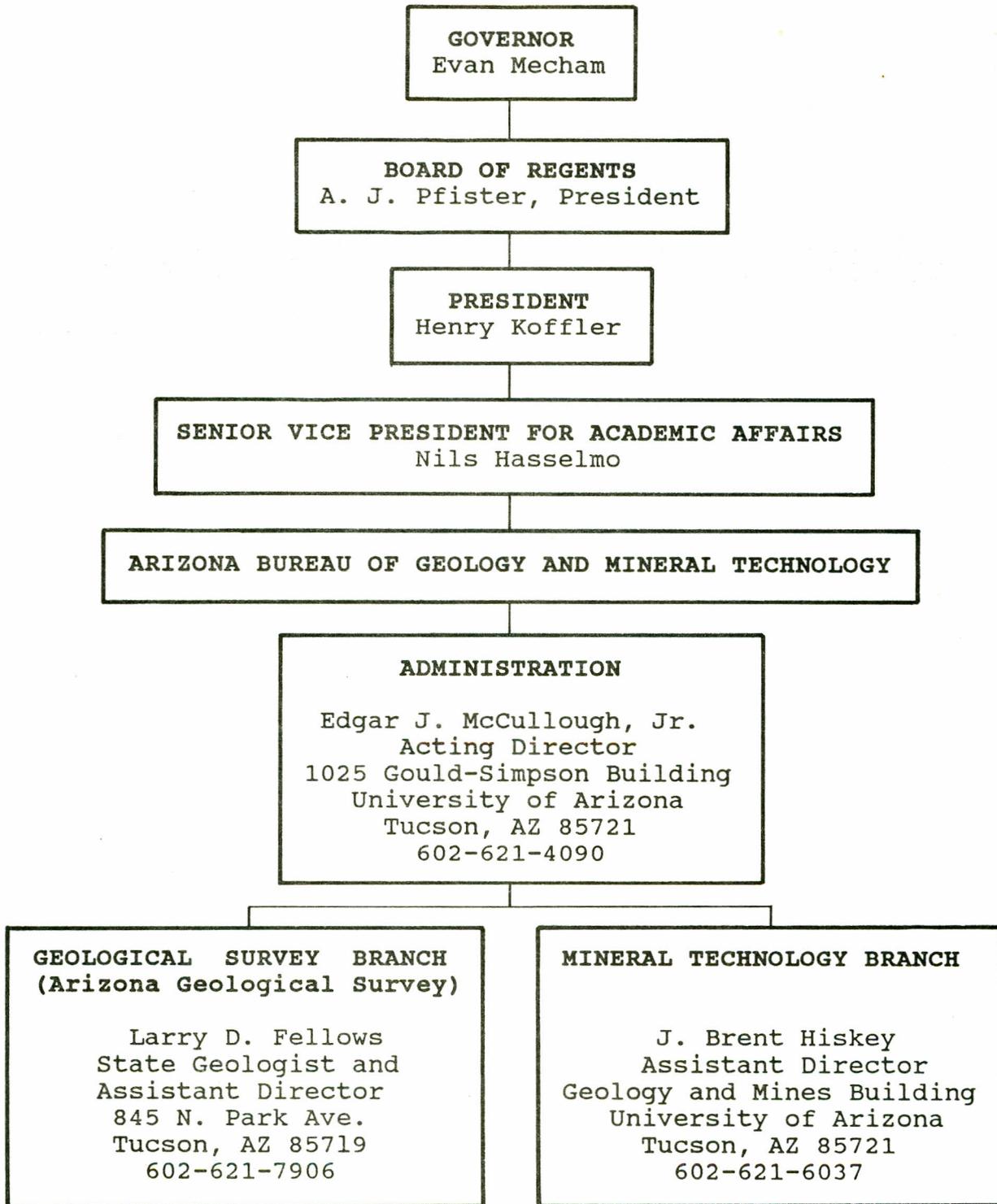
Amount spent in FY86-87: \$26,751

Persons employed in FY86-87: Philip Anderson, Michael J. Grubensky, Philip A. Pearthree, Michael S. Roddy, David E. Wahl, Jr., and John W. Welty

Reports and maps completed:

CAPPS, R. C., REYNOLDS, S. J., KORTEMEIER, C. P., and SCOTT, E. A., 1986, Geologic map of the northeastern Hieroglyphic Mountains, central Arizona: Arizona Bureau of Geology and Mineral Technology Open-File Report 86-10, 16 p., 1:24,000 scale map.

Organization



Statutory Provisions*

Administration. The Bureau of Geology and Mineral Technology shall be maintained as a Division of the University, under the administration of the Arizona Board of Regents and under the supervision of the President or his designate. Board members shall be paid their expenses incurred in the direction of the Bureau. (Section 27-151, A, Arizona Revised Statutes)

Director, qualifications. The Director shall be a geologist or a geological, mining, or metallurgical engineer graduated from an accredited institution, qualified by education and experience, and shall possess a certificate of registration issued by the State Board of Technical Registration. (Section 27-151, B, Arizona Revised Statutes)

Assistant directors, qualifications. The Assistant Director responsible for the Geological Survey Branch shall carry the title of State Geologist and shall be a geologist or a geological engineer graduated from an accredited institution, qualified by education and experience, and shall possess a certificate of registration issued by the State Board of Technical Registration. (Section 27-151, C, Arizona Revised Statutes)

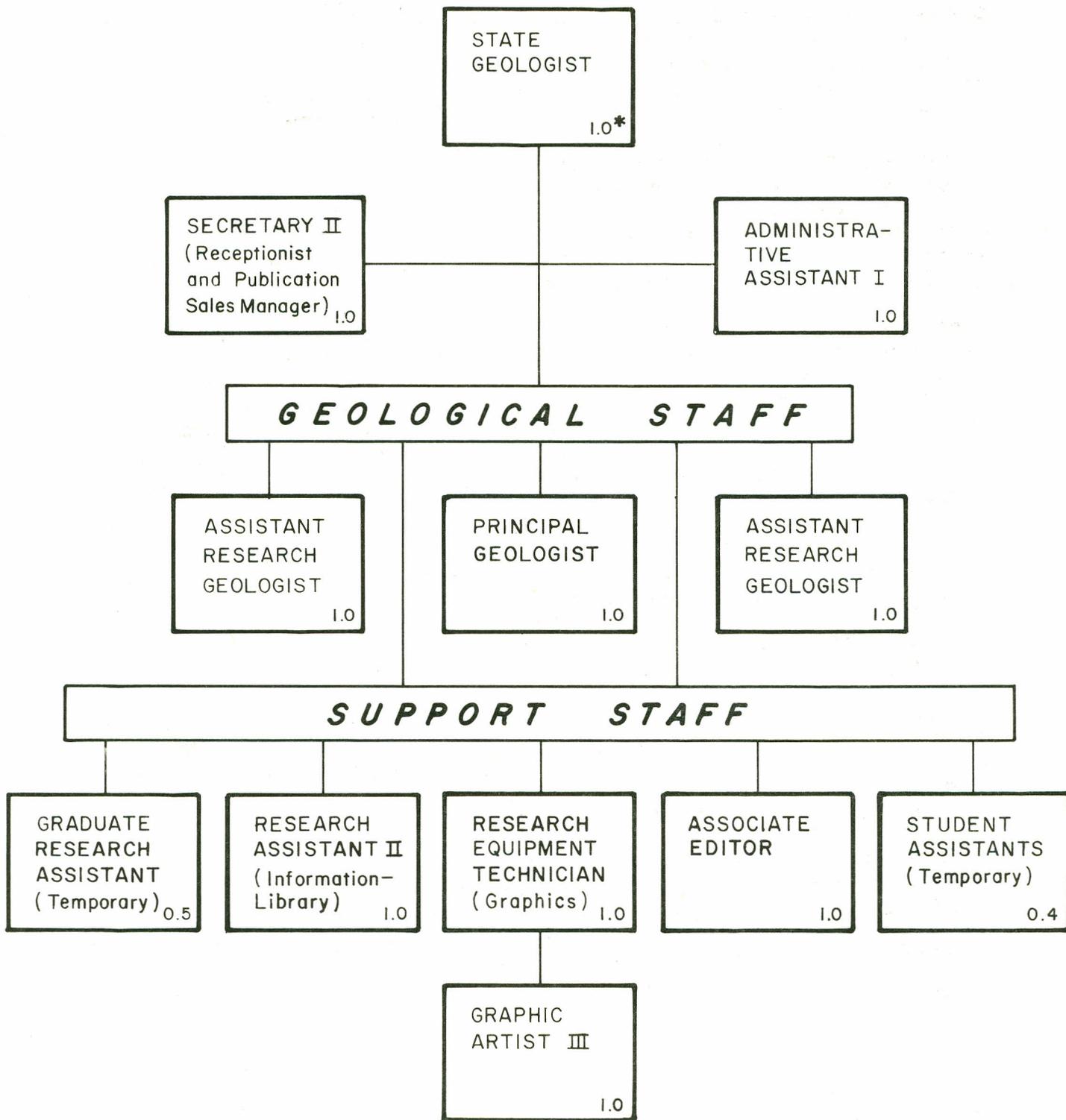
The Assistant Director responsible for the Mineral Technology Branch shall be a mining or metallurgical engineer graduated from an accredited institution, qualified by education and experience, and shall possess a certificate of registration issued by the State Board of Technical Registration. (Section 27-151, D, Arizona Revised Statutes)

Budget. The Bureau shall propose and submit to the Legislature through the Board of Regents an annual operating budget based on the projects necessary to fulfill the needs of this state within the objectives established for the Bureau. (Section 27-152.01, item 7, Arizona Revised Statutes)

Annual Report. The Director shall make an annual report to the Board to be transmitted to the Governor on the progress and condition of the Bureau, of pertinent facts concerning the state's geologic setting, mineral resources, and such other pertinent information as the board deems proper. (Section 27-155, Arizona Revised Statutes)

*Senate Bill 1102, which was passed by the 38th legislature and signed by Governor Mecham in April 1987, established the Arizona Geological Survey as an independent state agency, effective July 1, 1988.

Organization Chart



*Full-time equivalent

Employees

ARIZONA GEOLOGICAL SURVEY

Fiscal Year 1986-87

<u>REGULAR EMPLOYEES (full-time):</u>	<u>Full-time Equivalent</u>
OFFICE OF THE STATE GEOLOGIST	
Larry D. Fellows, State Geologist	1.0
Janet M. Christner, Admin. Assistant I	1.0
Olga O. Hernandez, Secretary II(a)	1.0
GEOLOGICAL INVESTIGATIONS	
H. Wesley Peirce, Principal Geologist(b)	1.0
Stephen J. Reynolds, Assistant Research Geologist	1.0
Jon E. Spencer, Assistant Research Geologist	1.0
PUBLICATIONS	
Peter F. Corrao, Graphic Artist III	1.0
Joseph R. LaVoie, Research Equipment Technician(b)	1.0
Evelyn M. VandenDolder, Associate Editor	1.0
INFORMATION	
Thomas G. McGarvin, Research Assistant II	<u>1.0</u>
	10.0
<u>STUDENT EMPLOYEES (part-time and temporary):</u>	
Clerical Assistants: Karen S. Fulton, Teri J. Hike, Mary C. Miller, Traci L. Newman, and Gary E. Spivey.	
Library Assistants: Richard E. Gates, Charles W. Silver, and Elizabeth A. Ybarra.	0.4
Graduate Research Assistants: Michael S. Roddy and Jonathan D. Shenk.	<u>0.5</u> <u>0.9</u>
TOTAL	10.9

- a) Resigned effective June 5, 1987
b) Retired June 30, 1987

GEOLOGISTS AND SPECIALTY AREAS

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

- geology of Arizona
- geologic hazards and limitations
- administration

H. WESLEY PEIRCE, Principal Geologist; B. S., University of Montana; M. S., Indiana University; Ph. D., University of Arizona.

- geology of Arizona
- impact of "things geologic"
- industrial minerals: salt, gypsum, limestone, etc.
- energy materials: petroleum and coal
- subsurface geology: Plateau and Cenozoic basins
- physiography: development, subdivision; Mogollon Escarpment
- Pennsylvanian-Permian stratigraphy: Plateau and Transition Zone
- earth science education

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

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

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

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

SUPPORT STAFF AND MAJOR FUNCTIONS

JANET M. CHRISTNER, Administrative Assistant I

- assist State Geologist
- accounting
- personnel
- purchasing
- payroll
- facility maintenance

PETER F. CORRAO, Graphic Artist III; B. A., Arizona State University

- Fieldnotes illustration and layout
- map drafting and illustration
- art work
- photography and darkroom

OLGA O. HERNANDEZ, Secretary II

- receptionist
- publication sales office
- manuscript typing
- data entry
- assist Administrative Assistant
- correspondence
- order supplies

JOSEPH R. LaVOIE, Research Equipment Technician

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

THOMAS G. McGARVIN, Research Assistant II; B. A., California Lutheran College

- general geology of Arizona
- availability of maps and reports on Arizona geology
- assist earth science teachers
- assist library users
- assist users of cuttings and core repository

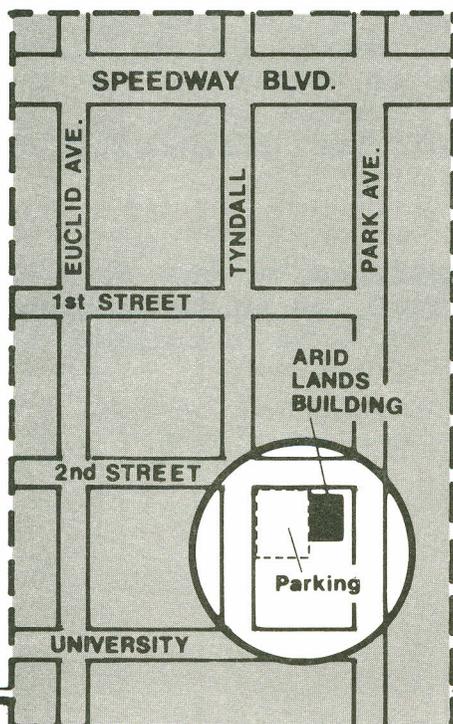
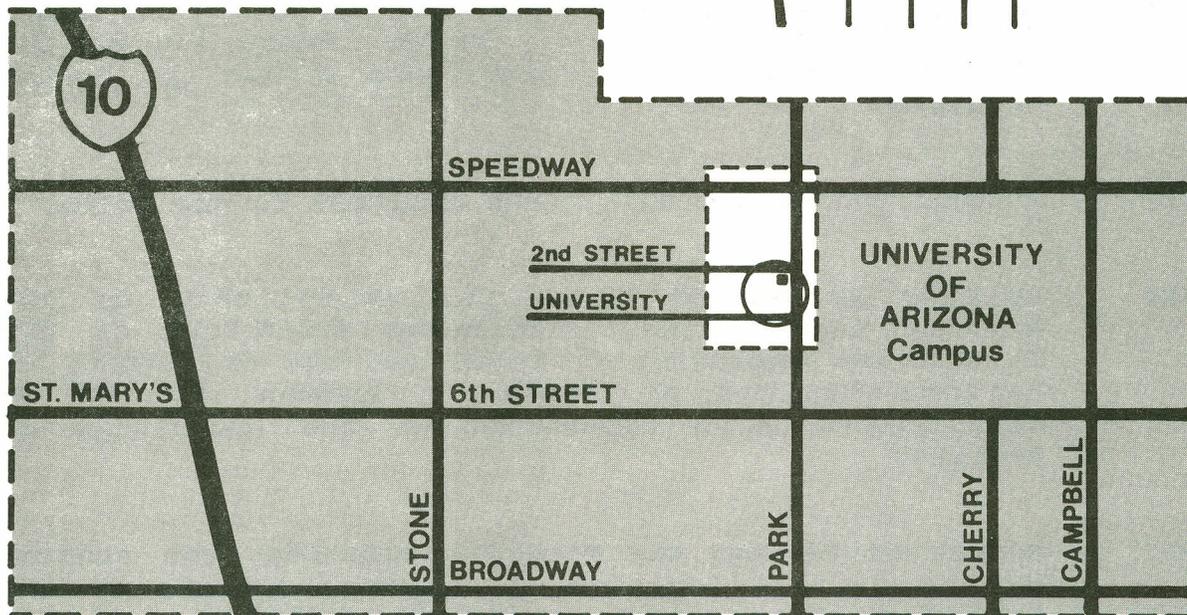
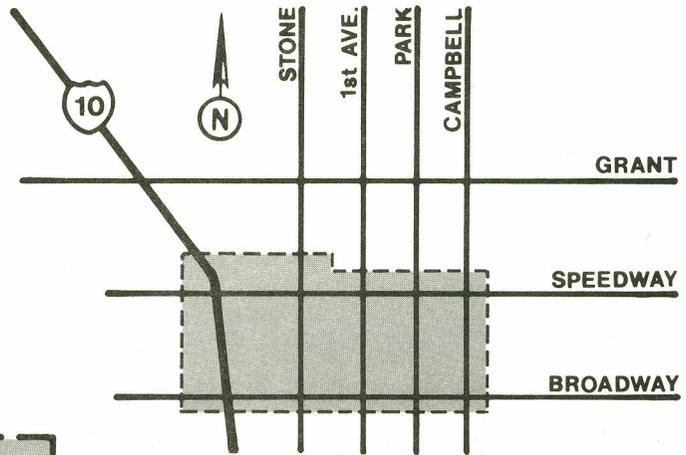
EVELYN M. VANDENDORER, Associate Editor; B. S., University of Connecticut; Publication Specialist Program, George Washington University

- editing
- Fieldnotes
- manuscript flow
- liaison with printer
- liaison with news media
- press releases

Milestones

- 1863 Arizona Territory established by Congress.
- 1888 **"Territorial Geologist"** position approved by Congress.
- 1891 University of Arizona began operations; a metallurgical testing laboratory, known informally as the **"Bureau of Mines"**, was established within the School of Mines.
- 1912 Arizona became the 48th state admitted to the Union.
- 1915 **Arizona Bureau of Mines** was established by the Arizona Legislature, continuing functions of the Territorial Geologist position and the University of Arizona **"Bureau of Mines"**. Bureau was to be administered as a department of the University of Arizona.
- 1977 **Bureau of Geology and Mineral Technology** was created by the Arizona Legislature. Major functions of the Bureau of Mines were continued, enabling act was updated, responsibility for geologic hazards and limitations was added, and Geological Survey and Mineral Technology Branches were established. Geological Survey Branch was to function as the **state geological survey**. Bureau was to be administered as a division of the University of Arizona.
- 1987 **Arizona Geological Survey** established by the Arizona legislature, effective July 1, 1988, as an independent state agency. State Geologist will be appointed by the Governor.

**our
location...**



ARIZONA GEOLOGICAL SURVEY

845 N. Park Avenue
Tucson, Arizona 85719
(602) 621-7906