ANNUAL REPORT

of the

Arizona Geological Survey

for

Fiscal Year 1987-1988
(July 1, 1987 - June 30, 1988)

prepared by
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State Geologist

ARIZONA GEOLOGICAL SURVEY
OPEN-FILE REPORT

88-23

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

Cover: A simplified geologic map of Arizona's proposed Maricopa Superconducting Super Collider (SSC) site.

State of Arizona
Arizona Geological Survey
845 North Park Avenue, #100
Tucson, Arizona 85719

Rose Mofford
Governor

Larry D. Fellows
Director and State Geologist

September 12, 1988

The Honorable Rose Mofford
Governor
State Capitol
1700 W. Washington
Phoenix, Arizona 85007

Dear Governor Mofford:

It is with great pride that I submit this report of activities of the Arizona Geological Survey during Fiscal Year 1987-88. Investigations completed and information provided, listed separately, were done in accordance with our statutory mandate. The Arizona Geological Survey, like most of the other State geological surveys, is responsible for investigating and describing the geologic framework of the State, including its mineral and energy resources and potential geologic hazards and limitations, and providing objective scientific information and assistance to those who make land- and resource-management decisions. Population growth, which requires land, water, and minerals, is increasing the need for such information and assistance.

My staff and I are looking forward to serving the citizens of Arizona as part of your administration.

Respectfully yours,

Larry D. Fellows

Larry D. Fellows
State Geologist

LDF:lc

Highlights, Fiscal Year 1987-88

Superconducting Super Collider (SSC). Arizona's proposed Maricopa SSC site is one of seven finalists selected by the U.S. Department of Energy. The geologic setting is one of the site's major strengths. The site has relatively simple geology, no surface- or groundwater-related problems, and no significant mineralization. The cemented alluvial gravels that cover bedrock at the site can be readily trenched without excavation walls collapsing, making the cheaper and quicker cut-and-fill construction process practical.

Geologic mapping of the Maricopa Mountains was completed during the year and the map was released as Open-File Report (OFR) 87-4. Other reports describing geotechnical aspects of the site were released as OFR 87-6, 87-7, 88-5, 88-6, 88-7 and 88-8. John W. Welty, SSC Project Geologist, is on loan from the Arizona Geological Survey (AZGS).

The Environmental Impact Statement for the seven final sites was released in August 1988. Final selection is to be made in December 1988 and announced by President Reagan in January 1989.

New gold mine. The Copperstone gold mine in La Paz County, which was opened in November 1987, will produce about 50,000 ounces of gold per year, doubling Arizona's production. Interpretation of geologic maps completed by AZGS geologists in western Arizona during the past 6 years indicates that a number of other areas have comparable mineral potential.

Geology in much of the State has not been mapped in adequate detail and is not well understood. Such mapping, although extremely important for assessing mineral potential, shows only the rock units exposed at the land surface. Virtually nothing is known about the subsurface.

During FY 1987-88, seven geologic maps were completed and released (OFR 87-4, 87-9, 87-10, 88-1, 88-4, 88-9, and 88-10). Most of this mapping was done as part of the U.S. Geological Survey and State Geological Survey Cooperative Geologic Mapping Program (COGEOMAP), a 50-50 matched funding program. Substantial progress was made on a report on the geology and mineral resources of the Buckskin Mountains and adjacent areas.

Potential geologic limitations to land use. A number of geologic factors have potential to limit or restrict the use and management of Arizona's land and resources. Major factors are groundwater availability and quality; subsidence due to groundwater withdrawal; clay soils that shrink, swell, or collapse; overbank flooding, sheetwash, or stream-bank erosion; and availability of construction materials and other mineral resources. Population growth and competition for land and resources continue to increase. Consideration of these and other potential geologic limitations, therefore, is becoming increasingly important.

During FY 1987-88 groundwater levels in many areas continued to decline, causing further land subsidence and earth-fissure development. Newly developed earth fissures near the Central Arizona Project (CAP) canal east and southeast of Phoenix are being monitored carefully. Failure of concrete along one of the feeder canals in Pinal County might have been related to problem clay soils over which the canal was constructed.

Arizona and California finalized a compact for disposing of low-level radioactive wastes. Geologic and other factors must be considered in siting a disposal facility.

A report on channel changes along Rillito Creek in the Tucson area was published as Special Paper 6. A bibliography of landslides was released as OFR 88-14 and the inventory of landslides continued, with financial support from the U.S. Geological Survey.

Natural radioactivity and radon. The AZGS completed a reconnaissance survey of natural radioactivity (gamma radiation) from bismuth-214, a decay product of radon, in rock and soil in 38 selected populated areas. The project was conducted with a special appropriation of $8,000 from the Arizona Legislature. Gamma-radiation levels in seven small areas in or near Prescott, Cave Creek, Phoenix, Tucson, Tombstone, Camp Verde, and Kirkland were higher than 2.5 picoCuries per gram equivalent radium, which, for this study, was considered to be anomalous. Buildings constructed on rock and soil in those areas are more likely to have elevated indoor radon levels than those built in other areas. Indoor radon levels were not measured in this study. Results of the study were provided to the Arizona Radiation Regulatory Agency, which is conducting a statewide survey of indoor radon levels using charcoal canisters. A summary of the investigation was released as OFR 88-11 and the technical descriptions and data as OFR 88-12.

Investigations completed. The AZGS published 1 bulletin, 2 special papers, and 2 maps and released 21 open-file reports. AZGS geologists authored or coauthored 4 reports or maps that were included in publications of professional societies; submitted 15 for publication; and made substantial progress on 19 others, which will be completed in FY 1988-89. Complete titles and authors of these reports and maps are listed elsewhere in this report.

Information provided. AZGS staff provided information and assistance to more than 4,195 persons who wrote, telephoned, or visited the office. Receipts from the sale of publications totalled $47,518, a new high. Four 12-page issues of *Fieldnotes*, the quarterly information publication, were printed. The AZGS and the U.S. Geological Survey cosponsored a 2-day workshop in Tempe to determine what types of research and data on nonmetallic mineral resources are needed by government agencies and industry. A summary report of the meeting, including recommendations made, is being prepared for review and publication.

AZGS geologists authored or coauthored 13 technical talks, with published abstracts, that were presented at professional society meetings; gave 29 talks to government, industry, civic, university, and earth-science groups; led 14 field trips; and advised 16 graduate students from 5 universities.

Personnel and budget. Ten full-time, State-funded positions and 0.9 full-time equivalent student positions were authorized. Fourteen students were employed on a part-time temporary basis and three part-time temporary geologists were hired to work on contracted projects.

Operating expenditures totalled $418,025 (State appropriation, $371,335; local accounts, $18,699; and printing fund, $27,991.) This figure does not include expenditures for leased space, utilities, or accounting, payroll, personnel, and purchasing services which were provided by the University of Arizona. Expenditure of contracted funds (three projects) totalled $47,058.

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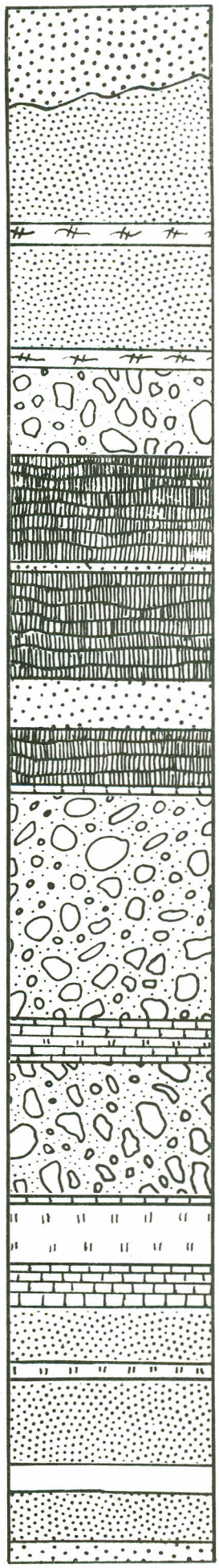
Objectives and Duties

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

To investigate, describe, and interpret the geological setting of this state, including its natural hazards and limitations, its natural attributes and its mineral resources.

To 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.

To 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.

To 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.

To 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

Investigations Completed

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Investigations Completed

Reports and maps completed and listed on the following pages are numbered consecutively for purposes of preparing the index below. Some investigations relate to more than one category. Projects on which substantial progress was made, and which will be completed in FY 1988-89, are designated by letters. Authors' names that are capitalized and in bold type are AZGS employees or were employed on the specific project listed. Student employees are also identified by an asterisk.

SUBJECT INDEX

Geologic Framework

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PUBLISHED BY THE ARIZONA GEOLOGICAL SURVEY

Bulletin and Special Papers

1. **BULLETIN 197:** Compilation of radiometric age determinations in Arizona: **REYNOLDS, S.J., FLORENCE, F.P.*, WELTY, J.W.*, RODDY, M.S.*, CURRIER, D.A.*, ANDERSON, A.V.***, and Keith, Stanley B., 1986, 258 p., 2 maps.

2. **SPECIAL PAPER 5:** Geologic diversity of Arizona and its margins: Excursions to choice areas: Davis, G.H., and **VANDENDOLDER, E.M.**, editors, 1987, 422 p.

3. _____: Geomorphology and structure of the Colorado Plateau/Basin and Range Transition Zone, Arizona: Young, R.A., **PEIRCE, H.W.**, and Faulds, J.E., 1987, p. 182-196.

4. _____: Field guide to lower- and upper-plate rocks of the South Mountains detachment zone, Arizona: **REYNOLDS, S.J.**, and Lister, G.S., 1987, p. 244-248.

5. _____: Field-trip guide to parts of the Harquahala, Granite Wash, Whipple, and Buckskin Mountains, west-central Arizona and southeastern California: **SPENCER, J.E., REYNOLDS, S.J.**, Anderson, J.L., Davis, G.A., Laubach, S.E., Richard, S.M., and Marshak, Stephen, 1987, p. 351-364.

6. **SPECIAL PAPER 6:** Channel change along the Rillito Creek system of southeastern Arizona, 1941 through 1983: Implications for flood-plain management: **PEARTHREE, M.S.***, and Baker, V.R., 1987, 58 p., 1 map.

Maps

7. **MAP 24:** Map of K-Ar and Ar-Ar age determinations in Arizona: **REYNOLDS, S.J., FLORENCE, F.P.*, RODDY, M.S.*, WELTY, J.W.***, and **TRAPP, R.A.***, 1986, scale 1:1,000,000.

8. **MAP 25:** Map of fission-track, Rb-Sr, and U-Pb age determinations in Arizona: **REYNOLDS, S.J., FLORENCE, F.P.*, RODDY, M.S.*, WELTY, J.W.***, and **TRAPP, R.A.***, 1986, scale 1:1,000,000.

Articles in Fieldnotes

9. Geologic highlights of the Phoenix region: **REYNOLDS, S.J.**, 1987, v. 17, no. 3, p. 8-10.

10. The Copperstone mine: Arizona's new gold producer: **SPENCER, J.E., DUNCAN, J.T.***, and Burton, W.D., 1988, v. 18, no. 2, p. 1-3.

Open-File Reports (OFR)

11. **OFR 87-4:** Geologic map of the Maricopa Mountains, central Arizona: Cunningham, Dickson, DeWitt, Ed, Haxel, Gordon, **REYNOLDS, S.J.**, and **SPENCER, J.E.**, 1987, scale 1:62,500.

12. **OFR 87-6:** Summary report of geotechnical investigations, 9/86 through 2/88; Maricopa Superconducting Super Collider site, Maricopa County, Arizona: Cummings, R.A., Salhaney, L.A., Zeihen, G.D., Armstrong, Robert, Daemen, Jaak, Farmer, I.W., Glynn, M.E., Mojtabai, Navid, Sternberg, B.K., DeNatale, J.S., Nowatzki, E.A., **REYNOLDS, S.J., SPENCER, J.E., WELTY, J.W.**, and Brooks, S.J., 1988, 144 p.

13. **OFR 87-7:** Geotechnical engineering investigations for Arizona's SSC sites: DeNatale, J.S., Nowatzki, E.A., and **WELTY, J.W.**, 1987, 338 p.

14. **OFR 87-8:** Radiometric and petrochemical characteristics of the Dells Granite, Yavapai County, Arizona: Proctor, P.D., Fleck, K.S., and Shahin, A.N., 1987, 67 p.

15. **OFR 87-9:** Geologic map of the Wickenburg, southern Buckhorn, and northwestern Hieroglyphic Mountains, central Arizona: **STIMAC, J.A.*, FRYXELL, J.E., REYNOLDS, S.J.**, Richard, S.M., **GRUBENSKY, M.J.***, and **SCOTT, E.A.**, 1987, 13 p., scale 1:24,000.

16. **OFR 87-10:** Geologic map of the northeastern Vulture Mountains and vicinity, central Arizona: **GRUBENSKY, M.J.*, STIMAC, J.A.*, REYNOLDS, S.J.**, and Richard, S.M., 1987, 7 p., scale 1:24,000.

17. **OFR 87-11:** Summary of a workshop on the search for unconventional ore deposits in Arizona: Theobald, P.K., Billone, M.A., Detra, P.S., and Vassalluzzo, C.A., editors, 1987, 16 p.

18. **OFR 87-12:** A report on earthquake activity recorded at Station Flagstaff in 1984: Brumbaugh, D.S., Davis, John, and Roberts, L., 1987, 40 p.

19. **OFR 88-1:** Geologic map of the southern Hieroglyphic Mountains, central Arizona: **WAHL, D.E., REYNOLDS, S.J., CAPPS, R.C., KORTEMEIER, C.P., GRUBENSKY, M.J.*, SCOTT, E.A.**, and **STIMAC, J.A.***, 1988, 6 p., scale 1:24,000.

20. **OFR 88-2:** Uranium procurement and geologic investigations of the Manhattan Project in Arizona: Chenoweth, W.L., 1988, 23 p.

21. **OFR 88-3:** Correlation of Stratigraphic Units of North America (COSUNA) documentation records for southern Arizona and vicinity: Childs, O.E., Knepp, R.A., **REYNOLDS, S.J.**, Haxel, G., Thompson, S. III, and Wright, J., 1988, 99 p.

22. **OFR 88-4:** Quaternary geologic map of the Salome quadrangle (30′ x 60′), west-central Arizona: **DEMSEY, K.A.***, 1988, scale 1:100,000.

23. **OFR 88-5:** Additional geotechnical engineering for Arizona's Maricopa SSC site: Nowatzki, E.A., Muller, Eugene, DeNatale, J.S., Ibarra-Encinas, G.A., Al-Ghanem, A.M.F., and **WELTY, J.W.**, 1988, 223 p.

24. **OFR 88-6:** Hydrogeology of basins encompassing the Maricopa Superconducting Super Collider site: Brooks, S.J., 1988, 29 p., 2 maps.

25. **OFR 88-7:** Volume 3, Geology and tunneling of the Maricopa Superconducting Super Collider site proposal: **WELTY, J.W.**, and others, 1988, 260 p.

26. **OFR 88-8:** Volume 3, Geology and tunneling of the Sierrita Superconducting Super Collider site proposal: **WELTY, J.W.**, and others, 1988, 270 p.

27. **OFR 88-9:** Geologic map of the southeastern Vulture Mountains, west-central Arizona: **GRUBENSKY, M.J.***, and **REYNOLDS, S.J.**, 1988, 16 p., scale 1:24,000.

28. **OFR 88-10:** Geologic map of the Vulture mine area, Vulture Mountains, west-central Arizona: **REYNOLDS, S.J., SPENCER, J.E.**, DeWitt, Ed, White, D.C., and **GRUBENSKY, M.J.**, 1988, 5 p., scale 1:24,000.

29. **OFR 88-11:** Background radioactivity in selected areas of Arizona and implications for indoor-radon levels: **SPENCER, J.E.**, Emer, D.F., and **SHENK, J.D.***, 1988, 14 p.

30. **OFR 88-12:** Reconnaissance gamma-ray spectrometer survey of radon-decay products in selected populated areas of Arizona: **EMER, D.F., SHENK, J. D.***, and **SPENCER, J.E.**, 1988, 88 p.

31. **OFR 88-14:** Bibliography of Arizona landslide maps and reports: **WELTY, J.W., RODDY, M.S.***, Alger, C.S., and Brabb, E.E., 1988, 13 p.

PUBLISHED EXTERNALLY

32. **Arizona Geological Society Digest:** Mesozoic stratigraphy of the Granite Wash Mountains, west-central Arizona, *in* Dickinson, W.R., and Klute, M.A., editors, Mesozoic rocks of southern Arizona and adjacent areas: Laubach, S.E., **REYNOLDS, S.J.,** and **SPENCER, J.E.,** 1987, v. 18, p. 91-100.

33. _____: Mesozoic stratigraphy of the Little Harquahala and Harquahala Mountains, west-central Arizona: Richard, S.M., **REYNOLDS, S.J.,** and **SPENCER, J.E.,** 1987, v. 18, p. 101-119.

34. **The Mineralogical Record:** The Tonopah-Belmont mine, Maricopa County, Arizona: **ALLEN, G.V.*,** and Hunt, W., 1988, v. 19, p. 139-144.

35. **Prentice-Hall:** Stratigraphy and U-Th-Pb geochronology of Triassic and Jurassic rocks in west-central Arizona, *in* Ernst, W.G., editor, Metamorphism and crustal evolution of the western United States: **REYNOLDS, S.J., SPENCER, J.E.,** and DeWitt, Ed, 1987, p. 466-501.

PUBLISHED ABSTRACTS

36. **Australian Bureau of Mineral Resources, Geology, and Geophysics (Applied Extension Tectonics Symposium, Canberra, November 1987):** Continental extension and related igneous history in the Basin and Range Province, U.S.A.: **REYNOLDS, S.J.,** 1987, Extended abstracts 1987/51, p. 10-15.

37. _____: Relationship between mineralization and detachment faults, southwestern U.S.A.: **REYNOLDS, S.J.,** 1987/51, supplemental handout.

38. **Geological Society of America (Annual Meeting, Phoenix, October 1987):** Superimposed domino-style normal faults in a Tertiary bimodal volcanic complex, Wickenburg Mountains and vicinity, central Arizona: Fryxell, J.E., Stimac, J.A., and **REYNOLDS, S.J.,** 1987, Abstracts with Programs, v. 19, no. 7, p. 670.

39. _____: Mesozoic structural evolution of the Maria fold and thrust belt, west-central Arizona and southeastern California: **REYNOLDS, S.J., SPENCER, J.E.,** Laubach, S.E., and Richard, S.M., 1987, Abstracts with Programs, v. 19, no. 7, p. 818.

40. _____: K-metasomatism of mid-Tertiary rocks in the upper plate of the Bullard detachment fault, west-central Arizona: **RODDY, M.S.*, REYNOLDS, S.J.,** Smith, B.M., and Ruiz, J., 1987, Abstracts with Programs, v. 19, no. 7, p. 823.

41. _____: Major early Miocene extensional deformation in southwestern Arizona and southeastern California: Sherrod, D.R., Pickthorn, L.G., Tosdal, R.M., **GRUBENSKY, M.J.***, and Koch, R.D., 1987, Abstracts with Programs, v. 19, no. 7, p. 841.

42. _____: Reduction of crustal flexural rigidity during folding of crystalline rocks in the Harcuvar and Whipple metamorphic core complexes, west-central Arizona and southeastern California: **SPENCER, J.E.**, 1987, Abstracts with Programs, v. 19, no. 7, p. 853.

43. _____: Interaction between Mesozoic and Cenozoic tectonic features in the Buckskin Mountains and adjacent areas, west-central Arizona and southeastern California: **SPENCER, J.E.**, and **REYNOLDS, S.J.**, 1987, Abstracts with Programs, v. 19, no. 7, p. 852-853.

44. **Geological Society of America (Cordilleran Section Meeting, Las Vegas, March 1988):** Role of crustal flexure in initiation of detachment faults: Inferences based on Airy stress functions: **SPENCER, J.E.**, 1988, Abstracts with Programs, v. 20, no. 3, p. 234.

45. _____: Geologic and geotechnical characteristics of the Maricopa Superconducting Super Collider (SSC) site, south-central Arizona: **WELTY, J.W.**, and Cummings, R.A., 1988, Abstracts with Programs, v. 20, no. 3, p. 242.

46. **Society of Mining Engineers (Annual Meeting, Phoenix, January 1988):** Arizona industrial minerals and rocks: **PEIRCE, H.W.**, and **SHENK, J.D.***, 1988, Preprint number 88-101, 7 p.

47. _____: The geology and development of the White Cliffs diatomite deposit, Mammoth, Arizona: **SHENK, J.D.***, 1988, Preprint number 88-129, 4 p.

48. _____: Control of mineralization by Mesozoic and Cenozoic low-angle structures in west-central Arizona: **SPENCER, J.E.**, **REYNOLDS, S.J.**, and **WELTY, J.W.**, 1988, Preprint number 88-46, 4 p.

SUBMITTED FOR PUBLICATION

49. **Arizona Geological Society:** Late Cenozoic tectonism and landscape evolution of Arizona: Menges, C.M., and **PEARTHREE, P.A.***, Digest 17.

50. _____: Middle Tertiary tectonics of Arizona and adjacent areas: **SPENCER, J.E.**, and **REYNOLDS, S.J.**, Digest 17.

51. _____: Geologic evolution of Arizona: Jenney, J.P., and **REYNOLDS, S.J.**, editors, Digest 17.

52. **Arizona Geological Survey:** Bibliographic conventions of the Arizona Geological Survey: **HORSTMAN, K.C.*, VANDENDOLDER, E.M.,** and **REYNOLDS, S.J.,** Open-File Report.

53. _____: Geologic Map of Arizona: **REYNOLDS, S.J.,** compiler, Map 26, scale 1:1,000,000.

54. _____: Map of landslides and talus deposits in Arizona: **WELTY, J.W., DEMSEY, K.A.*,** and **RODDY, M.S.*,** Open-File Report.

55. **Geological Society of America Bulletin:** Mesozoic structure and stratigraphy of the Little Harquahala Mountains, west-central Arizona: Richard, S.M., **REYNOLDS, S.J.,** and **SPENCER, J.E.**

56. _____: K-metasomatism and detachment-related mineralization, Harcuvar Mountains, Arizona: **RODDY, M.S.*, REYNOLDS, S.J.,** Smith, B.M., and Ruiz, J.

57. **Geology:** Early Mesozoic uplift in southwestern Arizona and southeastern California: **REYNOLDS, S.J., SPENCER, J.E.,** Asmermom, Yemane, DeWitt, Ed, and Laubach, S.E.

58. **Journal of Geophysical Research:** Role of crustal flexure in initiation of low-angle normal faults and implications for structural evolution of the Basin and Range Province: **SPENCER, J.E.,** and Chase, C.G.

59. **Journal of Structural Geology:** Progressive deformation and superposed fabrics related to crustal underthrusting in western Arizona, U.S.A.: Laubach, S.E., **REYNOLDS, S.J., SPENCER, J.E.,** and Marshak, Stephen.

60. _____: Ductile-to-brittle evolution of the South Mountains detachment zone, central Arizona: **REYNOLDS, S.J.,** and Lister, G.S.

61. **Museum of Northern Arizona:** Side canyons of the Grand Canyon, *in* Beus, S.S., and Morales, Michael, editors, Geology of the Grand Canyon: Potochnik, A.R., and **REYNOLDS, S.J.**

62. **U.S. Geological Survey:** Geologic map of the Castle Dome Mountains, southwestern Arizona: **GRUBENSKY, M.J.*,** Haxel, G.B., and Koch, R.D., Miscellaneous Investigations Series I map.

63. _____: Geologic map of the Tucson 1° x 2° quadrangle, Arizona: **REYNOLDS, S.J.,** Bergquist, Joel, **GRUBENSKY, M.J.*,** and Nedell-Page, Susan, Open-File Report.

OTHER PROJECTS COMPLETED

64. Structure, geochemistry, and volcanic history of mid-Tertiary rocks in the Kofa region, southwestern Arizona: **GRUBENSKY, M.J.***, 1987, unpublished M.S. thesis, University of Arizona, Tucson, 107 p.

IN ADVANCED STAGE OF COMPLETION
(Scheduled for completion in FY 1988-89)

A. Geology and mineral resources of the Buckskin and Rawhide Mountains, west-central Arizona: **SPENCER, J.E.**, and **REYNOLDS, S.J.**, editors.

B. Compilation geologic map of the Buckskin and Rawhide Mountains, west-central Arizona: **SPENCER, J.E.**, compiler, scale 1:100,000.

C. Geologic map of the Planet-Mineral Hill area, northwestern Buckskin Mountains, west-central Arizona: **SPENCER, J.E.**, **REYNOLDS, S.J.**, and Lehman, N.E., scale 1:24,000.

D. Geology and mineral deposits of the central Artillery Mountains: **SPENCER, J.E.**, **GRUBENSKY, M.J.***, **DUNCAN, J.T.***, **SHENK, J.D.***, Yarnold, J., and Lombard, J.P.

E. Geology and mineral resources of the Buckskin and Rawhide Mountains: Introduction and overview: **SPENCER, J.E.**, and **REYNOLDS, S.J.**

F. Geology of mineral deposits in the Buckskin and Rawhide Mountains: **SPENCER, J.E.**, and **WELTY, J.W.***

G. Geology of postdetachment, Miocene volcanic rocks in the southwestern Buckskin Mountains: **GRUBENSKY, M.J.***

H. K-Ar geochronology of Miocene extensional tectonism, volcanism, and potassium metasomatism in the Buckskin and Rawhide Mountains: **SPENCER, J.E.**, Shafiqullah, M., Miller, R.J., and Pickthorn, L.G.

I. Mineralization in the central part of the Planet mineral district, northeastern Buckskin Mountains: Lehman, N.E., and **SPENCER, J.E.**

J. Pre-Tertiary rocks and structures in the upper plate of the Buckskin-Rawhide detachment fault, Buckskin Mountains: **REYNOLDS, S.J.**, and **SPENCER, J.E.**

K. Tertiary structure, stratigraphy, and tectonics of the Buckskin Mountains: **SPENCER, J.E.**, and **REYNOLDS, S.J.**

L. Geologic limitations in a portion of the Tucson metropolitan area, **DEMSEY, K.A.*, McKITTRICK, M.A.***, and **PEARTHREE, P.A.**

M. Late Quaternary surface-rupture history of the Sand Tank fault, and associated seismic hazard for the proposed Superconducting Super Collider site, Maricopa County, Arizona: **DEMSEY, K.A.***, and **PEARTHREE, P.A.**

N. Preliminary geologic map of the Granite Wash Mountains, west-central Arizona: **REYNOLDS, S.J., SPENCER, J.E.**, Laubach, S.E., Cunningham, Dickson, and Richard, S.M.

O. Quaternary geologic map of a portion of the Tucson metropolitan area, scale 1:24,000: **McKITTRICK, M.A.***

P. Quaternary geologic map of the Phoenix North (30′ x 60′) quadrangle, scale 1:100,000: **DEMSEY, K.A.***

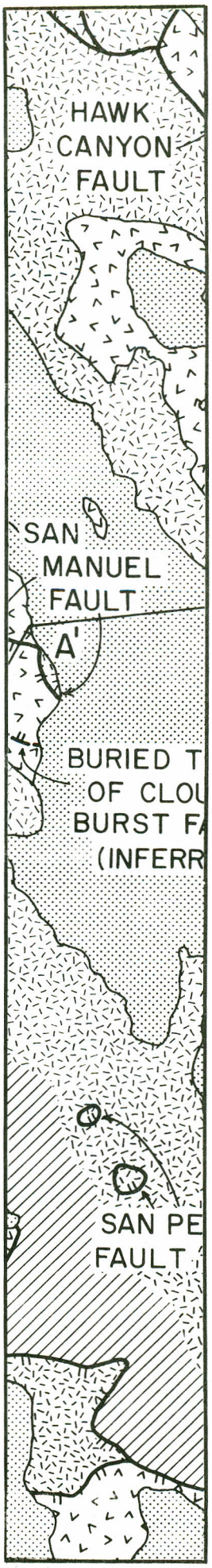
Q. Quaternary geologic map of the Tucson (1° x 2°) quadrangle, scale 1:250,000: **PEARTHREE, P.A.**

R. Petrology and stable isotope systematics of mylonitization and detachment faulting, South Mountains, Arizona: Smith, B.M., **REYNOLDS, S.J.**, Day, H.W., and Bodnar, R.

S. Origin and significance of the mylonitic front and back-dipping mylonitic zones in Cordilleran metamorphic core complexes: **REYNOLDS, S.J.**, and Lister, G.S.

Information and Service Provided

Summary	16
Government Agencies	19
Industrial Groups, Consultants, and Associations	22
Professional Societies	24
Universities	26
Earth-Science Teachers	28
Public and Other Groups	29



Information and Service Provided

AZGS geologists provided information or assistance to more than 4,195 persons who telephoned, wrote, or visited the office. This figure includes 534 recorded library visitors.

Geologic data users included staff of local, State, and Federal government agencies; legislators and legislative committee staff; industrial groups, consultants, and related associations; professional society members; university faculty and students; earth-science teachers; members of civic and other groups; and the public. Information and assistance provided to the various categories of users are summarized on the following pages. Selected examples of types of information sought are listed on page 17.

Publication sales. A record high was set in receipts from the sale of publications with a total of $47,518, which was deposited in the printing revolving fund. Expenditures incurred in printing and distributing publications totalled $27,991. The excess of revenue over expenses, $19,527, will be used to print and distribute new AZGS publications. Primary reasons for the increase were (1) more open-file reports were sold and (2) Special Paper 5, a field-trip guidebook published for use at the annual meeting of the Geological Society of America, held in Phoenix in late 1987, was distributed. Because publication of the guidebook was a one-time event, anticipated revenues during FY 1989 are projected to be less than $25,000.

Talks given. Opportunities to summarize the results of investigations and to describe AZGS projects and related activities by giving technical or nontechnical talks are welcomed. During FY 1987-88, 56 talks were either presented or coauthored by AZGS geologists. Abstracts prepared and published for 13 of the talks were listed on previous pages. The number of talks given was higher than usual for three reasons: (1) John W. Welty, Project Geologist for the Superconducting Super Collider (SSC), on loan from the AZGS, gave 19 talks on the geologic and other attributes of the proposed SSC site. (2) Stephen J. Reynolds, Research Geologist, was invited to present 3 talks on the geology of western Arizona at a symposium sponsored by the Australian Bureau of Mineral Resources, Geology, and Geophysics in Canberra. Expenses for his participation in the symposium were paid by the Australian government. After the symposium, Reynolds gave 11 other talks to various university and industry groups. (3) Two national meetings of professional societies were held in Phoenix. Nine talks were presented at those meetings.

Fieldnotes. Through *Fieldnotes*, published quarterly, the AZGS informs the public about the results of geologic investigations recently completed; reports, maps, and theses added to the library; and other aspects of Arizona's geologic framework, mineral and energy resources, and geologic limitations to development. An index of *Fieldnotes* for FY 1987-88 is listed on page 18.

EXAMPLES OF INFORMATION REQUESTED (Showing County)

Alamo Lake (La Paz, Mohave)
Apache Group sedimentary rocks (Gila, Pima, Pinal)
Asbestos (Gila)
Basalt samples (Maricopa)
Bentonite clays (Apache, Navajo)
Big Horn Mountains gold (Maricopa)
Breccia pipes (Coconino, Mohave)
Cerbat Mountains volcanic rocks (Mohave)
Chiricahua Mountains geology (Cochise)
Cinder cones (Coconino)
Computerized databases (statewide)
Conglomerate in the McCoy Mountains Formation (La Paz)
Copperstone gold mine (La Paz)
Detachment faults (La Paz, Maricopa, Pima)
Diatomite occurrences (Pinal)
Dome Rock Mountains gold (La Paz)
Douglas 1° x 2° quadrangle, metallic and nonmetallic mineral resources (Cochise)
Earthcracks (Maricopa, Pima, Pinal)
Earthquakes (Maricopa, Pima, Yuma)
Echo Cliffs, Vermilion Cliffs (Coconino)
Geohydrology of Tempe Buttes (Maricopa)
Geologic Map of Arizona (statewide)
Geologic mapping in the Buckskin Mountains (La Paz)
Geologic maps of the Maria fold and thrust belt (La Paz, Maricopa)
Geothermal energy (Yuma)
Gold in Black Mountains (Mohave)
Grand Canyon geology (Coconino)
Gravity information and depth-to-bedrock (La Paz, Maricopa, Pima, Yuma)
Gypsum occurrences (Cochise, Graham, Greenlee, Pima, Pinal)
Harquahala and Harcuvar Mountains mineralization (La Paz, Maricopa)
Hieroglyphic Mountains gold (Maricopa)
Importing Mexican ore into the United States
Industrial rocks and minerals (Apache, Coconino, Maricopa, Pima, Pinal)
Isotopic age determinations (statewide)
Kofa Mountains geology (Yuma)
Kyanite (La Paz, Yuma)
Laguna Mountains Tertiary rocks (Yuma)
Maricopa hazardous waste site (Maricopa)
Massive sulfide copper and gold deposits, Jerome (Yavapai)
Mercury occurrences, Mazatzal Mountains (Gila, Maricopa, Yavapai)
Metamorphic core complexes (La Paz, Maricopa, Pima)
Meteor Crater (Coconino)
Mineral deposits, Buckskin and Rawhide Mountains (La Paz, Mohave)
New Waddell Dam (Maricopa)
Nonmetallic mineral occurrences (Maricopa, Pima, Pinal)
Oil and gas potential (Apache, Yuma)
Paleozoic rocks and gold deposits (Cochise, Pima, Santa Cruz)
Paleozoic rocks of the Mogollon Rim (Apache, Gila)
Petroleum potential near Florence (Pinal)
Picacho State Park (Pinal)
Platinum in Rainbow Valley (Maricopa)
Potassium-rich volcanic rocks (La Paz, Pinal, Yavapai)
Precambrian rocks and mineral deposits (Gila, Yavapai)
Prescott geology (Yavapai)
Radon occurrences (Maricopa, Pima, Yavapai)
Radon testing methods
Rare earth elements (Mohave)
Salt occurrences (Maricopa, Mohave)
Salt River Canyon copper occurrences and archaeology (Apache, Gila, Navajo)
Sand and gravel
Santa Catalina and Rincon Mountains geology (Pima, Pinal)
Santa Rita Mountains geology (Pima, Santa Cruz)
Santa Teresa Mountains granites (Graham)
South Mountains Freeway (Maricopa)
Spheroidal weathering in granites
Subsidence (Cochise, Maricopa, Pima, Pinal)
Superconducting Super Collider site geology (Maricopa, Pima)
Superstition Mountains (Maricopa, Pinal)
Thrust faults and petroleum potential (La Paz)
Tortolita Mountains geology (Pinal)
Tucson basin Quaternary geology (Pima)
U-Pb age-determination collecting localities (Maricopa)
Uranium occurrences in Cave Creek - Carefree areas (Maricopa)
Water-resource information (Cochise, Coconino, Maricopa, Pima, Yuma)
Whetstone Mountains (Cochise)
Volcanic rocks, Buckskin Mountains (La Paz)
Volcanoes in Arizona
Vulture Mountains gold (Maricopa)
Zeolites near Gila Bend (Maricopa)

FIELDNOTES INDEX, FY 1987-88

Fall 1987, Volume 17, No. 3, 12 p.

Arizona geology: An aerial tour: Peter L. Kresan, University of Arizona
Geologic highlights of the Phoenix region: **STEPHEN J. REYNOLDS**
Water: Lifeblood of civilization in the Salt River Valley: James P. Lombard, University of Arizona

Winter 1987, Volume 17, No. 4, 12 p.

Maps: The Earth on canvas: **EVELYN M. VANDENDOLDER**
Arizona is among finalists for SSC
New report examines U.S. mineral industry
100th annual GSA meeting: Arizona Geological Survey participation
New publications from the Arizona Geological Survey

Spring 1988, Volume 18, No. 1, 12 p.

Recognition of breccia pipes in northern Arizona: Karen J. Wenrich and Hoyt B. Sutphin, U.S. Geological Survey
Arizona agencies: Activity summaries:
- Arizona Radiation Regulatory Agency: John O'Neill
- Arizona Earthquake Information Center: David S. Brumbaugh, Northern Arizona University
- Arizona Department of Mines and Mineral Resources: Nyal J. Niemuth and Diane R. Bain
- Arizona State Land Department: Robert A. Larkin
- U.S. Bureau of Land Management, Arizona State Office: John J. Haas, Alan S. Rabinoff, and William H. Ward
- Arizona Geological Survey: **LARRY D. FELLOWS**

Earth science information: **THOMAS G. MCGARVIN**
New publications from the Arizona Geological Survey

Summer 1988, Volume 18, No. 2, 12 p.

The Copperstone mine: Arizona's new gold producer: **JON E. SPENCER, JOHN T. DUNCAN***, and William D. Burton (Cyprus Minerals Corporation)
Three questions about Arizona's mineral resources: **LARRY D. FELLOWS**
The nonfuel mineral industry: 1987 summary: **EVELYN M. VANDENDOLDER**
Theses and dissertations, 1987
Arizona's state fossil and bicentennial stone
ADMMR receives new director
New report outlines mineral potential on Federal lands
Nonmetallic mineral map available
Staff notes
New publications from the Arizona Geological Survey

Information and Service to
GOVERNMENT AGENCIES

INQUIRIES ANSWERED

AZGS staff responded to 170 requests for information or assistance from the 53 government units listed below.

State of Arizona

Land Department
Department of Mines and Mineral Resources
Department of Water Resources
Department of Environmental Quality
Department of Transportation
Department of Health Services
Department of Education
Radiation Regulatory Agency
Oil and Gas Conservation Commission
Department of Administration
Office of the Attorney General
Department of Commerce
Arizona Highways Magazine
Arizona Historical Society
Mine Inspector
Department of Real Estate
Department of Revenue
Superconducting Super Collider

County, Local, and Other

Northern Arizona Council of Governments
Phoenix Public Library
Pima County Attorney
Pima County Center for Educational Development
Pima County Flood Control District
Pima County Health Department
Pima County Planning Department
Pima County Board of Supervisors
Pinal County Planning Department
Salt River Project
Tucson Public Library
Western Arizona Council of Governments
Yavapai County Health Department

Other States

California Division of Mines and Geology
Colorado Geological Survey
Oklahoma Geological Survey
Oregon State Department of Insurance and Finance
Utah Energy Office
Council of State Governments

Federal

Geological Survey of Canada
Department of Energy
Environmental Protection Agency
Forest Service
Geological Survey
Federal Highway Administration
Department of Justice
Bureau of Land Management
Lawrence Livermore Laboratory
Bureau of Mines
Bureau of Reclamation
Smithsonian Institute
Soil Conservation Service
National Bureau of Standards

Indian Nations

Navajo
Tohono O'odham

TALKS GIVEN

Workshop on Industrial Rock and Mineral Resources of Arizona, Tempe: Overview of the current geologic and economic availability of industrial rock and mineral resources in Arizona. **H.W. PEIRCE.**

U.S. Geological Survey, Flagstaff: Radioactive rocks and radon in Arizona. **L.D. FELLOWS.**

Tucson Public Library, Himmel Branch: Fun with rocks. **T.G. McGARVIN.**

_____, **Woods Branch:** Fun with rocks. **T.G. McGARVIN.**

City of Casa Grande, Mayor and City Council: Superconducting Super Collider in Arizona. **J.W. WELTY.**

City of Gila Bend, Mayor and City Council: Superconducting Super Collider in Arizona. **J.W. WELTY.**

Australian Bureau of Mineral Resources, Geology, and Geophysics, Symposium on Applied Extension Tectonics, Canberra, Australia: Continental extension and related igneous history in the Basin and Range Province, U.S.A. (Abstract published). **S.J. REYNOLDS.**

_____: Relationship between mineralization and detachment faults, southwestern U.S.A. (Abstract published). **S.J. REYNOLDS.**

_____: Cenozoic crustal extension in the Basin and Range Province, southwestern U.S.A. **S.J. REYNOLDS.**

Australian Bureau of Mineral Resources, Geology, and Geophysics, Canberra, Australia: Ductile-to-brittle evolution of the South Mountains metamorphic core complex, Arizona. **S.J. REYNOLDS.**

_____: Structural evolution of metamorphic core complexes of the western United States. **S.J. REYNOLDS.**

_____: Relationship between potassium metasomatism and detachment-related mineralization. **S.J. REYNOLDS.**

South Australian Geological Survey, Adelaide, Australia: Continental extension of the southwestern U.S.A. **S.J. REYNOLDS.**

_____: Relationship between potassium metasomatism and detachment-related mineralization. **S.J. REYNOLDS.**

FIELD TRIPS LED

U.S. Forest Service, Advanced Minerals Management Course, Marana: Applied geology in Pinal County. **L.D. FELLOWS.**

_____, Minerals Administration Course, Marana: Applied geology in Pinal County. **L.D. FELLOWS.**

U.S. Geological Survey: Geology of South Mountains, Harcuvar Mountains, and Merritt Hills. **S.J. REYNOLDS.**

OTHER

Association of American State Geologists: **L.D. FELLOWS** elected as President-Elect and served as chairman of the Liaison Committee.

Commission on the Arizona Environment: **L.D. FELLOWS,** advisory council member.

National Science Foundation: **S.J. REYNOLDS** reviewed four research proposals. **J.E. SPENCER** reviewed three research proposals.

State Mapping Advisory Committee, Phoenix: **L.D. FELLOWS,** member.

Superconducting Super Collider: **S.J. REYNOLDS** reviewed drafts of technical reports.

Workshop on Industrial Rock and Mineral Resources in Arizona, sponsored by the U.S. Geological Survey (USGS) and the AZGS. Invited participants represented State and Federal land-management agencies and industry. Purpose of workshop was to determine types of research and data needed by land-management agencies and industry. **L.D. FELLOWS** and E.W. Tooker (USGS) were coconveners.

Information and Service to
INDUSTRIAL GROUPS, CONSULTANTS, AND ASSOCIATIONS

INQUIRES ANSWERED

AZGS geologists responded to 420 requests for information from 99 companies, consultants, and associations.

TALKS GIVEN

American Association of Cost Engineers, Arizona Chapter, Tucson: Superconducting Super Collider in Arizona. **J.W. WELTY.**

Arizona Small-Mine Operators Association, Tucson: Arizona Geological Survey activities and plans. **L.D. FELLOWS.**

_____: Some Arizona gold deposits. **S.J. REYNOLDS.**

Institute of Shaft Drilling Technology, Annual Meeting, Las Vegas: Superconducting Super Collider in Arizona. **J.W. WELTY.**

Society of Mining Engineers, Annual Meeting, Phoenix, Technical session on Arizona industrial minerals: Arizona industrial minerals and rocks. (Abstract published). **H.W. PEIRCE** and **J.D. SHENK***.

_____: The geology and development of the White Cliffs diatomite deposit, Mammoth, Arizona. (Abstract published). **J.D. SHENK***.

_____, **Technical session on Arizona-California borderland settings of precious metal deposits through time:** Control of mineralization by Mesozoic and Cenozoic low-angle structures in west-central Arizona. (Abstract published). **J.E. SPENCER, S.J. REYNOLDS,** and **J.W. WELTY.**

Southwest Builders, Phoenix: Superconducting Super Collider in Arizona. **J.W. WELTY.**

Structural Engineers Association of Arizona, Annual Meeting, Tucson: Superconducting Super Collider in Arizona. **J.W. WELTY.**

Tucson Economic Development Corporation: Superconducting Super Collider in Arizona. **J.W. WELTY.**

Tucson Trade Bureau: Superconducting Super Collider in Arizona. **J.W. WELTY.**

Western Mining Corporation, Olympic Dam, Australia: Relationship between potassium metasomatism and detachment-related mineralization. **S.J REYNOLDS.**

Workshop on Industrial Rock and Mineral Resources of Arizona, Tempe: Overview of the current geologic and economic availability of industrial rock and mineral resources in Arizona. **H.W. PEIRCE.**

OTHER

Workshop on Industrial Rock and Mineral Resources of Arizona, sponsored by the U.S. Geological Survey (USGS) and the AZGS. Invited participants represented State and Federal land-management agencies and industry. Purpose of workshop was to determine types of research and data needed by land-management agencies and industry. **L.D. FELLOWS** and E.W. Tooker (USGS) were coconveners.

Information and Service to
PROFESSIONAL SOCIETIES

TALKS GIVEN

Arizona Geological Society, Tucson: Miocene calderas and gold mineralization in the Kofa region, southwestern Arizona. **M.J. GRUBENSKY.**

_____: Reminiscing 36 years of Arizona geology. **H.W. PEIRCE.**

Arizona State Library Association, Annual Meeting, Phoenix: Geologic highlights of 1987-88. **L.D. FELLOWS.**

Geological Society of America, Annual Meeting, Phoenix: Superimposed domino-style normal faults in a Tertiary bimodal volcanic complex, Wickenburg Mountains and vicinity, central Arizona. (Abstract published). **J.E. FRYXELL*, J.A. STIMAC*,** and **S.J. REYNOLDS.**

_____: Mesozoic structural evolution of the Maria fold and thrust belt, west-central Arizona and southeastern California. (Abstract published). **S.J. REYNOLDS, J.E. SPENCER,** S.E. Laubach, and S.M. Richard.

_____: K-metasomatism of mid-Tertiary rocks in the upper plate of the Bullard detachment fault, west-central Arizona. (Abstract published). **M.S. RODDY*, S.J. REYNOLDS,** B.M. Smith, and J. Ruiz.

_____: Major early Miocene extensional deformation in southwestern Arizona and southeastern California. (Abstract published). D.R. Sherrod, L.G. Pickthorn, R.M. Tosdal, **M.J. GRUBENSKY,** and R.D. Koch.

_____: Reduction of crustal flexural rigidity during folding of crystalline rocks in the Harcuvar and Whipple metamorphic core complexes, west-central Arizona and southeastern California. (Abstract published). **J.E. SPENCER.**

_____: Interaction between Mesozoic and Cenozoic tectonic features in the Buckskin Mountains and adjacent areas, west-central Arizona and southeastern California. (Abstract published). **J.E. SPENCER** and **S.J. REYNOLDS.**

Geological Society of America, Cordilleran Section Meeting, Las Vegas: Role of crustal flexure in initiation of detachment faults: Inferences based on Airy stress functions. (Abstract published). **J.E. SPENCER.**

_____: Geologic and geotechnical characteristics of the Maricopa Superconducting Super Collider (SSC) site, south-central Arizona. (Abstract published). **J.W. WELTY** and R.A. Cummings.

Society of Sigma Xi, University of Arizona: Superconducting Super Collider in Arizona. **J.W. WELTY.**

FIELD TRIPS LED

Geological Society of America, Annual Meeting, Phoenix: Geomorphology and structure of the Colorado Plateau--Basin and Range Transition Zone. (Trip guide published.) R.A. Young, **H.W. PEIRCE,** and J.E. Faulds.

_____: Lower- and upper-plate rocks of the South Mountains detachment zone. (Trip guide published.) **S.J. REYNOLDS** and G.S. Lister.

_____: Geology of parts of the Harquahala, Granite Wash, Whipple, and Buckskin Mountains. (Trip guide published.) **J.E. SPENCER, S.J. REYNOLDS,** J.L. Anderson, G.A. Davis, S.E. Laubach, S.M. Richard, and Stephen Marshak.

OTHER

Arizona Geological Society, Tucson: **S.J. REYNOLDS** served as Vice President in charge of programs, as coeditor of Digest 17, and as a member of the Publications Committee.

_____: **S.J. REYNOLDS** conceived and organized short course, Origin of Gold Deposits, held in April 1988.

_____: **J.E. SPENCER** gave a summary of the tectonic setting and fluid-inclusion characteristics of the Copperstone mine to participants on the Spring 1988 field trip.

Chemical Society of America Petroleum Research Fund: **S.J. REYNOLDS** reviewed a research proposal.

Geological Society of America: **J.E. SPENCER** served as Vice Chairman of Field Trip Committee and was responsible for coordinating budgets for the 34 field trips conducted in association with the annual meeting of the Society in Phoenix.

_____: **S.J. REYNOLDS** and G.J. Axen presided at the symposium on Tertiary extensional tectonics of the lower Colorado River region, held during the annual meeting of the Society in Phoenix.

_____: **S.J. REYNOLDS** reviewed five manuscripts and **J.E. SPENCER** reviewed three manuscripts submitted for publication by the Society.

_____: G.H. Davis and **E.M. VANDENDOLDER** were coeditors of the field-trip guidebook (Geologic diversity of Arizona and its margins: Excursions to choice areas) for the annual meeting of the Society in Phoenix.

Information and Service to UNIVERSITIES

INQUIRIES ANSWERED

Arizona State University
Northern Arizona University
University of Arizona
University of California - Irvine
University of Illinois
University of New Mexico
Pima Community College
Sonoma State University
University of Sonora
University of Texas - Austin
Virginia Polytechnic Institute
University of Wisconsin - River Falls

TALKS GIVEN

Northern Arizona University, Department of Geology, Flagstaff: Cenozoic tectonics and mineral deposits of west-central Arizona. **J.E. SPENCER.**

University of Arizona, Department of Geosciences, Tucson: Cenozoic tectonics and mineral deposits of west-central Arizona. **J.E. SPENCER.**

_____, Graduate Library School, Tucson: State geological surveys as information sources. **L.D. FELLOWS.**

Grand Canyon College, Geology class, Phoenix: Geology of Arizona. **L.D. FELLOWS.**

Melbourne University, Melbourne, Australia: Continental extension--an overview based on the Basin and Range Province, southwestern U.S.A. **S.J. REYNOLDS.**

_____, Relation between mineralization and extensional tectonics. **S.J. REYNOLDS.**

Monash University, Melbourne, Australia: Continental extension in the Basin and Range Province, southwestern U.S.A. **S.J. REYNOLDS.**

FIELD TRIPS LED

University of Arizona and Zurich Institute of Technology, professors and graduate students: Santa Catalina Mountains. **S.J. REYNOLDS.**

University of California at Los Angeles, professors and graduate students: Santa Catalina Mountains. **S.J. REYNOLDS.**

California State University, Los Angeles, professor and graduate student: South Mountains. **S.J. REYNOLDS.**

University of Melbourne and U.S. Geological Survey: Geology of South Mountains, Harcuvar Mountains, and Merritt Hills. **S.J. REYNOLDS.**

Monash University, Australia, professor: Santa Catalina Mountains. **S.J. REYNOLDS.**

University of Saskatchewan, professor: Buckskin Mountains. **S.J. REYNOLDS.**

Virginia Polytechnic Institute, professor: Santa Catalina and Rincon Mountains. **S.J. REYNOLDS.**

GRADUATE STUDENTS ASSISTED

University of Arizona (12)
University of California at Los Angeles (1)
California State University, Los Angeles (1)
Massachusetts Institute of Technology (1)
University of New Mexico (1)

Information and Service to
EARTH SCIENCE TEACHERS

INQUIRIES ANSWERED

Arizona Association for Learning in and about the Environment
Arizona Department of Education
Arizona Science Teachers Association
Mesa School System, Science Resource Center
Pima County Center for Educational Development
Resource Center for Environmental Education
Tucson Unified School District
  Bilingual Education Unit
  Camp Cooper

TALKS GIVEN

Arizona Science Teachers Association, 1987, Annual Meeting, Phoenix: Earthquakes: Where does the fault lie? **T.G. McGARVIN.**

_____: Rock relationships: Concepts for the classroom. **T.G. McGARVIN.**

Tucson Unified School District, Bilingual Education Unit: Science curriculum design--presentation on geology for primary grades. **T.G. McGARVIN.**

FIELD TRIPS LED

Geology of western Tucson basin. **T.G. McGARVIN.**

Geology of northern and eastern Tucson basin. **T.G. McGARVIN.**

OTHER

Smithsonian Institute, Regional Workshop Planning session: **T.G. McGARVIN** was an invited participant.

Information and Service to
THE PUBLIC AND OTHER GROUPS

INQUIRIES ANSWERED

Office of Arid Land Studies
Arizona-Sonora Desert Museum
Children's Museum of Tucson
Drachman Institute
Museum of Northern Arizona
Nature Conservancy
Arizona Public Service
Arizona State Museum

TALKS GIVEN

Casas Adobes Business Club: Superconducting Super Collider in Arizona. **J.W. WELTY.**

Exchange Club, Tucson: Superconducting Super Collider in Arizona. **J.W. WELTY.**

Green Valley Business Men's Club: Superconducting Super Collider in Arizona. **J.W. WELTY.**

Kiwanis Club, Casa Grande: Superconducting Super Collider in Arizona. **J.W. WELTY.**

Kiwanis Club, Tucson: Superconducting Super Collider in Arizona. **J.W. WELTY.**

Optimist Club, Tucson: Superconducting Super Collider in Arizona. **J.W. WELTY.**

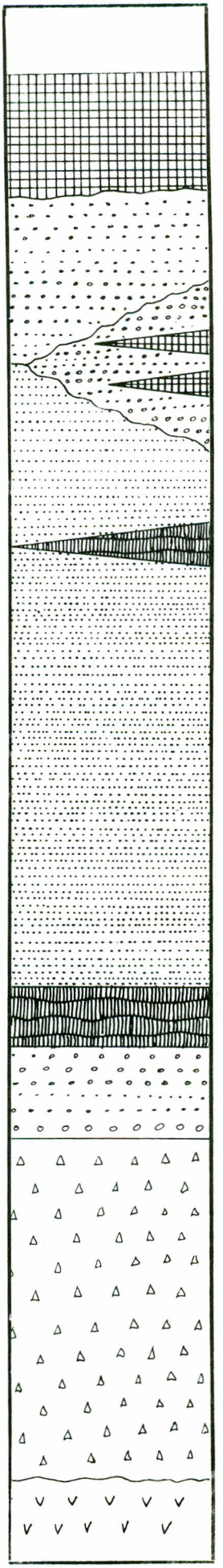
American Association of Retired Persons, Green Valley: Superconducting Super Collider in Arizona. **J.W. WELTY.**

Rotary Club, Catalina: Superconducting Super Collider in Arizona. **J.W. WELTY.**

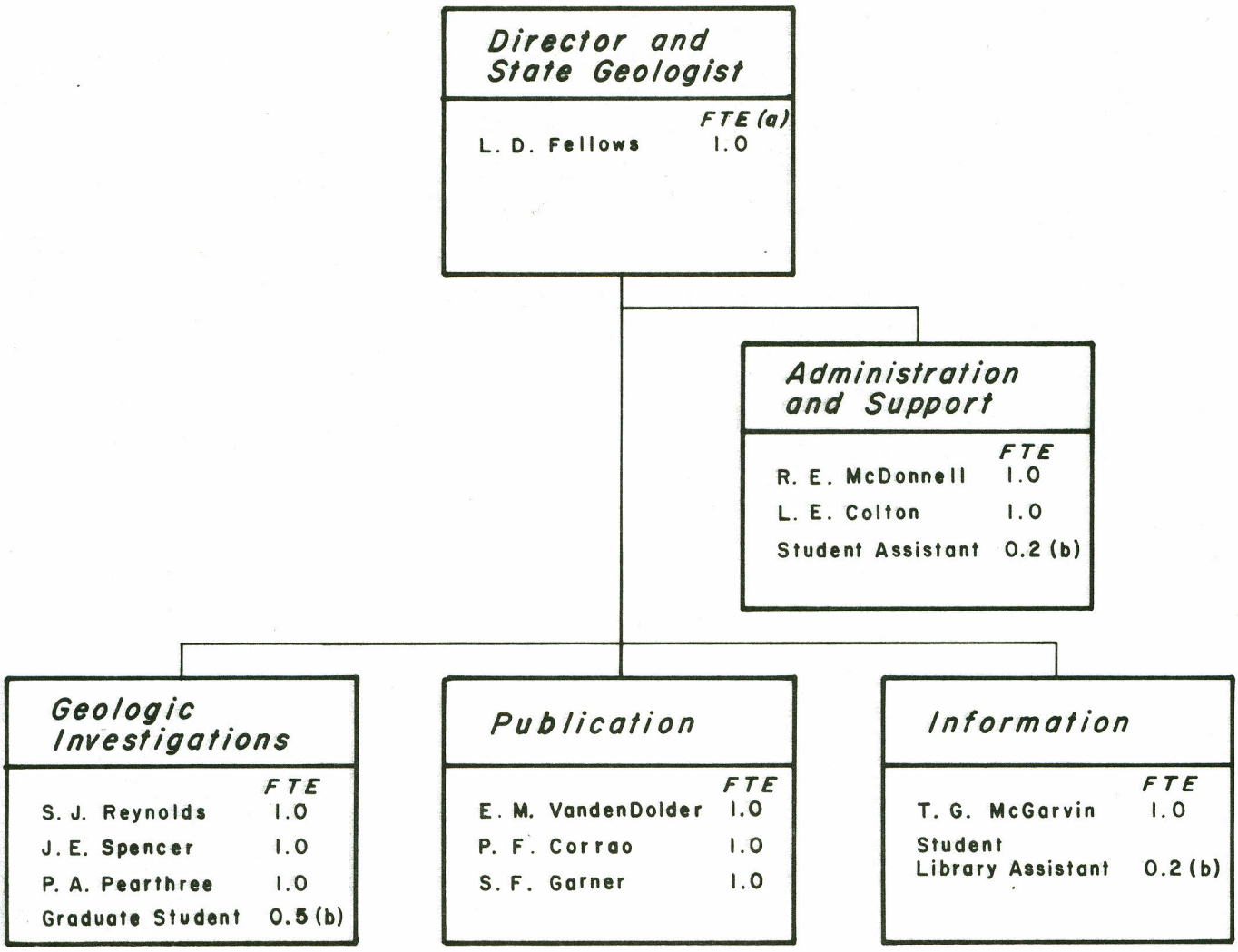
Rotary Club, Tucson: Superconducting Super Collider in Arizona. **J.W. WELTY.**

Organization and Personnel

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. The Bureau shall consist of at least a geological survey branch and a mineral technology branch. **(Section 27-152, A, Arizona Revised Statutes)**



Organization Chart
Arizona Geological Survey
June 1988



(a) - Full-time equivalent

(b) - Temporary

10.9 F.T.E.

Personnel
Arizona Geological Survey
Fiscal Year 1987-88

REGULAR EMPLOYEES (full-time):	Full-time Equivalent
STATE GEOLOGIST	
Larry D. Fellows	1.0
ADMINISTRATION AND SUPPORT	
Rose Ellen McDonnell, Administrative Assistant I (a)	1.0
Janet M. Christner, " " (b)	
Laurette E. Colton, Secretary II (c)	1.0
Joyce K. Gardner, " " (d)	
GEOLOGICAL INVESTIGATIONS	
Philip A. Pearthree, Assistant Research Geologist (e)	1.0
H. Wesley Peirce, Principal Geologist (f)	
Stephen J. Reynolds, Associate Research Geologist	1.0
Jon E. Spencer, Assistant Research Geologist	1.0
PUBLICATION	
Evelyn M. VandenDolder, Associate Editor	1.0
Peter F. Corrao, Research Equipment Technician (g)	1.0
Sherry F. Garner, Graphic Artist III (h)	1.0
INFORMATION	
Thomas G. McGarvin, Research Assistant II	1.0
TOTAL REGULAR EMPLOYEES	**10.0**

STUDENT EMPLOYEES (part-time and temporary):

Clerical Assistants: Karen S. Fulton, Mary C. Miller, and Traci L. Newman	
Library Assistants: Richard E. Gates, Charles W. Silver and Ann L. Smith	0.4
Graduate Research Assistants: Karen A. Demsey, John T. Duncan, Mary E. Glynn, Kevin C. Horstman, George C. Lin, Mary Anne McKittrick, Karen L. Oden, and Jonathan D. Shenk	0.5
TOTAL STUDENT EMPLOYEES	**0.9**
TOTAL STATE-FUNDED EMPLOYEES	**10.9**

a) 08/17/87 -

b) 07/01/86 - 07/05/87

c) 03/28/88 -

d) 08/24/87 - 02/19/88

e) 05/01/88 -

f) 07/01/56 - 07/30/87

g) promoted 07/01/87

h) 07/17/87 -

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

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

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

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

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

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

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

SUPPORT STAFF AND MAJOR FUNCTIONS

LAURETTE E. COLTON, Secretary II.

- manager of publication sales office
- typing and data entry

PETER F. CORRAO, Research Equipment Technician; B.A., Arizona State University.

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

SHERRY F. GARNER, Graphic Artist III; B.A., University of Kentucky.

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

ROSE ELLEN MCDONNELL, Administrative Assistant I; B.S., University of Arizona.

- special assistant to State Geologist
- accounting, personnel, payroll, purchasing
- facility maintenance

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

- provide information to public on general geology of Arizona and on availability of maps and reports on Arizona geology
- assist earth-science teachers
- manage library and assist users
- manage cuttings and core repository and assist users

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

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

Appropriation and Expenditures

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)

State Appropriation and Expenditures

	FY 1986-87		FY 1987-88		FY 1988-89
Category	Budgeted	Spent	Budgeted	Spent	Budgeted
Personal Services	297,141	298,100	290,448	290,637	337,100
ERE (Benefits)	56,214	53,015	46,547	45,198	76,100
Operations	26,500	26,554	28,100	27,838	93,900(1)
In-state Travel	5,212	5,183	4,200	4,337	5,900
Out-of-state Travel	2,593	2,609	1,800(2)	1,800	4,500
Capital	12,410	12,410	1,525	1,525	14,200
TOTAL	400,070	397,871	372,620	371,335	531,700

(1) Includes funding or rent and utilities.

(2) Includes $1,000 provided by Vice President for Academic Affairs.

Contracted Projects
FY 1987-88 Expenditures

Category	Landslides	Radiation Survey	Geologic Mapping Vulture Mts.	Geologic Mapping Wickenburg Area	Total
Personal Services			9,237	11,379	20,616
ERE (Benefits)			1,810	891	2,701
Operations	292	7,082	153	3,689	11,216
In-state Travel			321	1,521	1,842
Equipment		918			918
Indirect	129		5,334	4,282	9,745
TOTAL	421	8,000	16,855	21,762	47,038

LANDSLIDES

Description: This statewide inventory of landslides will ultimately result in completion of a 1:500,000-scale map that includes seven selected areas mapped 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 FY87-88: $421

Persons employed in FY87-88: John W. Welty

Reports and maps completed:

WELTY, J.W., RODDY, M.S.*, Alger, C.S., and Brabb, E.E., 1988, Bibliography of Arizona landslide maps and reports: Arizona Geological Survey Open-File Report 88-14, 13 p.

WELTY, J.W., DEMSEY, K.A.*, and **RODDY, M.S.***, Map of landslides and talus deposits in Arizona: in preparation.

GAMMA-RADIATION SURVEY

Description: A reconnaissance gamma-radiation survey of bismuth-214, a decay product of radon, in 38 populated areas in Arizona. Project was funded by a special appropriation from the Arizona Legislature.

Principal investigators: Jon E. Spencer and Larry D. Fellows

Amount of contract: $8,000

Duration of contract: July 1, 1987 to June 30, 1988

Amount spent in FY87-88: $8,000

Persons employed in FY87-88: Dudley F. Emer and Jonathan D. Shenk

Reports and maps completed:

SPENCER, J.E., Emer, D.F., and **SHENK, J.D.***, 1988, Background radio-activity in selected areas of Arizona and implications for indoor-radon levels: Arizona Geological Survey Open-File Report 88-11, 14 p.

EMER, D.F., SHENK, J.D.*, and **SPENCER, J.E.**, 1988, Reconnaissance gamma-ray spectrometer survey of radon-decay products in selected populated areas of Arizona: Arizona Geological Survey Open-File Report 88-12, 88 p.

GEOLOGIC MAPPING - VULTURE 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 Vulture Mountains.

Principal investigators: Stephen J. Reynolds, Jon E. Spencer, and Larry D. Fellows

Amount of contract: $60,000

Duration of contract: March 1, 1988 to April 30, 1989

Amount spent in FY87-88: $16,855

Persons employed in FY87-88: Michael J. Grubensky

Reports and maps completed: (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, Jon E. Spencer, and Larry D. Fellows

Amount of contract: $60,000

Duration of contract: January 1, 1987 to January 31, 1988

Amount spent in FY87-88: $21,762

Persons employed in FY87-88: Michael J. Grubensky

Reports and maps completed:

STIMAC, J.A.*, FRYXELL, J.E.*, REYNOLDS, S.J., GRUBENSKY, M.J., and **SCOTT, E.A.**, 1987, Geologic map of the Wickenburg, southern Buckhorn, and northwestern Hieroglyphic Mountains, central Arizona: Arizona Geological Survey Open-File Report 87-9, 13 p., scale 1:24,000.

GRUBENSKY, M.J.*, STIMAC, J.A.*, REYNOLDS, S.J., and Richard, S.M., 1987, Geologic map of the northeastern Vulture Mountains and vicinity, central Arizona: Arizona Geological Survey Open-File Report 87-10, 7 p. scale 1:24,000.

WAHL, D.E., REYNOLDS, S.J., CAPPS, R.C., KORTEMEIER, C.P., GRUBENSKY, M.J.*, SCOTT, E.A., and **STIMAC, J.A.***, 1988, Geologic map of the southern Hieroglyphic Mountains, central Arizona: Arizona Geological Survey Open-File Report 88-1, 6 p., scale 1:24,000.