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Congratulations, SSC Team!

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

Congratulations to all who worked on the Superconducting Super Collider (SSC) project and brought Arizona to the "Final Seven." Well done, team! On November 10, 1988 Secretary of Energy John S. Herrington announced that the site proposed by the State of Texas is the U.S. Department of Energy's preferred site for the SSC. The 7 sites under consideration (Arizona, Colorado, Illinois, Michigan, North Carolina, Tennessee, and Texas) were recommended by the National Academies of Sciences and Engineering from a list of 36 proposals. In Secretary Herrington's own words, "It was a highly competitive list of sites, all of which had serious merit."

The effort to bring the SSC to Arizona involved the cooperation of hundreds of Arizonans working on all phases of the project. Governor Rose Mofford fought hard for the project, which began during the administration of Governor Bruce Babbitt and was strongly supported by Governor Evan Mecham and the entire congressional delegation. Several State agencies, including the Arizona Geological Survey (AZGS), Federal agencies, the State's universities, Maricopa and Pima County governments, and the private sector tried their best to convince the U.S. Department of Energy (DOE) that the Arizona site would permit the highest level of research productivity and effectiveness at a reasonable cost of construction and operation with minimal impact on the environment. Special thanks are due to the SSC Project Technical Committee, including Dr. Peter A. Carruthers (Chairman), Dr. Richard J. Jacob (Deputy Chairman), Donald W. Morris (Project Manager), Ian A. Macpherson (Project Coordinator), Tara E. Fuchs (Assistant Director, Arizona Department of Commerce), and John W. Welty (Project Geologist).

Nearly $3 million of public and private funds were expended to produce more than 2 tons of documentation presented to the DOE for both the Maricopa and Sierrita sites. The SSC proposals provide the most current demographic sketches of the Phoenix and Tucson metropolitan areas and offer new insights into the geologic settings and constructibility of earth materials within and surrounding the Maricopa and Sierrita Mountains, in particular, and in the Basin and Range Province, in general.

Arizona's efforts to host the SSC began in 1983 when the Arizona SSC Project was formed to assess the possibility of finding SSC sites within the State. A multidisciplinary team canvassed the State and located 31 potential sites using an extensive list of geologic, topographic, demographic, economic, environmental, and political criteria. These sites were limited to the physiographic Basin and Range Province, which is char-

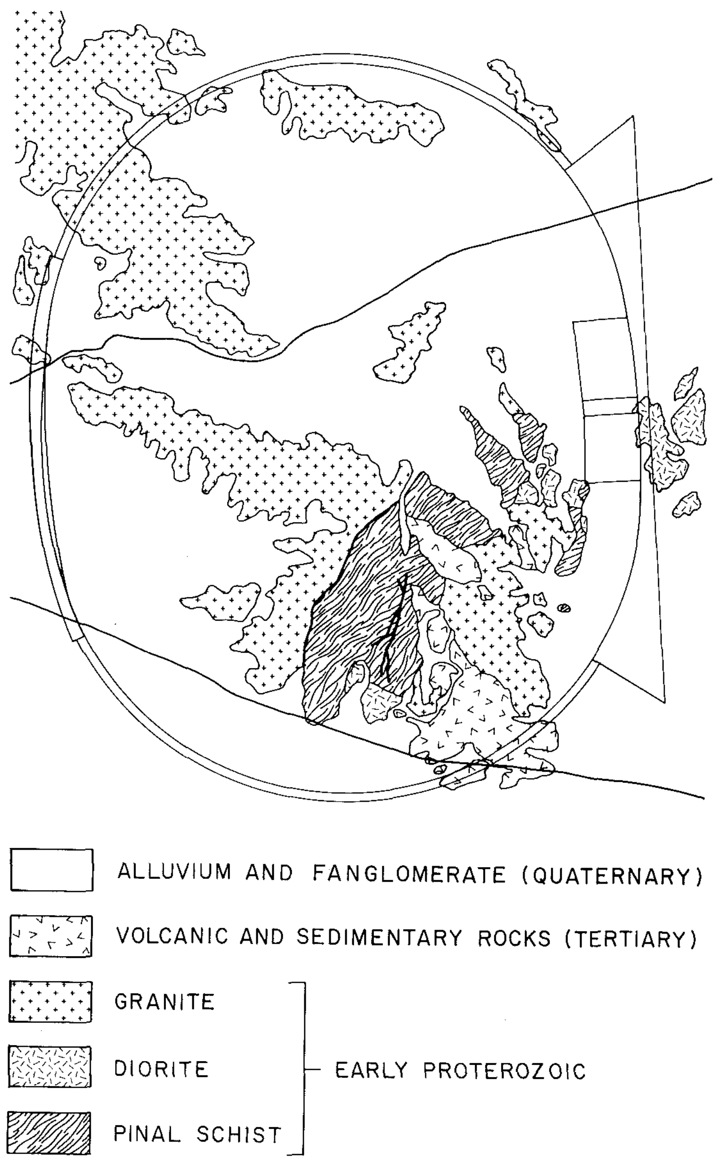

Figure 1. Geologic map of the Maricopa site.

acterized by broad expanses of relatively flat alluvial basins in between mountain ranges. The Transition Zone and Colorado Plateau were considered unsuitable because of rugged topography or remoteness from metropolitan areas. By 1985 the list of 31 sites had been reduced to 6. When the DOE released a conceptual design for the SSC in 1986, Arizona had settled on two sites: Maricopa and Sierrita. Proposals for both sites were submitted to the DOE and Maricopa was selected for the "best qualified list." (See Cunningham, 1987, for a short geologic summary of both sites.)

The proposed collider-ring path at the Maricopa site passes through approximately 18 miles of bedrock and 34 miles of fanglomerate and alluvium (Figure 1). Several major bedrock types, including granite, diorite, conglomerate, basalt, and welded tuff, are present in the Maricopa Mountains. The basins surrounding the mountains mainly consist of fanglomerates, which are cemented conglomeratic deposits derived from the weathering of bedrock in the Maricopa Mountains. The fanglomerates are overlain by unconsolidated alluvium typical of desert basins in the Southwest.

Site-specific geologic and geotechnical investigations were primarily concerned with identifying the following: (1) geologic setting of the subsurface bedrock and the alluvial basin; (2) engineering properties of the bedrock and basin fill; (3) structures that might impact construction; (4) seismic and other potential geologic hazards; and (5) geohydrologic constraints. The proposed collider-ring alignment was explored through core and air-rotary drilling that included detailed geotechnical logging; seismic, gravity, and electrical geophysical investigations; large and standard auger boring; laboratory geomechanical testing; downhole *in situ* testing; detailed geotechnical mapping of the surface; and reconnaissance geologic mapping.

The granitic rocks are uniformly strong but variably fractured. The fracturing would have aided excavation with a tunnel-boring machine (TBM). The volcanic and sedimentary rocks also would have been excellent media for tunneling. The basalts would have required no support except occasional rock bolts. The welded tuff might have required pattern-bolting in places or a light, reinforced shotcrete lining. The conglomerates might have required a segmental liner, particularly where the transition to more competent units would have been made. The fanglomerate would have been uniquely suited for deep open-cut and backfill operations and had excellent TBM suitability where greater depth would have dictated tunneling. Seismic velocity data and measured physical characteristics suggested that its tunnel behavior would have been that of a weak sandstone.

Cooperative efforts to prepare Volume 3, Geology and Tunneling, of the site proposals relied upon the resources of three State agencies, two Federal agencies, nine private firms, five departments at the University of Arizona, and one department at Arizona State University. Primary responsibility for the preparation of this volume, judged by the DOE to be the most important evaluation document, was given to John W. Welty, who has been "on loan" to the Arizona SSC Project from the AZGS since early 1987. Welty assumed the role of Project Geologist from W. Dickson Cunningham, who had served the Arizona SSC Project from 1983 to 1987. AZGS geologists attended planning sessions and provided expertise about the geology of both the Maricopa and Sierrita sites. The Maricopa site was first suggested to the Arizona SSC Project by AZGS geologist Stephen J. Reynolds. Cunningham, Welty, Reynolds, AZGS geologist Jon E. Spencer, and U.S. Geological Survey geologists Ed DeWitt and Gordon Haxel completed a reconnaissance geologic map of the entire Maricopa Mountains, which were previously unmapped (Cunningham and others, 1987). Spencer and AZGS geologist Michael J. Grubensky mapped in greater detail the stratigraphic succession of volcanic and sedimentary rocks in the southern Maricopa Mountains. Philip A. Pearthree, also an AZGS geologist, supervised a seismotectonic and geomorphic study of the Sand Tank fault 6 miles southwest of the Maricopa SSC site. Much of the site mapping would not have been possible without the assistance of the Arizona Public Service Co., which provided use of their helicopter and pilot Ron Wallace. The Arizona Department of Transportation also played an important role in the geologic evaluation by providing aerial photographs and cartographic services under the direction of Carl C. Winikka. Greg Wallace, chief hydrologist for the Arizona Department of Water Resources, and his staff provided essential hydrologic data and advice during the preparation of geohydrologic and water-supply summaries for both SSC sites.

The U.S. Bureau of Land Management was an important contributor to Arizona's effort to garner the SSC. Both the Phoenix district, under whose jurisdiction the Maricopa site resides, and the Arizona State office granted permission to conduct geologic and geotechnical evaluations and helped to craft a land-management plan that would integrate the SSC with current land uses. William T. Childress, Frank Daniels, and Hank Molz of the Phoenix district office were instrumental in gaining the necessary permits for site evaluations. Arizona State Director D. Dean Bibles and his staff provided invaluable assistance and worked diligently with representatives of Arizona State government to produce an effective real-estate acquisition plan for the Maricopa SSC site.

Private-sector support for Arizona's evaluation of the two sites included both contracted and volunteer efforts. The Phoenix-based firm of Sergent, Hauskins & Beckwith provided contracted geotechnical-engineering expertise for an evaluation of the constructibility of basin-fill sediments surrounding the Maricopa and Sierrita Mountains. George H. Beckwith and Ralph E. Weeks, principals of this firm, also gave their time freely during the relentless review process of proposal preparation. The Tucson office of Engineers International, Inc., under the direction of Robert A. Cummings, provided essential assistance during geotechnical exploration drilling of both sites and during proposal preparation. Charles F. Barter of Errol L. Montgomery & Associates, Inc., Philip C. Briggs of Geraghty & Miller, Inc., and Drupad B. Desai of Daniel, Mann, Johnson & Mendenhal labored tirelessly while reviewing both site proposals and greatly improved the quality. Robert M. Miller, Jr. and P.E. "Joe" Sperry were contracted to work with Arizona SSC Project engineers, geologists, and hydrologists and M.M. Sundt Co. estimators to compile a heavy-construction cost-and-schedule estimate for both sites. The Arizona Consulting Engineers Association organized their membership to review and critique early drafts of the proposal, which added greatly to its quality. Local mining companies, especially ANAMAX Mining Co., ASARCO, Inc., Cyprus Sierrita, and the Park Corp., gave freely of their experience in construction and excavation in Arizona.

Faculty and students at the University of Arizona and Arizona State University played an important role in the development of both proposals. Funding for the first several years of the site-selection process was provided directly by University of Arizona President Henry Koffler. The Departments of Civil Engineering and Engineering Mechanics, Hydrology and Water Resources, and Mining and Geological Engineering in the University of Arizona College of Engineering and Mines were actively involved in the characterization of earth materials at both sites. Drs. Jay S. DeNatale and Edward A. Nowatzki and their students from Civil Engineering and Engineering Mechanics conducted geotechnical engineering investigations of the basin-fill sediments at both sites. Civil Engineering Professor Philip B.

Newlin, working with engineers from the Arizona Department of Transportation, surveyed critical facility locations at both sites. Dr. Stanley N. Davis, Steven J. Brooks, and graduate students from Hydrology and Water Resources took lead responsibility for geohydrologic evaluations of both sites. Brooks served as Project Hydrologist from 1985 until 1988. Dr. David K. Kreamer and several of his students in the Civil Engineering Department at Arizona State University helped Brooks with ground-water modeling at the Maricopa site. Drs. Ian W. Farmer, Ben K. Sternberg, Jaak J. Daemen, Carl E. Glass, and Robert C. Armstrong and their students from the Department of Mining and Geological Engineering, University of Arizona, conducted geophysical surveys and geotechnical engineering investigations of the "hard rock" at both sites. Graduate-student involvement in SSC-related research resulted in the writing of six theses on hydrologic and geotechnical engineering aspects of both sites. Drs. William B. Bull, Spencer R. Titley, and Terry C. Wallace of the University of Arizona Department of Geosciences reviewed early drafts of the Sierrita site proposal and offered valuable advice on the site-characterization plans. Five graduate students from this department were employed during the geophysical and geotechnical surveys of both sites. The University of Arizona Drachman Institute, under the direction of Marshall A. Worden and John J. Regan, Jr., provided cartographic services and presentation graphics for the proposals.

The results of site investigations were released in 15 reports, which are available in the AZGS library. Cunningham and others (1987) presented the results of the first comprehensive mapping of the Maricopa Mountains. Welty and others (1988a; 1988b) described the findings of the geologic and geotechnical investigations, as presented to the DOE. The results of engineering investigations of the basin-fill deposits were delineated by DeNatale and others (1987) and Nowatzki and others (1988). Cummings and others (1988) summarized geotechnical investigations at the Maricopa site. Details of geophysical investigations at both sites were given in several reports (Sternberg, 1986; Sternberg and others, 1986; Bryan and others, 1987; Sternberg and Esher, 1987; Sternberg and others, 1987; Sternberg and Sutter, 1987; Sternberg and others, 1988). Results of geohydrologic investigations at the Maricopa site were outlined by Brooks (1988a; 1988b).

Thanks again, to all who participated, for your cooperation and contributions. We're disappointed that Arizona did not win the SSC, but we're proud of your individual and combined efforts. Congratulations for a job well done!

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Professional Meetings

Geosciences Symposium. Annual student colloquium, March 30-31, 1989, Tucson, Ariz. Contact David Shafer, Dept. of Geosciences, Gould-Simpson Bldg., University of Arizona, Tucson, AZ 85721; tel: (602) 621-6024.

Arizona-Nevada Academy of Science. Annual meeting, April 15, 1989, Las Vegas, Nev. Contact Sandra Brazel (President), Laboratory of Climatology, Arizona State University, Tempe, AZ 85287; tel: (602) 965-6265; or Fred Bachhuber (Geology Section Chairman), Dept. of Geoscience, University of Nevada, Las Vegas, NV 89154; tel: (702) 739-3120.

Great Basin Symposium Planned for 1990

The Great Basin region hosts a wide variety of metallic and nonmetallic mineral deposits and is the scene of an unprecedented modern-day "gold rush." To bring together earth scientists from industry, academia, and government agencies so they might share the results of their research on the economic geology of the region, the Geological Society of Nevada and U.S. Geological Survey are sponsoring a symposium titled "Geology and Ore Deposits of the Great Basin." The symposium, which will be held April 1-5, 1990 in Sparks and Reno, Nevada, will feature oral presentations, poster sessions, and field trips to operating mines and significant geologic localities. Abstracts of papers to be presented at the symposium are being accepted. For information, contact the Geological Society of Nevada, 777 Sinclair St., Suite 202, Reno, NV 89501; tel: (702) 786-0870.

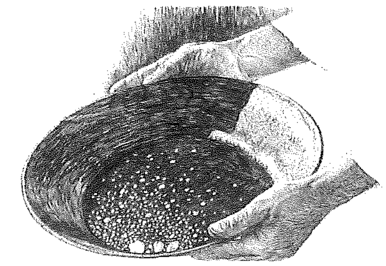
USGS Finds Gold in the Silver Bell Mountains

by Jon E. Spencer
Arizona Geological Survey
and David A. Sawyer
U.S. Geological Survey
MS 913, Federal Center
Denver, CO 80225

On October 17, 1988, the U.S. Geological Survey (USGS) announced that unusually high concentrations of gold had been discovered in several stream-sediment samples from within or adjacent to the Ragged Top Wilderness Study Area (WSA). The Ragged Top WSA is in the Silver Bell Mountains of Pima County, approximately 35 miles northwest of Tucson. The announcement made newspaper headlines in Arizona and triggered a minor gold rush as prospectors quickly staked unclaimed land in the area. To date, 45 new lode mining claims have been staked as a result; 59 claims had been previously recorded in the area. Although the Silver Bell Mountains contain large base-metal deposits (copper, lead, zinc, and molybdenum), gold production has been negligible.

The USGS mineral-assessment survey was conducted as part of a routine evaluation of a Bureau of Land Management WSA to determine suitability for wilderness designation. Laramide porphyry copper deposits in the Silver Bell Mountains (Richard and Courtright, 1966; Graybeal, 1982) south of the WSA have yielded more than a billion pounds of copper, large amounts of other base metals, and 6 million ounces of silver, but only 2,200 ounces of gold (Keith and others, 1983). Considering the large production of the Silver Bell mineral district and its proximity to the Ragged Top WSA, the occurrence of metallic mineralization in the WSA is not surprising; the high gold concentrations, however, are somewhat surprising.

Gold concentrations above 0.05 parts per million (ppm) are considered anomalous for raw panned-concentrate samples from stream sediments within WSA's, and concentrations greater than 1 ppm are considered highly anomalous. By these criteria, most raw panned-concentrate samples from stream sediments in a several-square-mile area adjacent to Ragged Top Peak are anomalous or highly anomalous (Figure 1). The sample with the highest reported gold concentration (150 ppm) was from a stream that drains an approximately 2-square-mile basin. Reported gold concentrations from several other samples within the basin range from 1 to 10 ppm and are also highly anomalous. Samples from drainages to the north and west are anomalous; a raw panned-concentrate of one sample near the western edge of the area shown in Figure 1 contained 29 ppm gold. Most of the sediments in the samples were derived from Laramide volcanic, volcaniclastic, sedimentary, and intrusive rocks and less abundant Tertiary volcanic and intrusive rhyolite. Anomalous gold concentrations are sufficiently widespread to suggest that gold is widely distributed in the area and is not restricted to any single rock type (Figure 1). Virtually all of the drainages that register high gold concentrations, however, contain Oligocene rhyolitic intrusive rocks, fault veins, or faults.



Variably developed, late Laramide or middle Tertiary brecciation, alteration, and sulfide vein mineralization in the granodiorite and middle Tertiary veins containing quartz, calcite, barite, and fluorite (Joseph, 1982; Kreidler, 1987; McHugh and others, 1988) indicate that one or more mineralizing events occurred after all of the Laramide rocks were deposited or intruded. The anomalous gold concentrations in stream-sediment samples may be a result of this (these) late mineralizing event(s). Sawyer and Nowlan (1988) proposed that mineralization resulted from a hydrothermal system associated with the Oligocene Ragged Top rhyolite and related dikes and that hydrothermal fluids redistributed and concentrated gold, silver, lead, vanadium, and molybdenum from low-grade base- and precious-metal halos surrounding the Laramide porphyry copper deposits. Mid-Tertiary hypogene redistribution (by ascending solutions) of base and precious metals in the halos of porphyry copper deposits may have caused mineralization in other areas of Arizona: for example, the Mammoth-St. Anthony vein deposit near the San Manuel porphyry copper deposit (Sawyer and Nowlan, 1988). Other possible interpretations for the origin of the gold anomalies include simple, mid-Tertiary volcanic-hosted veins or small, polymetallic Laramide veins in the outer periphery of the Silver Bell porphyry copper deposits. Recently recognized anomalous gold concentrations in stream sediments from the area of the Baboquivari Peak WSA in Pima County (Adrian and others, 1988; Nowlan, 1988) also may be the result of mid-Tertiary hypogene mineralization associated with rhyolitic magmatism.

The anomalous gold concentrations in samples from the area of the Ragged Top WSA represent a previously unrecognized precious-metal prospect and may or may not indicate the presence of economic gold deposits. They probably did not warrant the public excitement generated by the popular media. They do, however, suggest the existence of another variant of the many types of mineral deposits in Arizona. A better understanding of such occurrences may help to identify undiscovered, economic gold deposits in the State.

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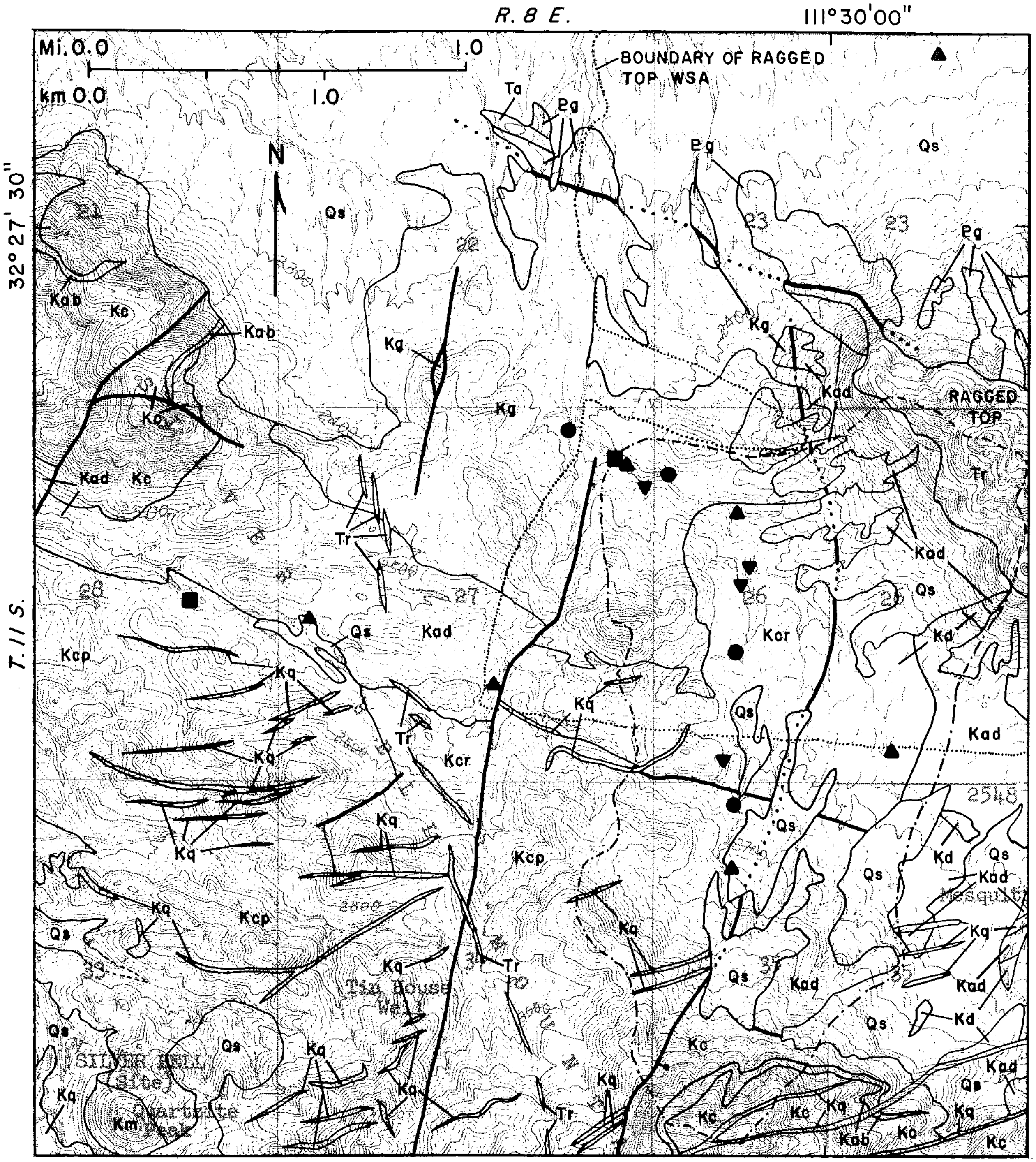

MAP LEGEND

Qs	Surficial deposits (Quaternary)	Kab	Andesite breccia (Cretaceous)	Au (ppm)	
Tr	Ragged Top rhyolite (Tertiary)	Kad	Silver Bell andesite/dacite (Cretaceous)	■	10 - 150
Ta	Andesite intrusive (Tertiary)	Kd	Silver Bell dacite (domes) (Cretaceous)	▲	1.0 - 9.9
Kq	Quartz monzonite porphyry (Cretaceous)	Kcr	Claflin Ranch formation (Cretaceous)	▼	0.10 - 0.99
Kg	Granodiorite porphyry (Cretaceous)	Kcp	Confidence Peak Tuff (Cretaceous)	●	0.05 - 0.099
Kc	Cat Mountain Tuff (Cretaceous)	Km	Megabreccia (Cretaceous)		
		Pg	Granite (Proterozoic)		

Figure 1. Geologic map of the central Silver Bell Mountains (modified from D. Sawyer, 1987, and unpublished map) showing locations and gold concentrations of panned heavy-mineral concentrates (data from McHugh and others, 1988, and D. Sawyer, unpublished). The dash-dot line encloses the drainage basin that is the source for stream sediments at the 150-ppm-gold sample locality. The El Tiro pit is just south of the lower left part of the map area, and some of the area designated Qs in the southwestern corner of the map includes mine-dump material. The northeastern part of the map area is within the Ragged Top WSA.

Southern Arizona Earthquake Update

by Terry C. Wallace, University of Arizona
Anna M. Domitrovic, Arizona-Sonora Desert Museum
and Philip A. Pearthree, Arizona Geological Survey

The largest earthquake to affect southeastern Arizona in more than 25 years occurred on June 11, 1988 near Agua Prieta, just south of the Arizona-Sonora border (Figure 1). The earthquake, which had a magnitude of 4.0, occurred at 1:58 a.m. local time (08:58:35 Greenwich mean time) and was widely felt in Agua Prieta and Douglas, although there was no reported damage. The event had several small aftershocks, the largest of which occurred on June 19 with a magnitude of 3.1.

The epicenter of the earthquake was very close to the Pitaycachi fault in the San Bernardino Valley. This fault ruptured in 1887 in a major 7.2-magnitude earthquake, sometimes referred to as the great Sonoran earthquake.* Bull and Pearthree (1988) studied the Quaternary history of the Pitaycachi fault and found a recurrence interval of at least 100,000 years between large earthquakes. Large earthquakes that have such recurrence intervals typically have aftershocks for 100 to 150 years, so the June seismicity probably represents aftershocks from the Sonoran earthquake.

The June 1988 event occurred near a major discontinuity in the surface trace of the 1887 earthquake. This is the same region where Natali and Sbar (1982) found a concentration of earthquake activity when they investigated the Pitaycachi region with an array of portable seismometers. It is not unusual to have a concentration of aftershocks at fault discontinuities; the stress appears to concentrate at "restraining" points, which may be bends or complexities in the fault zone. The June 1988 earthquake was actually the fourth earthquake to occur in the Pitaycachi region during the past 15 months. (Table 1 gives the dates and magnitudes of the other events.) In the southeastern Arizona-northern Sonora region, "normal" earthquake activity is about one earthquake with a magnitude greater than 3.0 per year. Although this is hardly active by California standards (where a 3.0-magni-

*The magnitude of the 1887 earthquake is an estimate based on the length of the surface rupture and the amount of displacement along the Pitaycachi fault.

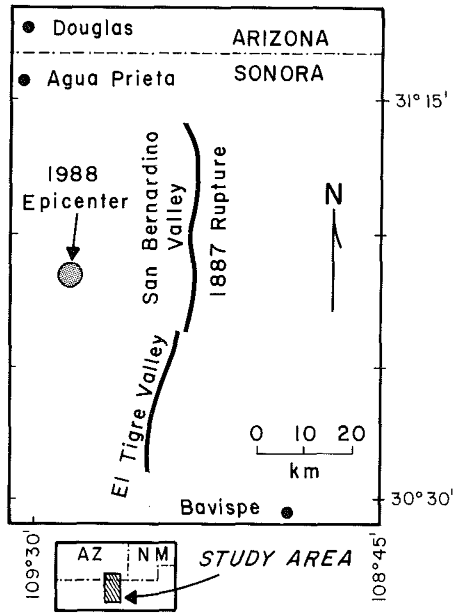

Figure 1. Location map of Pitaycachi fault region, showing epicenter of June 1988 earthquake. Solid line indicates surface rupture due to 1887 earthquake. Note discontinuity near northern part of El Tigre Valley.

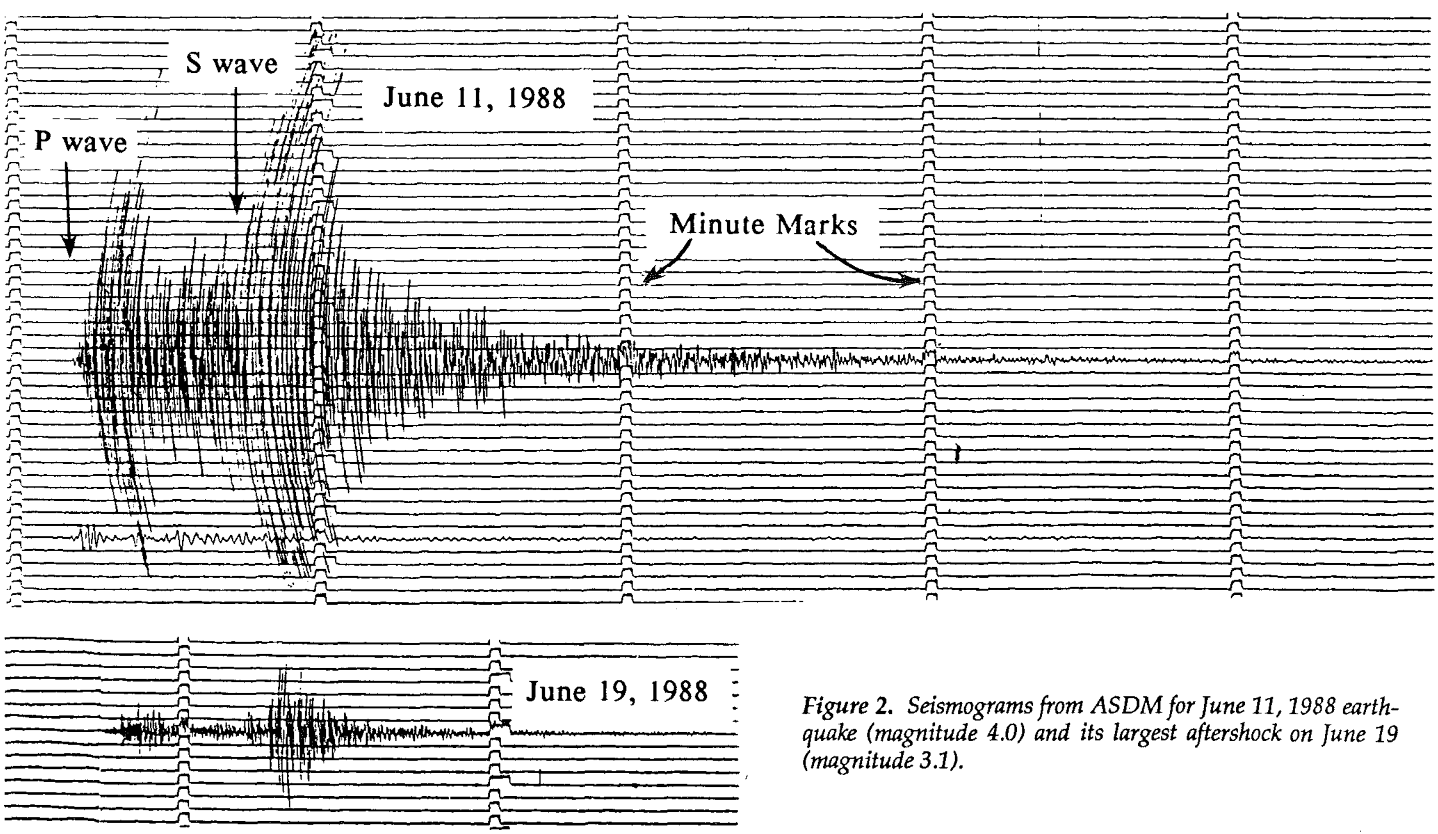

Figure 2. Seismograms from ASDM for June 11, 1988 earthquake (magnitude 4.0) and its largest aftershock on June 19 (magnitude 3.1).

tude earthquake is expected every 28 hours), it is indicative of the Quaternary fault history of the region. Pearthree (1986) identified about a dozen faults in the area that have probably experienced significant Quaternary earthquakes with magnitudes greater than 6.0.

The seismogram from a seismic station at the Arizona-Sonora Desert Museum (ASDM) for the June 1988 earthquake is shown in Figure 2. The first arrival, the P wave, is complicated; ground shaking began gradually and built up, indicating that the earthquake was preceded by a minor foreshock. The large arrival 30 seconds after the P wave is the S wave. By using the differential arrival times of P and S waves recorded at ASDM, the University of Arizona seismic station (TUC), and an array of seismometers operated by New Mexico Institute of Mining and Technology in Socorro, New Mexico, we can locate the event ±7 kilometers in the east-west direction and ±4 kilometers in the north-south direction. The magnitude of the event is determined by the length of time it takes the ground shaking to decay to the background level. Figure 2, which shows both the main event of June 11 and the aftershock of June 19, also indicates that the duration of shaking was more than 4 $^1/_2$ minutes for the former and about 2 minutes for the latter.

On December 31, 1988 at 7:33:32 a.m. local time, a 3.2-magnitude earthquake occurred 6 kilometers southwest of the June event. Considering the seismic quiescence in this area during the last quarter century, it is somewhat surprising that two 3- to 4-magnitude events occurred within the span of 6 months. Like the earthquakes earlier in the year, the December quake was located near the south-central portion of the 1887 fault trace.

Table 1. Recent seismicity in Pitaycachi area.

Date	Longitude	Latitude	Magnitude
3-14-87	109° 25.8′ W	30° 50.6′ N	3.1
12-19-87	109° 29.0′ W	30° 58.1′ N	3.2
4-10-88	109° 26.8′ W	30° 58.1′ N	3.1
6-11-88	109° 25.5′ W	30° 55.4′ N	4.0
12-31-88	109° 25.8′ W	30° 45.6′ N	3.2

Although overall earthquake activity in southeastern Arizona is low, the region around the Pitaycachi fault remains active. It is unlikely that the region will produce a large event that could be felt in Tucson or Nogales in the near future, but it is quite likely that Douglas and Agua Prieta will feel more moderate-sized events.

References

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Natali, S.G., and Sbar, M.L., 1982, Seismicity in the epicentral region of the 1887 northeastern Sonoran earthquake, Mexico: Bulletin of the Seismological Society of America, v. 72, p. 181-196.

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STAFF NOTES

Thomas G. McGarvin presented a workshop titled "Arizona's Auriferous Occurrences" at the annual convention of the Arizona Science Teachers Association on October 21. On October 29, he presented two workshops as part of the "4th R" educational program for teachers, sponsored by the Tucson Association of Museums and the Smithsonian Institution. The workshops were titled "Geology Unearthed" and "Rock Recipes." McGarvin also led four Saturday field trips on October 15, November 5 and 19, and December 3 for Tucson-area educators to examine and discuss the geologic setting of the western, northern, and eastern Tucson region.

Philip A. Pearthree presented two papers at a meeting of the Arid West Committee of the Association of State Floodplain Managers (cosponsored by the Arizona Floodplain Management Association), which was held in Las Vegas on October 19-21. The purpose of this meeting was to focus attention on floodplain-management issues in the arid and semiarid portions of the western United States. One paper, which was coauthored by Marie S. Pearthree, discussed the use of geomorphology and hydrology to delineate areas of potential alluvial-fan flooding in the Scottsdale area. A second paper summarized occurrences of debris flows in southeastern Arizona.

Stephen J. Reynolds has been reelected Vice President for Programs by the Arizona Geological Society. On November 1, he presented a talk to the society titled "Advances in Arizona Geology--A Cook's Tour of the New Geologic Map of Arizona." He also discussed the new geologic map on the programs "Arizona Illustrated" and "Reflexiones" on KUAT-TV (Channel 6, PBS affiliate), which aired on November 7 and November 27, respectively. On November 4-6, Reynolds served as coleader of a Geological Society of America field trip, which was associated with the national meeting held in Denver, to examine the structural geology of southeastern Arizona. On December 1, he presented a talk, "Mesozoic Evolution of Western Arizona," to participants in the University of Arizona Department of Geosciences Colloquium series. On December 2, he gave a lecture to faculty and graduate students at the Massachusetts Institute of Technology (MIT) and Harvard University. Reynolds, an invited speaker whose expenses were paid by MIT, discussed "Fluids in Detachment Faults – Metasomatism, Mineralization, and Structural Aspects."

Denise M. Siewert joined the Arizona Geological Survey on December 5 as a clerk-typist. She formerly worked for Career and Placement Services at the University of Arizona. Born in Toledo, Ohio, she has lived in Tucson since 1961 and is working on an Associate in Applied Science - General Secretary degree at Pima Community College.

John W. Welty opened this year's University of Arizona Department of Geosciences Colloquium series with a presentation on August 25 titled "Geologic and Geotechnical Characteristics of the Arizona Superconducting Super Collider (SSC) Site." He also accompanied Governor Mofford and 18 other distinguished Arizonans to Washington, D.C. in early October to brief Secretary of Energy John Herrington on the attributes of the Arizona SSC site. At this briefing, the Governor unveiled a three-dimensional 1:18,000-scale model of the Arizona site; this model was presented to the people of Arizona at a public unveiling at the State Capitol in late October. In November, Welty presented an invited paper at the 100th annual meeting of the Geological Society of America (GSA) in Denver. The paper, "Superconducting Super Collider (SSC) Site Selection in Arizona," was given at a symposium titled "The Role of Geology in the Superconducting Super Collider Site-Selection Process." An abstract for the talk was printed in GSA Abstracts with Programs.

USGS and BOM Open Joint Field Office in Tucson

On April 26, 1988, the U.S. Department of the Interior announced the establishment of a joint mineral field office in Tucson. The purpose of the new office is to coordinate U.S. Geological Survey (USGS) and U.S. Bureau of Mines (BOM) mineral-resource research, assessment, and informational activities with other Federal, State, and local agencies in the southwestern United States. The major plans and activities of the USGS and BOM center around minerals and mining. The new field office will provide ready access to people and information about the programs of these two agencies.

USGS Field Office

by Fred S. Fisher
U.S. Geological Survey
Corbett Building
210 E. 7th St.
Tucson, AZ 85705

The purpose of the USGS field office is to (1) establish closer communication with State and local governments, industry, and other Federal agencies with interests in the resources of the Southwest; (2) develop and maintain a digital mineral-resource information base for the Southwest; and (3) improve the areal expertise of the USGS in mineral resources through detailed studies of the region's mineral deposits and mining districts. The operational area of the USGS field office includes western Texas, southern New Mexico, Arizona, and southeastern California. It is anticipated that responsibilities will be addressed by approximately 20 scientists from the USGS. These persons will form a multidisciplinary team of geologists, geochemists, geophysicists, and computer specialists. They and their support personnel will operate out of offices on the fourth floor of the Gould-Simpson Building on the University of Arizona campus and in the Corbett Building, 210 E. 7th St. (tel: 602-629-5500). Two of the USGS personnel will have offices with the Arizona Geological Survey, 845 N. Park Ave.

One of the goals of the USGS field office is to develop new techniques for predicting the presence of mineral deposits in areas beneath cover and to apply these techniques to mineral-resource assessment of such areas in the Southwest. The term *cover* means any material that conceals mineral deposits, including unconsolidated sediments, volcanic and sedimentary rocks, and rock materials that compose the upper plates of thrust and detachment faults. An important corollary of this goal is to encourage collaboration between the USGS and State geological surveys, universities, and the mining industry. These outside organizations can make major contributions to USGS mineral studies, especially during their early stages, when information concerning mines, prospects, surface geology, and drilling can be best used in formulating research strategy.

The framework of this research may be divided into three parts: (1) pre-field studies of the mineral-resource potential of the region, including compilation and interpretation of existing data and recommendations for the direction of subsequent research; (2) field and laboratory studies of mineral deposits and selected geologic terranes using geologic, geochemical, geophysical, and geostatistical techniques; and (3) mineral-resource assessment of the covered areas. These assessments will analyze the possibility of the presence of specific types of mineral deposits both within and beneath the cover.

Information from these studies will be published as USGS maps, bulletins, and professional papers and in outside journals. Maps in these publications will show geologic, geochemical, and geophysical data and will delineate the terranes that are favorable for the presence of mineral deposits in both exposed and covered areas. Because much of the information will be presented as maps, the USGS will be using Geographic Information Systems (GIS) for manipulation and interpretation of spatial data. Cooperative agreements are currently being established with State agencies and the University of Arizona for development of databases, topical research, and joint studies.

USGS Minerals Information Office

by Karen S. Bolm
USGS Minerals Information Office
Arizona Geological Survey
845 N. Park Ave., #100
Tucson, AZ 85719

The USGS, in conjunction with its Arizona Field Office and in cooperation with the Arizona Geological Survey (AZGS), has opened a Minerals Information Office (MIO) at the AZGS, 845 N. Park Ave., Tucson (tel: 602-882-4795; ext. 21). The MIO, a new endeavor of the USGS, will complement the services available from the AZGS and make the location a "one-stop shopping place" for mineral-resource information. The MIO is part of a network of four such offices. The others are the Washington, D.C. facility, which opened in June 1988, and the Reno, Nevada and Spokane, Washington offices, which will become operational during 1989.

The MIO staff can provide information about and access to USGS databases, commodity specialists, and publications for the benefit of the public, industry, and State and Federal officials. The office also seeks to improve the exchange of information among Federal agencies and other mineral-information users.

A computer system in the office can provide clients with responses to their questions while they wait. The USGS Resource Oriented Computer System (ROCS) permits retrieval of graphic and tabular data on mineral deposits throughout the world using the Mineral Resource Data System (MRDS). The database, which includes 70,000 records, contains information on political boundaries, administrative boundaries, and geology for selected areas, as well as a guide to selected USGS mineral research. These data may be accessed in ways designed to meet each user's specific needs. Paper copies of graphics display and tabular and textual information are also available.

The MIO also serves as a collector of data useful to USGS scientists. Data are compiled and digital files are acquired to enhance the breadth and depth of information available to government researchers. Sources of data include other State and Federal agencies, as well as private industry.

BOM Field Office

by Michael N. Greeley
U.S. Bureau of Mines
Corbett Building
210 E. 7th St.
Tucson, AZ 85705

The Tucson office of the BOM provides regional and local representation for the main office and contact with the mineral-producing industries, government agencies, and mineral-consuming public in Arizona, New Mexico, and Utah. It develops information that contributes to the formulation of mineral policies and BOM programs.

The establishment of the Tucson office is an attempt by the BOM to become more responsive to the needs of the local mineral community. The Southwest is one of the most productive mining areas in the Nation. In 1987 Arizona, New Mexico, and Utah produced more than $3.2 billion in nonfuel minerals, accounting for more than 12 percent of U.S. production. The region is also a major producer of fuel minerals. Arizona mines approximately 40 percent of the domestically produced uranium, ranking it number one in this commodity.

Because the population is rapidly increasing in the Southwest and mineral competitiveness is accelerating worldwide, the BOM recognizes the sensitivity of the mineral industry to local and far-flung concerns. Economic, environmental, educational, and technological issues must be quickly addressed and solutions obtained in a timely manner. The BOM plans to identify these issues and act as an effective source of information to all those interested.

Specific duties of the Tucson office staff include the following: (1) To provide a liaison between the BOM and top industry and State officials; (2) To interface with State and local mineral-related agencies, private companies, educational and research institutions, the media, and the public; (3) To author analytical assessments of various aspects of the mineral industry; (4) To monitor mineral-related activities of interest to the BOM and U.S. Department of the Interior; (5) To determine issues or concerns that impact the mineral industry and suggest means for their resolution; (6) To analyze and interpret data on mineral deposits and assess mineral potential; (7) To describe and delimit mineralized zones and develop probabilistic reserve and resource evaluations; (8) To estimate capital and operating costs for mining and metallurgical systems; and (9) To assist the community and speak for the BOM at conferences and meetings.

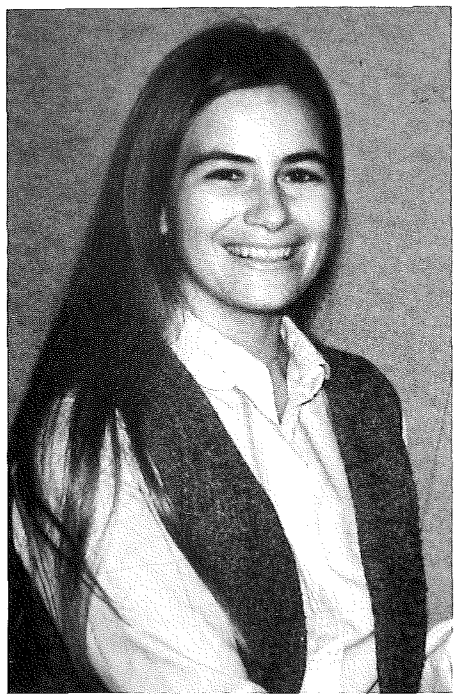
The phone number of the BOM, located in the Corbett Building, is (602) 629-5110. BOM staff include Michael N. Greeley (State Mineral Officer), Darwin K. Marjaniemi (Resource Evaluation Specialist), and Ellen C. Pearson (Program Assistant).

IN MEMORIAM

Cathy Schulten Wellendorf

The Arizona geological community lost a much loved and respected member with the passing of Cathy Schulten Wellendorf on December 23, 1988. Cathy was born in Louisville, Kentucky on February 3, 1956. She received her elementary education at Our Lady of Lourdes School and her secondary education at Sacred Heart Academy. In 1974 she entered the University of Dayton in Ohio and graduated in 1977 with a B.S. degree in geology. In April 1977, she received a graduate teaching assistantship at Arizona State University in Tempe and received an M.S. degree in geology in 1979. Her thesis was titled "Environmental Geology of the Tempe Quadrangle, Maricopa County, Arizona." She coauthored a report with the same title that was published by the Arizona Geological Survey as Folio Series GI-2.

In April 1980, Cathy began her $8^1/_2$-year-long career as an engineering geologist with the U.S. Bureau of Reclamation's (BOR) Arizona Projects Office in Phoenix. From 1980 to 1984, Cathy conducted geologic field studies for several features of the Salt-Gila and Tucson aqueducts and monitored the construction of the Salt-Gila aqueduct, reach 3, and the Gila River siphon. Starting in mid-1984, Cathy assumed the role of lead geologist for the Stewart Mountain Dam Modification Project. In this capacity, she directed all preconstruction geologic investigations and monitored the geologic and seepage conditions and rock-slope stability of the new auxiliary-spillway excavation. This project was described in the Winter 1986 issue (vol. 16, no. 4) of *Fieldnotes*.



Throughout her career with the BOR, Cathy planned and carried out numerous special studies and unique projects, including studies of earth fissures in the Apache Junction and Picacho areas, application of the terrestrial camera to geologic field mapping, and production of geologic maps using Computer Assisted Drafting (CAD). Cathy was a gifted geologist and was highly respected for her consistently excellent work, her thoroughness, and her clarity of thought and presentation. She loved a challenge and had an amazing ability to plan, organize, and execute each project.

Cathy was a giving person and was always eager to share with her coworkers and other professionals. She was a member of the Association of Engineering Geologists and the Geological Society of America (GSA). She led or contributed to field trips conducted by the American Institute of Professional Geologists (AIPG) and Friends of the Pleistocene (FOP), gave talks to students and professionals at Arizona State University, Northern Arizona University, and the Salt River Project, provided articles to *Fieldnotes*, and participated in the poster session at the 1987 annual meeting of the GSA.

Most of all, Cathy was a loving person who appreciated others and brought out the best in them. She brought a sense of joy and humor to the office, to a drill rig, and to a construction site. She was a remarkable woman whose life enriched the lives of all who knew her.

Cathy is survived by her husband, William, of Phoenix; parents, Mr. and Mrs. Robert H. Schulten, of Louisville, Kentucky; sisters, Tracy Plunkett of Tucson, Martha Martin of Louisville, and Sara Schulten of Atlanta, Georgia; and brother, Robert Schulten, Jr., of Bowling Green, Kentucky.

In her memory, Cathy's family has established the Cathy Wellendorf Memorial Fund with the Arizona Geological Survey. This fund will be used to support projects and activities in the areas of engineering and environmental geology. Remembrances may be made to the Cathy Wellendorf Memorial Fund, Arizona Geological Survey, 845 N. Park Ave., Suite 100, Tucson, AZ 85719; attn: Larry D. Fellows.

Applied Geoscience: Mapping Surficial Deposits

by Philip A. Pearthree
Arizona Geological Survey

The Arizona Geological Survey (AZGS) is enhancing the understanding of the geologic framework of the State by mapping the geologically young surficial deposits. Most residents of the State live in the basins of central and southern Arizona; these are also the areas of most rapid growth. Basins are mainly composed of young deposits, some of which may foster certain geologic hazards or limitations; for example, areas that are likely to be affected by flooding can be defined by mapping the distribution of surficial deposits of different ages. Maps of surficial deposits can also be used to outline areas where geologic resources may be present. Knowledge of surficial geology is, therefore, critical to the wise use and development of basin areas in the State.

Most surficial deposits in Arizona are of fluvial origin, although playa or lacustrine deposits and eolian deposits are locally important. Fluvial deposits are present as active stream channels, stream terraces, and alluvial fans. Basin areas are typically composed of materials that were deposited from as recently as yesterday to several million years ago. From aerial photographs and field work, one can differentiate deposits by relative age on the basis of topographic position, surface characteristics, and soil development. Areas that have been active most recently are the most likely to be affected by flooding. Correlation between surface ages and soil properties can aid in understanding potential geologic limitations, such as foundation problems, that are related to the material properties of surficial deposits.

Efforts to map surficial deposits have been focused in the Phoenix and Tucson metropolitan areas, where the pressure of development is the greatest. Mapping in urban and urban-fringe areas around Phoenix and Tucson is being conducted at 1:24,000 scale (1 inch equals 2,000 feet), with fairly intensive field work. The objective of this mapping is to provide a detailed geologic database for use by geologists, engineers, and others involved in land-use planning or assessment of geologic hazards and limitations. Surficial-geology maps of twelve 7 $^{1}/_{2}$′ quadrangles in the Tucson area have recently been released as AZGS Open-File Report 88-18 (see "New Publications from the Arizona Geological Survey" on page 11); maps of seven additional quadrangles are in progress (Figure 1). Similar mapping efforts will begin in the western portion of the Phoenix metropolitan area in spring 1989.

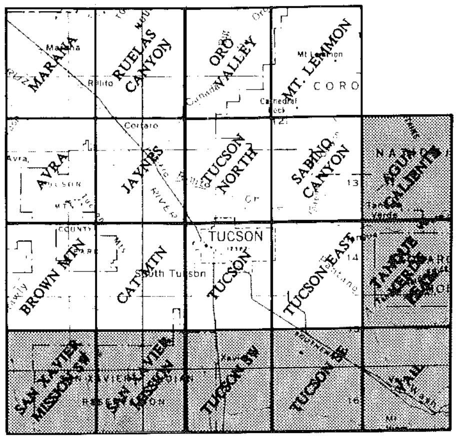


Figure 1. Outline map of 7 $^{1}/_{2}$′ quadrangles in Tucson area. Surficial-geology maps of 12 unshaded quads have been completed and are available from the AZGS; 7 shaded quads are currently being mapped.

The entire Phoenix 1° x 2° quadrangle is being mapped at 1:100,000 scale through the use of aerial photographs and field reconnaissance. The objectives of this mapping are to define the distribution of surficial units of different ages and to improve the understanding of the late Cenozoic evolution of basin areas. Partial funding for this work has been provided by the U.S. Geological Survey as part of the Cooperative Geologic Mapping Program. Maps of the two northern quarters (Salome and Phoenix North quadrangles) have been released as AZGS Open-File Reports 88-4 and 88-17, respectively (see page 11). A 1:250,000-scale map of the surficial deposits of the Tucson 1° x 2° quadrangle is available as AZGS Open-File Report 88-21 (see page 11).

Earth Fissures Discovered Near CAP Canals

Soil collapse, surficial drainage, and earth fissures related to ground-water withdrawal threatened main and subsidiary canals of the Central Arizona Project (CAP) in several locations during the summer and fall of 1988. The above photograph shows an earth fissure that developed adjacent to the CAP canal near Marana High School in northern Avra Valley, northwest of Tucson. The fissure, discovered after a moderately intense rainfall in mid-October, measured up to 16 feet wide and 12 feet deep and could be traced for more than 750 feet. It was most pronounced where water ponded immediately upslope of the earthen embankment built to divert surface runoff away from the CAP canal. A smaller fissure (covered with white plastic in the photo) extended through the diversion embankment to the north side of the canal. (The canal is behind the embankment.) The U.S. Bureau of Reclamation (BOR), the agency responsible for construction of the CAP, had anticipated the potential development of earth fissures in this area by building the canal with steel reinforcement and rubber water-retention structures within the concrete. Although the canal was damaged slightly by the earth fissure, water did not drain from it. The BOR filled the earth fissure with a slurry of bentonite, concrete, and soil in late October. An article about subsidence and earth fissures was published in the Spring 1987 issue of *Fieldnotes* (the former name of *Arizona Geology*). The Arizona Geological Survey is cooperating with the BOR and the Arizona Department of Transportation in a study on the development of earth fissures in the Picacho basin. This study will be summarized in a future issue. Photo by Steve Slaff.

New Publications From the Arizona Geological Survey

The following publications may be purchased over the counter or by mail from the Arizona Geological Survey (AZGS), 845 N. Park Ave., #100, Tucson, AZ 85719. For price information on these and other AZGS publications, contact the AZGS offices at (602) 882-4795.

Demsey, K.A., 1988, Geologic map of Quaternary and upper Tertiary alluvium in the Phoenix North 30' x 60' quadrangle, Arizona: Open-File Report 88-17, scale 1:100,000.

See "Applied Geoscience: Mapping Surficial Deposits" on page 10.

McKittrick, M.A., 1988, Surficial geologic maps of the Tucson metropolitan area: Open-File Report 88-18, 7 p., scale 1:24,000, 12 sheets.

The following 7 $^{1}/_{2}$-minute quadrangle maps, which may also be purchased separately, are included in this open-file report: 1-Avra; 2-Brown Mountain; 3-Cat Mountain; 4-Jaynes; 5-Marana; 6-Mt. Lemmon; 7-Oro Valley; 8-Ruelas Canyon; 9-Sabino Canyon; 10-Tucson; 11-Tucson East; 12-Tucson North. For further information, see "Applied Geoscience: Mapping Surficial Deposits" on page 10.

Chenoweth, W.L., 1988, The geology and production history of the uranium-vanadium deposits in the Lukachukai Mountains, Apache County, Arizona: Open-File Report 88-19, 64 p.

Uranium-vanadium deposits were mined for nearly two decades in the Lukachukai Mountains, a high rugged spur of the Chuska Mountains on the Navajo Indian Reservation in northeastern Arizona. All of the economic deposits were in the Salt Wash Member of the Jurassic Morrison Formation, in a well-defined belt that trends north-south across the southeast end of the range. This belt accounts for 99.6 percent of the total production and includes an area of 6.5 square miles.

Due to the remoteness of the mountains, the deposits were not discovered until 1949. Because this was a new district in the Salt Wash, the U.S. Atomic Energy Commission was interested in developing the uranium resources of the area. Mining commenced in early 1950 and continued until 1968. During this 19-year period, 53 mines produced 324,754 tons of ore that averaged 0.24 percent U_3O_8 and 1.02 percent V_2O_5 and contained 3.5 million pounds of U_3O_8 and 14.7 million pounds of V_2O_5.

Brooks, S.J., 1988, Potential land surface subsidence at the Arizona Superconducting Super Collider (SSC) site; considering past, current and possible future ground-water withdrawal: Open-File Report 88-20, 28 p.

The search for a suitable site for the SSC, the racetrack-shaped particle accelerator to be built by the U.S. Department of Energy, generated a proliferation of technical reports, including this one. Because particle-beam stability is required for successful collider experimentation, the structural stability of the underlying material is vital. Approximately 36 miles of the proposed alignment at the Maricopa site in Arizona would have been cut through alluvium, and about 25 of these miles would have been through thick alluvial deposits with large ground-water reserves. Subsidence of this type of material due to ground-water withdrawal is well-documented in southern Arizona.

To evaluate the potential for subsidence at the proposed SSC site, the author calculated the maximum previous water-table decline, estimated future decline during the lifetime of the project, and determined if the total decline would exceed 100 feet, an amount thought to be large enough to cause noticeable subsidence. The available geologic and hydrologic information suggested that subsidence would not be a problem at the Maricopa site.

Pearthree, P.A., McKittrick, M.A., Jackson, G.W., and Demsey, K.A., 1988, Late Cenozoic surficial deposits of the Tucson 1° x 2° quadrangle: Open-File Report 88-21, scale 1:250,000.

See "Applied Geoscience: Mapping Surficial Deposits" on page 10.

Welty, J.W., 1988, Additions to bibliographies for metallic mineral districts in Cochise, Graham, Greenlee, La Paz, Mohave, Pima, Santa Cruz, and Yuma Counties, Arizona: Open-File Report 88-22, 32 p.

This report is an update to Circulars 24, 25, and 26, which were published by the AZGS in 1986. The mineral-district classification used in these circulars and in this open-file update groups mineral deposits according to geologic and metallogenic criteria rather than the geographic associations used in the traditional mining-district classification. More than 150 new citations are included in this open-file report.

New Publications List Available

The Arizona Geological Survey has issued a new publications list, which includes 19 publications that were not mentioned in the previous version. To obtain a free copy, contact the AZGS at 845 N. Park Ave., Suite 100, Tucson, AZ 85719; tel: (602) 882-4795.

Gold Placers Bulletin Reprinted

Bulletin 168, **Gold Placers and Placering in Arizona,** was out-of-print for almost 2 years, during which time photocopies were distributed. Originally published in 1961, it was one of the AZGS's best-selling publications. Because of its continuing popularity, it has been reprinted. To obtain a copy, send $10.25 ($8.00, plus $2.25 shipping and handling) to the Arizona Geological Survey, 845 N. Park Ave., Suite 100, Tucson, AZ 85719. Payment should be made by check or money order payable to the Arizona Geological Survey.

Publications From Other Agencies

The Arizona Department of Mines and Mineral Resources (ADMMR) has several new publications. **Directory of Active Mines in Arizona--1988** (14 p.) and **Active Mines in Arizona--1988** (scale 1:1,000,000) may be purchased together for $5.00 or separately for $3.50 each. **Exploration Offices--1988** (18 p.) is available for $3.50. **Laws and Regulations Governing Mineral Rights in Arizona** (9th ed.) has been reprinted and may be purchased for $6.50. All of the prices listed above include shipping and handling fees. A free publications list is available upon request. The ADMMR has two offices: Mineral Building, Fairgrounds, Phoenix, AZ 85007; tel: (602) 255-3791; and 416 W. Congress, Suite 190, Tucson, AZ 85701; tel: (602) 628-5399.

A free publications list is also available from the Oil and Gas Conservation Commission, 3110 N. 19th Ave., Suite 190, Phoenix, AZ 85015; tel: (602) 255-5161. Their most recent publication, **Electric Log Stratigraphic Section, T. 42 N., R. 18 E. to T. 41 N., R. 30 E., Four-Corners Area, Arizona,** released in 1987, may be purchased for $4.00, including postage and handling.

Depository Library Network Established

The Arizona Department of Library, Archives, and Public Records (State Library) and the Arizona Geological Survey (AZGS) have initiated a cooperative program to make AZGS publications more accessible to Arizonans by establishing a series of 14 depository libraries throughout the State (Figure 1). New AZGS publications (Bulletin, Circular, Special Paper, and Map series) are provided to the State Library, which distributes them to the member depositories. Reports and maps in the Open-File Report and Miscellaneous Map series are not included, but may be examined or purchased at the AZGS office. Janet L. Fisher and Dale J. Steele of the Documents and Maps Section (State Library) and Larry D. Fellows, State Geologist (AZGS), planned and organized the project. For further information, contact either Fisher (542-4121) or Fellows (882-4795).

The following depository libraries are shown on the index map (Figure 1).

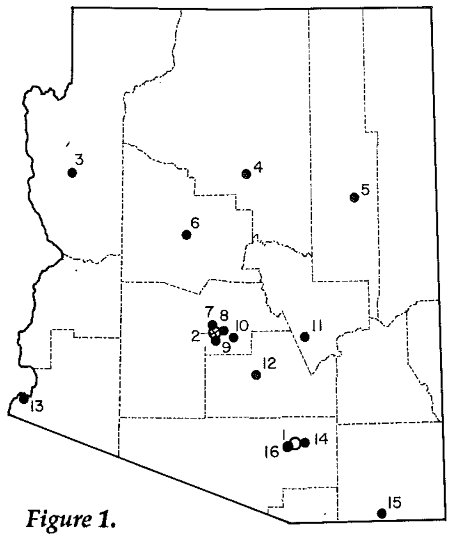


Figure 1.

1. Arizona Geological Survey
   845 N. Park Ave., Suite 100
   Tucson, AZ 85719
2. Arizona Dept. of Library, Archives, and Public Records
   1700 W. Washington, State Capitol
   Phoenix, AZ 85007
3. Mohave Community College
   District Resource Center
   1971 Jagerson Ave.
   Kingman, AZ 86401
4. Northern Arizona University Library
   Government Documents Collection
   P.O. Box 6022
   Flagstaff, AZ 86011
5. Northland Pioneer College
   Learning Resources Center
   1200 E. Hermosa Dr.
   Holbrook, AZ 86025
6. Yavapai College
   Learning Resource Center
   1100 E. Sheldon St.
   Prescott, AZ 86301
7. Glendale Public Library
   7010 N. 58th Ave.
   Glendale, AZ 85301
8. Phoenix Public Library
   Business and Sciences Division
   12 E. McDowell Rd.
   Phoenix, AZ 85004
9. Arizona State University Main Library
   Government Documents Service
   Tempe, AZ 85287
10. Mesa Public Library
    64 E. 1st St.
    Mesa, AZ 85201
11. Miami Memorial–Gila County Library
    1052 Adonis Ave.
    Miami, AZ 85539
12. Central Arizona College
    Signal Peak Campus
    Learning Resource Center
    Woodruff at Overfield Rd.
    Coolidge, AZ 85226
13. Yuma City-County Library
    350 Third Ave.
    Yuma, AZ 85364
14. University of Arizona Main Library
    Government Documents Section
    Tucson, AZ 85721
15. Cochise County Library
    Bisbee, AZ 85603
16. Tucson Public Library
    200 S. 6th Ave.
    Tucson, AZ 85701

AZGS Has New Phone Number

The phone number of the Arizona Geological Survey has been changed to (602) 882-4795. The AZGS address, however, has remained the same.

Arizona Geology

Vol. 18, No. 4 Winter 1988

State of Arizona: Governor Rose Mofford

Arizona Geological Survey

Director & State Geologist: Larry D. Fellows
Editor: Evelyn M. VandenDolder
Illustrators: Peter F. Corrao, Sherry F. Garner

Arizona Geological Survey
845 N. Park Ave., #100
Tucson, AZ 85719
TEL: (602) 882-4795