Arizona Bureau of Geology and Mineral Technology
FIELDNOTES
Vol. 15, No. 2 Summer 1985

The Nonfuel Mineral Industry of the Southwest:
1984 Summary

In 1984, the value of nonfuel mineral production in the Southwest reached $5.5 billion, a 2 percent increase from the 1983 value of $5.4 billion (Table 1). Production in the Southwest accounted for more than 24 percent of total output in the Nation, estimated to be $22.7 billion in 1984. For the purposes of this article, the Southwest includes Arizona, California, Colorado, Nevada, New Mexico, and Utah.

These preliminary figures were recently published by the U.S. Bureau of Mines, which has also released State-by-State estimates of nonfuel mineral production for 1984. Excerpts from the preliminary summaries for the southwestern States appear below. These Mineral Industry Surveys were prepared by State mineral specialists from the U.S. Bureau of Mines (USBM), in cooperation with the respective State mineral agencies. Lorraine B. Burgin, USBM State mineral specialist in Denver, compiled the Arizona summary, in cooperation with the Arizona Department of Mines and Mineral Resources. Ms. Burgin also provided assistance in compiling additional information for this article. For copies of the preliminary reports, please write to Mineral Industry Surveys, U.S. Department of the Interior, Bureau of Mines, Washington, DC 20241.

Arizona

The value of nonfuel mineral production in Arizona in 1984 was estimated at $1.4 billion, down 7.2 percent from 1983 (Table 2). Metals output dropped from $1.3 billion in 1983 to $1.2 billion in 1984. Despite this decline, Arizona still accounted for 25 percent of total nonfuel mineral production in the Southwest.

Arizona copper production continued to rank first in the Nation and to contribute nearly three-fourths of the State's nonfuel mineral production; however, declining copper prices and competition with foreign copper producers stalled recovery of the industry from the 1983 recession. Molybdenum, copper's principal coproduct/byproduct, suffered from low market demand and depressed prices.

Copper producers continued to deal with strikes, reduced work forces and schedules, and closures. Of 3 underground and 19 open-pit mines operating in 1981, only 1 underground and 9 surface properties were being mined by conventional methods in 1984; 1 underground and 4 surface mines shut down; and 7 properties suspended mining and reverted to leaching low-grade ores, stockpiles, or waste dumps.

Nonmetal production, in descending order of value, included portland cement, construction sand and gravel, crushed stone, and lime.

California

California was the leading State in the Nation in the production of nonfuel minerals for 1984. Value rose to an estimated $1.9 billion, an increase of 6.7 percent from that reported in 1983 (Table 1).

Industrial minerals played a major part in California's nonfuel mineral industry. Commodities in which California led the other States include rare-earth metal concentrates, tungsten concentrate, boron minerals, diatomite, sand and gravel, and portland cement.

Activity continued in the production of metallic minerals. Exploration for and development of low-grade, high-tonnage, open-pit gold deposits increased during the year, and the slowly improving tungsten market prompted the reopening of a tungsten mine and mill.

Front-page photo: *View of the Ray copper mine (Kennecott Copper Corp.), located about 20 kilometers south of Superior, Arizona. This currently active mine (as of April 1985) is within the Mineral Creek mineral district, which produced from 1905 to 1981 approximately 5.6 million pounds of copper; 12 million pounds of lead; 8 million pounds of molybdenum; 300,000 pounds of zinc; 9 million ounces of silver; and 60,000 ounces of gold. The Ray mine was recently visited by participants in the 21st Forum on the Geology of Industrial Minerals, held in Tucson April 9-12. Forum activities will be summarized in the next issue of* Fieldnotes.

Table 1. *Nonfuel mineral production, measured by mine shipments, sales, or marketable production (including consumption by producers). All figures are from the U.S. Bureau of Mines; totals for 1984 are preliminary estimates.*

State	Value (thousands) 1983	Value (thousands) 1984	Percent of Total Value in 1984 Southwest	Percent of Total Value in 1984 United States	Major Commodities
Arizona	$ 1,510,878	$ 1,402,321	25.5	6.2	portland cement, copper, molybdenum, construction sand and gravel, silver, crushed stone
California	1,764,401	1,882,402	34.2	8.3	boron minerals, portland cement, diatomite, construction sand and gravel, sodium carbonate, crushed stone
Colorado	337,652	422,066	7.7	1.9	portland cement, gold, molybdenum, construction sand and gravel, silver, crushed stone
Nevada	615,785	622,423	11.3	2.7	portland cement, diatomite, gold, lithium, molybdenum, silver
New Mexico	517,194	645,546	11.7	2.8	portland cement, copper, gold, molybdenum, potash, salt
Utah	656,579	525,258	9.6	2.3	portland cement, copper, gold, salt, construction sand and gravel, silver
SOUTHWEST	5,402,489	5,500,016	100.0	24.3	
U.S. TOTAL	21,134,000	22,672,000	—	100.0	

Table 2. *Nonfuel mineral production in Arizona. Production is measured by mine shipments, sales, or marketable production (including consumption by producers). All figures are from the U.S. Bureau of Mines; totals for 1984 are preliminary estimates.*

Mineral	Value (thousands of dollars) 1983	1984
Clays	1,425	886
Copper	1,144,285	1,044,483
Gem stones	2,800	2,800
Gold	26,284	W
Gypsum	1,929	2,411
Lead	69	W
Lime	16,700	19,716
Molybdenum	79,459	78,827
Pumice	15	18
Sand and gravel (construction)	75,000	74,500
Silver	51,383	33,557
Stone (crushed)	24,079	26,800
Other*	87,449	118,323
TOTAL	1,510,878	1,402,321

W Withheld to avoid disclosing company proprietary data; value included in "other" figure.

* Combined value of cement, perlite, pyrites, salt, industrial sand and gravel, tin (1984), and values indicated by symbol W.

Colorado

The value of nonfuel mineral production in Colorado in 1984 was estimated at $422.1 million (Table 1). This was an increase of 25 percent over the 1983 value, the first year-to-year increase in 4 years. The 1984 level of output, however, was just one-third of the State's peak level attained in 1980. Most of the upturn in output was the result of the reopening of two large molybdenum mines. The output of all other metals produced in the State also increased, except for lead and silver.

Gold-mining activity resulted in almost a 50-percent increase in output, despite lower prices. Silver output declined slightly in the face of considerably lower prices. Gold dredging occurred for the first time along the Arkansas River in eastern Colorado. Bankruptcy proceedings and changes in joint-venture partners highlighted the year for several of the State's largest gold producers.

Nevada

Nevada's nonfuel mineral production was valued at $622.4 million in 1984, an increase of 1 percent from that recorded in 1983 (Table 1). The State continued to lead the Nation in the production of barite, gold, and mercury, and was the sole producer of mined magnesite. Based on preliminary statistics, Nevada ranked 11th nationally in the value of its nonfuel mineral production. Barite mining remained at depressed levels throughout the year, owing to reduced demand for the commodity by the oil industry and to foreign competition.

New Mexico

The value of nonfuel mineral production in New Mexico in 1984, estimated to be $645.5 million, increased nearly 25 percent over the 1983 value (Table 1). Major commodities included portland cement, copper, gold, molybdenum, potash, and salt.

On October 22, the International Trade Commission ruled that potash imports from Israel (amounting to $41 million, or 7.5 percent of total potash imports) and Spain ($3 million, or 0.5 percent of the total) were not harming domestic producers. Partial shutdowns and layoffs at five of the seven remaining potash operations in New Mexico cut employment from nearly 3,000 to about 1,900. About 85 percent of the potash produced in the United States in 1984 was mined in Eddy County, New Mexico.

Utah

The value of nonfuel mineral production in Utah declined 20 percent in 1984 to $525.3 million (Table 1). Metal production fell to less than two-thirds of the total value of nonfuel mineral output because of low metal prices and the corresponding drop in copper, gold, molybdenum, silver, and vanadium production.

Traditionally, copper is Utah's most important nonfuel mineral. In 1984, however, output plummeted as one major company reduced production because of continuing losses and contract disputes.

The total value of nonmetals production also declined because of decreases in the output of gypsum, lime, phosphate rock, potassium salts, and dimension stone. In descending order of value, the leading commodities in the group were estimated to be portland cement, salt, construction sand and gravel, gilsonite, lime, potassium salts, and phosphate rock.

A FLUORITE-BEARING GRANITE
Belmont Mountains, Central Arizona

by Stephen J. Reynolds [1], Elizabeth A. Scot [2], and Robert T. O'Haire [3]

Recent geologic mapping of the Belmont and Bighorn Mountains in central Arizona (Figure 1) has resulted in the recognition of a granite that locally contains fluorite, a calcium-fluoride mineral (CaF_2) that is rare in granitic rocks in the State. The existence of this fluorite-bearing granite has not, to our knowledge, been previously described in the published literature. The presence of this granite has implications for the geologic history and mineral potential of the Belmont Mountains and surrounding area.

Geologists from the Arizona Bureau of Geology and Mineral Technology are revising the present geologic map of Arizona that was published in 1969, but was largely based on reconnaissance mapping done before 1960. As part of the Geologic Map Revision Project, the Bureau entered into a cooperative geologic mapping agreement (COGEOMAP) with the U.S. Geological Survey (USGS).* Funding of COGEOMAP activities is evenly shared by the Bureau and USGS. Under the auspices of COGEOMAP, Bureau geologists mapped the Bighorn and Belmont Mountains earlier this year. The geology of neither range had previously been mapped, except in a reconnaissance manner (Wilson and others, 1957). Geologic mapping for the present project was done on 1:24,000- and 1:50,000-scale topographic base maps and 1:24,000-scale color aerial photographs that the U.S. Bureau of Land Management contributed. The mapping, presently being compiled, will be published at scales of 1:24,000 and 1:50,000 and will be accompanied by detailed discussions of the geology and mineral deposits of both ranges.

The geology of the Belmont Mountains is shown on the present geologic map of Arizona (Wilson and others, 1969) as being composed of Precambrian granite with lesser amounts of Pre-

[1] Geologist, Geological Survey Branch, Arizona Bureau of Geology and Mineral Technology
[2] Geologist
[3] Mineralogist, Mineral Technology Branch, Arizona Bureau of Geology and Mineral Technology

* See *Fieldnotes*, vol. 15, no. 1, p. 4–5.

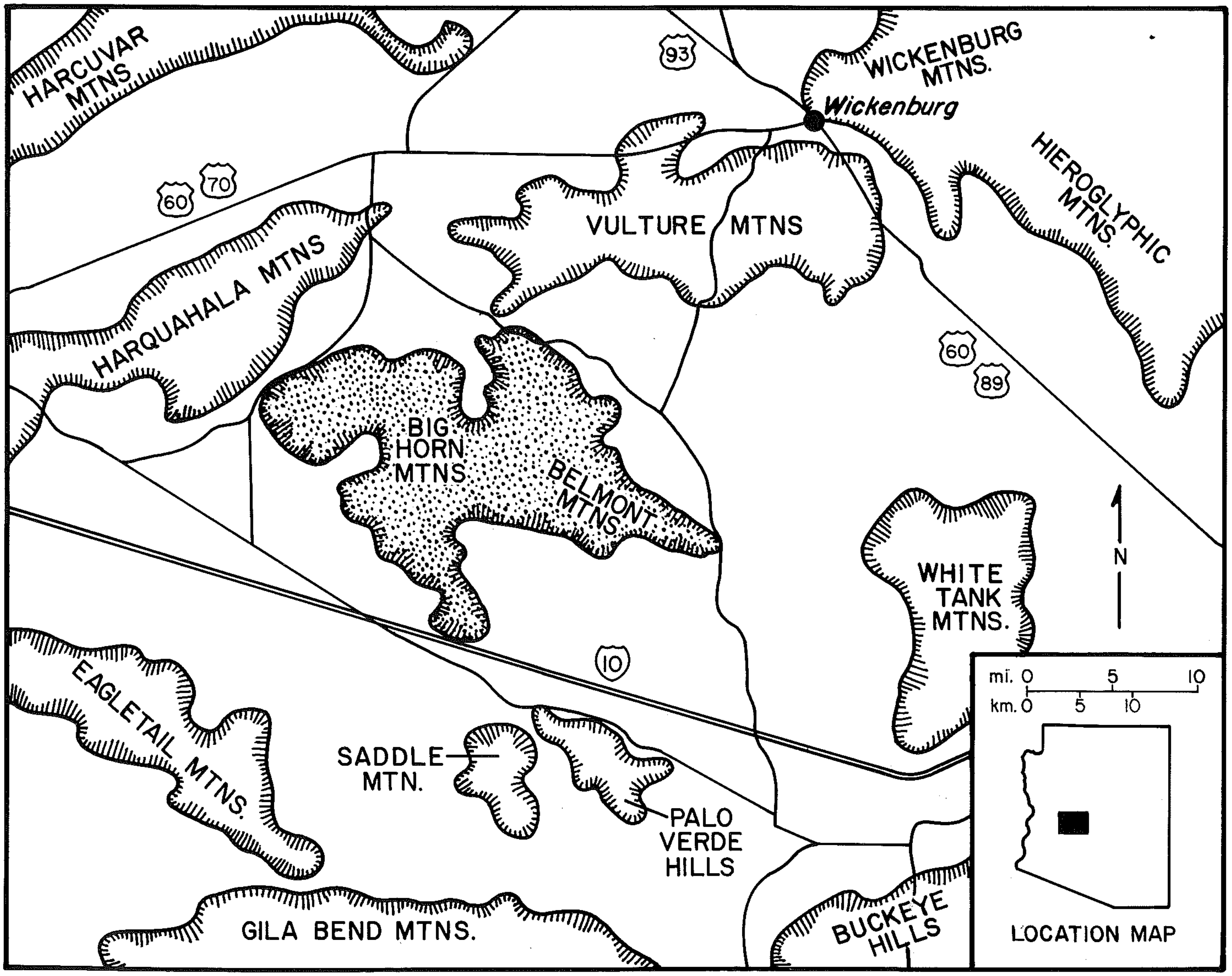

Figure 1. Map showing the location of the Belmont and Bighorn Mountains.

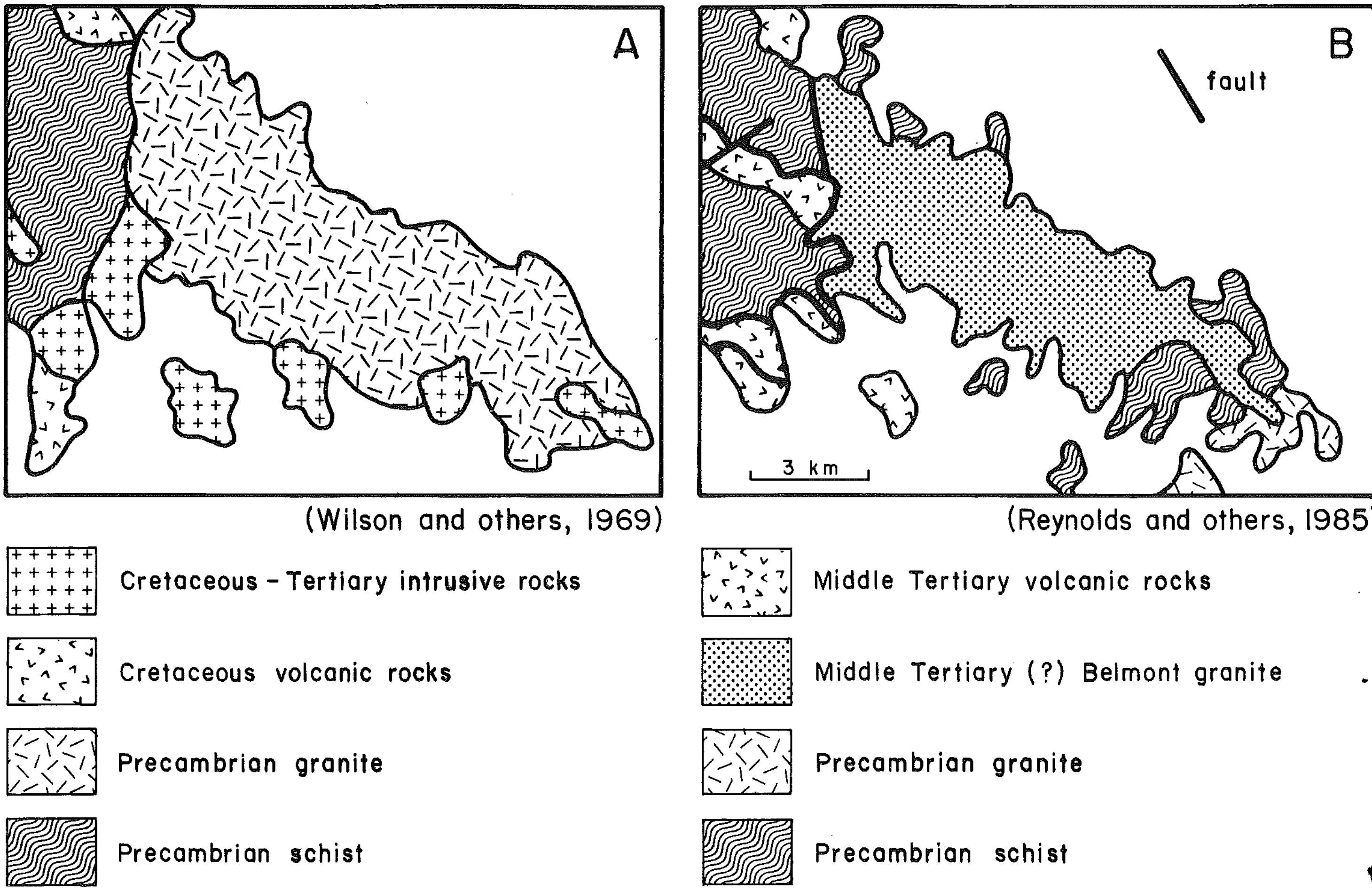

Figure 2. *Geologic maps of the Belmont Mountains. Maps illustrate the evolution in understanding the area's geology from Wilson and others (1969) to Reynolds and others (1985; this study).*

Figure 3. *Photograph of miarolitic cavity in the Belmont Granite.*

cambrian schist and Cretaceous volcanics and intrusions (Figure 2a). As a result of our more detailed mapping (Figure 2b), we have reinterpreted the "Cretaceous" volcanic and intrusive rocks as being middle Tertiary in age. In addition, most of the area shown on previous maps as Precambrian granite is composed of the fluorite-bearing granite, which we interpret as middle Tertiary, rather than Precambrian in age.

The fluorite-bearing granite occurs as a large mass that forms most of the high crest of the Belmont Mountains (Figure 2b). It is a very light-colored rock because of a pronounced lack of dark minerals, except for a small amount of biotite and magnetite. The granite varies in texture from a typical, medium-grained granite to a very fine-grained granite with scattered, larger crystals of quartz. Unlike most granites in Arizona, it contains miarolitic cavities (Figure 3), which are small, crystal-lined voids that represent pockets of water-rich fluid and vapor that formed late in the crystallization history of the granitic magma. The presence of such cavities indicates that the granite crystallized from a magma at a very shallow depth, probably within several kilometers of the surface. The miarolitic cavities are lined with well-formed crystals of quartz and feldspar (Figure 3), and lesser amounts of muscovite, biotite, purple fluorite, epidote, and other minerals.

Granites that contain fluorite are apparently rare in Arizona. No fluorite-bearing granite is identified in the book *Mineralogy of Arizona* (Anthony and others, 1977), although fluorite is described in some pegmatites. Fluorite is present in the Dells Granite near Prescott and the Lawler Peak Granite near Bagdad (Silver and others, 1980). In addition to containing fluorite, both of these granites are anomalously rich in rubidium, uranium, thorium, and other lithophile elements (elements that are concen-

Table 1. Chemical composition of Belmont granite and selected granites. Data are from Silver and others (1980;Dells), Creasey (1984;Schultze), Nockolds (1954; Average Granite oxides), Turekian and Wedepohl (1961; Average Granite trace elements), and S. J. Reynolds (unpublished data; Belmont and South Mountains).

	Belmont	Average Granite	Dells	Schultze	South Mountains
MAJOR OXIDES (Weight Percentages)					
SiO_2	74.7	72.1	75.6	70.89	73.8
TiO_2	0.12	0.37	0.03	0.25	0.15
Al_2O_3	12.0	13.9	13.1	16.1	13.9
FeO	0.39	1.67	0.32	0.46	—
Fe_2O_3	0.96	0.86	0.46	1.12	1.36
MnO	0.05	0.06	0.03	0.03	0.05
MgO	0.05	0.52	0.05	0.55	0.35
CaO	0.46	1.33	0.62	2.01	1.19
Na_2O	4.06	3.08	4.14	4.67	4.31
K_2O	5.05	5.46	4.53	3.58	4.13
P_2O_5	0.05	0.18	<0.01	0.12	0.11
H_2O	0.25*	0.53	0.52	0.35	0.15*
TRACE ELEMENTS (parts per million)					
Ba	<15	420	25	1010	—
F	630	520	—	—	—
Li	16	24	—	—	—
Mo	2	1	—	—	—
Nb	42	20	77	—	21
Rb	259	110	294	106	95
Sn	4	1.5	—	—	—
Sr	23	440	11	635	262
W	4	1.3	—	—	—
Y	27	35	111	—	9
Zr	109	140	107	120	73

* Loss on ignition

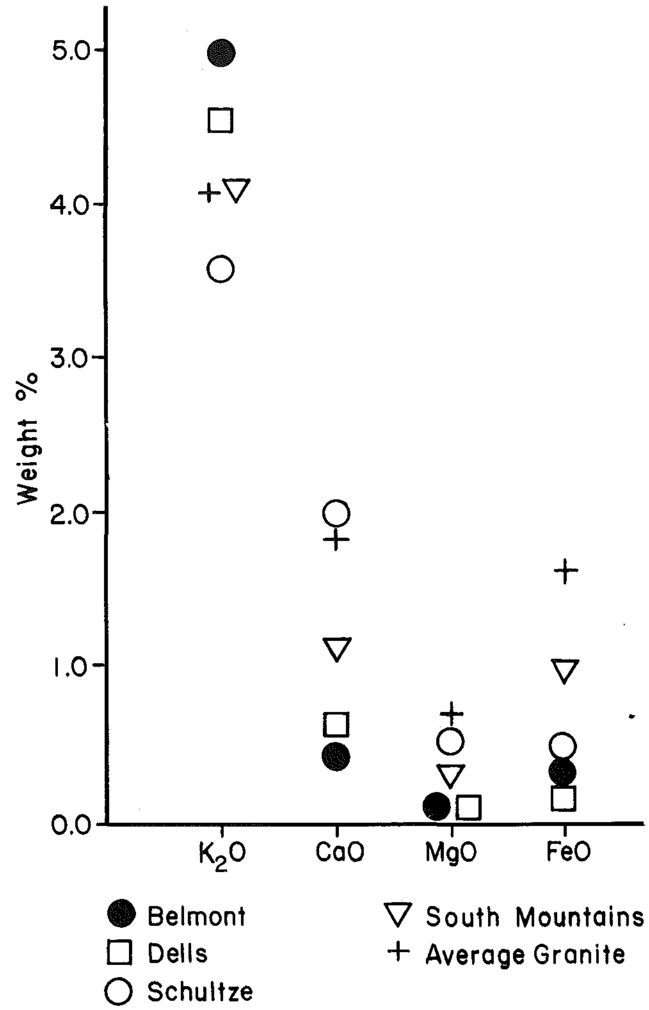

Figure 4. Plot comparing compositions of the major-element oxides of the Belmont Granite with those of other granites. See Table 1 for data and references.

trated in the Earth's silicate crust). Recognizing that the presence of fluorite in a granite could indicate a high potential for mineralization of elements such as molybdenum, beryllium, and tin, we have analyzed the chemical composition of one phase of the Belmont granite (Table 1). The chemical analyses confirm that the granite is very different in overall chemical composition from most other granites in Arizona, except the Dells Granite (Figure 4). The Belmont granite contains much less magnesium, iron, and calcium than most other granites in Arizona, but is slightly enriched in elements, such as rubidium and niobium, that are abundant in granites associated with molybdenum and tin mineralization.

Although the Belmont granite itself is generally fresh and unaffected by significant mineralization, some important occurrences of precious- and base-metal mineralization in the Belmont and Bighorn Mountains are accompanied by fluorite, as well as quartz, calcite, and barite. Much of this mineralization is related to middle Tertiary volcanism and faulting (George Allen, 1985, personal communication). If the Belmont granite is middle Tertiary, as we presently interpret based on field relationships, then the granite may represent a magma chamber that was a source of middle Tertiary volcanics and mineralizing fluids.

It is important to note that the Belmont granite has probably been tilted about 40° to the northeast by middle Tertiary faulting. If this interpretation is correct, the Belmont Mountains contain an exposure of a large, middle Tertiary, fluorite-rich, granitic magma chamber that is lying on its side.

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Turekian, K. K., and Wedepohl, K. H., 1961, Distribution of the elements in some major units of the earth's crust: Geological Society of America Bulletin, v. 72, p. 175 – 192.

Wilson, E. D., Moore, R. T., and Cooper, J. R., 1969, Geologic map of Arizona: Arizona Bureau of Mines and U.S. Geological Survey, scale 1:500,000.

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Study of the Basin and Range Province Completed

by Larry D. Fellows

**State Geologist and Assistant Director
Arizona Bureau of Geology
and Mineral Technology**

Solid and liquid wastes, especially those that are hazardous, toxic, or radioactive, must be disposed of with extreme caution. This is particularly true of radioactive waste, some components of which require thousands of years to decay. All areas are not equally suited for waste repositories because geologic and hydrologic conditions differ from one area to another. It is important, therefore, to evaluate the geologic and hydrologic characteristics and their interactions to locate a setting in which radionuclides will be effectively isolated from human access.

With these considerations in mind, the U.S. Geological Survey (USGS) initiated a pilot project in 1981 to compile and evaluate existing geologic and hydrologic data in the Basin and Range Province (Figure 1). The purpose of this project was to identify large areas (several thousand to tens of thousands of square miles) that meet predetermined criteria for storage of high-level radioactive waste in deep-mined repositories. Smaller portions of these areas could then be studied in detail at a later date. An important objective of the project was to assemble all available published and unpublished geologic and hydrologic data and make them available to those who make land-management decisions.

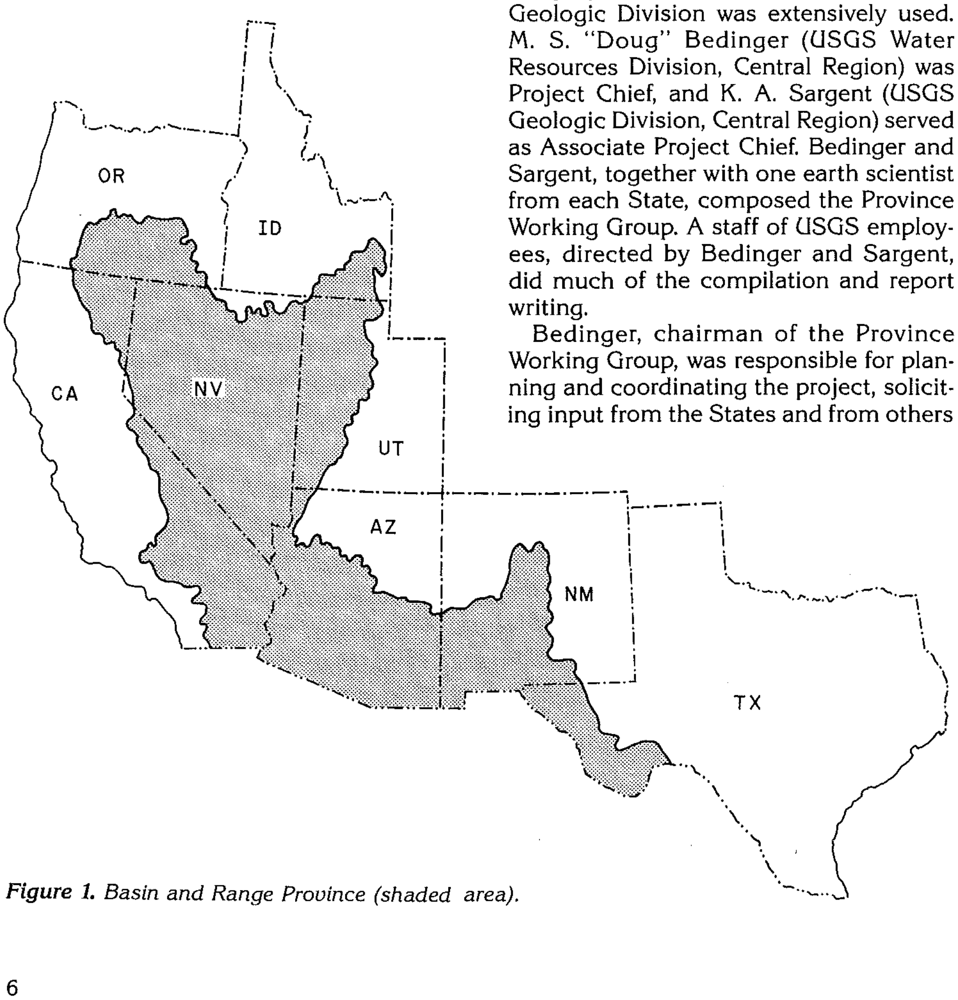

Figure 1. Basin and Range Province (shaded area).

In May 1981 the project was announced to the Governors of the States in the Basin and Range Province. Each Governor was asked to participate by nominating an earth scientist to represent the State on the Province Working Group, composed of State and USGS representatives. The States of Arizona, California, Idaho, Nevada, New Mexico, Texas, and Utah participated. One representative from each State geological survey was nominated by that State's Governor to serve on the Province Working Group, except in Idaho, where a Department of Water Resources representative was asked to serve.

The USGS Water Resources Division was assigned the lead responsibility for the project, although expertise from the Geologic Division was extensively used. M. S. "Doug" Bedinger (USGS Water Resources Division, Central Region) was Project Chief, and K. A. Sargent (USGS Geologic Division, Central Region) served as Associate Project Chief. Bedinger and Sargent, together with one earth scientist from each State, composed the Province Working Group. A staff of USGS employees, directed by Bedinger and Sargent, did much of the compilation and report writing.

Bedinger, chairman of the Province Working Group, was responsible for planning and coordinating the project, soliciting input from the States and from others within the USGS, reviewing progress, keeping the project on schedule, and preparing maps and reports. The State representatives were asked to provide input at all stages: to write and review maps and reports; to ensure that all available geologic and hydrologic data and maps were incorporated and accurately depicted; to share geologic and hydrologic knowledge of areas within their States; and to serve as liaisons between their Governors and other State agencies.

Arizona's participation in the project involved interagency cooperation. Larry D. Fellows, State Geologist and Assistant Director, Arizona Bureau of Geology and Mineral Technology, represented Arizona on the Province Working Group. H. Wesley Peirce, also of the Bureau, served as his alternate, and Robert B. Scarborough of the Bureau assembled most of the geologic data and prepared reports. Terry M. Turner, Arizona Department of Water Resources, reviewed the hydrologic data, maps, and reports. Charles F. Tedford, Executive Director of the Radiation Regulatory Agency, monitored progress of the project, which was periodically reviewed by George Britton, Executive Assistant to Governor Bruce Babbitt.

The project, "Geologic and Hydrologic Characterization and Evaluation of the Basin and Range Province Relative to the Disposal of High-Level Radioactive Waste," included descriptions of (1) potential host-rock types (granite, basalt, shale, etc.); (2) regional ground-water flow systems and related data (depth to water, water use, water quality, and recharge areas); (3) tectonic stability (young faults, historic seismicity, and volcanic activity); (4) mineral and energy resources (metals, nonmetals, coal, oil, and gas); and (5) other provincewide data (geothermal heat flow, uplift, subsidence, and Ice Age lakes). The project was completed September 30, 1984.

USGS and State geological survey geologists were involved in all phases of the project. The USGS provided expertise many State geological surveys do not have, such as staff persons who are familiar with radionuclide migration, Nuclear Regulatory Commission regulations, and the methods used by other countries to dispose of radioactive waste. State personnel, in turn, provided valuable information about published and unpublished maps and reports, specific areas within their respective States, and locations of drill holes.

(text continued on page 12)

Table 1. *Maps and reports prepared as part of the geologic and hydrologic characterization of the Basin and Range Province. Items listed are of provincewide scope or involve only Arizona. Copies may be obtained from the respective offices.*

U.S. Geological Survey

Circulars and Professional Papers: Eastern Distribution Branch, Text Products Section, U.S. Geological Survey, 604 S. Pickett St., Alexandria, VA 22304.

Maps: Western Distribution Branch, U.S. Geological Survey, Box 25286, Federal Center, Denver, CO 80225.

Open-File Reports and Water-Resources Investigations: Open-File Services Section, Western Distribution Branch, U.S. Geological Survey, Box 25425, Federal Center, Denver, CO 80225.

Arizona Bureau of Geology and Mineral Technology, 845 N. Park Ave., Tucson, AZ 85716.

U.S. Geological Survey

Circular 904
Geologic and hydrologic characterization and evaluation of the Basin and Range Province relative to the disposal of high-level radioactive waste:

904-A Bedinger, M. S., Sargent, K. A., and Reed, J. E., 1984, Part I, Introduction and guidelines, 16 p., 6 illus.

904-B Sargent, K. A., and Bedinger, M. S., (in preparation), Part II, Geologic and hydrologic characterization, 80 p., 22 illus.

904-C Bedinger, M. S., Sargent, K. A., and Brady, B. T., (in preparation), Part III, Geologic and hydrologic evaluation, 78 p., 14 illus.

Map I-1522
Selected geologic and hydrologic characteristics of the Basin and Range Province, western United States:

I-1522-D Williams, T. R., and Bedinger, M. S., 1984, Pleistocene lakes and marshes, scale 1:2,500,000. Also available as USGS Open-File Report 83-751.

I-1522-E Brady, B. T., 1984, Coal, oil and gas wells, seeps and tar sandstone occurrences, scale 1:2,500,000. Also available as USGS Open-File Report 83-549.

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82-500 Hildenbrand, T. G., and Kucks, R. P., 1982, A description of colored gravity maps of the Basin and Range Province, southwestern United States, 18 p.

82-579 Nakata, J. K., Wentworth, C. M., and Machette, M. N., 1982, Quaternary fault map of the Basin and Range and Rio Grande rift provinces, western United States, scale 1:2,500,000, 2 sheets.

83-86 Askew, B. L., and Algermissen, S. T., 1983, An earthquake catalog for the Basin and Range Province, 1803-1977, 21 p.

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84-86 Keith, S. B., Schnabel, Lorraine, DeWitt, Ed., Gest, D. E., and Wilt, Jan, 1983, Map, description, and bibliography of the mineralized areas of the Basin and Range Province in Arizona, 129 p., scale 1:500,000.

Professional Paper 1370
Studies of geohydrologic environments in the Basin and Range Province, western United States, for isolation of high-level radioactive waste:

Chapter A Bedinger, M. S., and others, (in preparation), Basis of geohydrologic characterization and evaluation, 203 p., 21 illus.

Chapter D Bedinger, M. S., Sargent, K. A., and Langer, W. H., eds., (in preparation), Characterization of the Sonoran Desert region, Arizona, 160 p., 18 illus.

Chapter H Bedinger, M. S., Sargent, K. A., and Langer, W. H., (in preparation), Evaluation of the regions, 202 p., 27 illus.

Water-Resources Investigations Report 83-4114
(on the Basin and Range Province, Arizona)

83-4114-A Bedinger, M. S., Anderson, T. W., and Langer, W. H., 1984, Maps showing ground-water units and withdrawal, 7 p., scale 1:1,000,000 and 1:500,000, 2 sheets.

83-4114-B Langer, W. H., Mulvihill, D. A., and Anderson, T. W., 1984, Maps showing ground-water levels, springs, and depth to ground water, 7 p., scale 1:1,000,000 and 1:500,000, 2 sheets.

83-4114-C Thompson, T. H., Nuter, Janet, and Anderson, T. W., 1984, Maps showing distribution of dissolved solids and dominant chemical type in ground water, 7 p., scale 1:500,000, 4 sheets.

83-4114-D Johnson, W. D., Jr., and Scarborough, R. B., 1984, Map showing outcrops of granitic rocks, 33 p., scale 1:500,000, 2 sheets.

83-4114-E Johnson, W. D., Jr., 1984, Map showing outcrops of thick, dominantly argillaceous sedimentary and metasedimentary rocks, 11 p., scale 1:500,000, 2 sheets.

83-4114-F Jenness, J. E., Lopez, D. A., and LaFortune, J. R., 1984, Map showing outcrops of pre-Quaternary ash-flow tuff and volcaniclastic rock, 16 p., scale 1:500,000, 2 sheets.

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Arizona Bureau of Geology and Mineral Technology

Maps

20 Scarborough, R. B., (in preparation), Map of mid-Tertiary (40-15 m.y.) volcanic, plutonic, and sedimentary rock outcrops in Arizona, scale 1:1,000,000 (partial funding by the USGS).

21 Scarborough, R. B., 1985, Map of post-15-m.y. volcanic outcrops in Arizona, scale 1:1,000,000 (partial funding by the USGS).

22 Scarborough, R. B., Menges, C. M., and Pearthree, P. A., (in preparation), Map of late Pliocene-Quaternary (post-4-m.y.) faults, folds, and volcanic outcrops in Arizona, scale 1:1,000,000 (partial funding by the USGS).

Open-File Reports

83-19 Menges, C. M., 1983, The neotectonic framework of Arizona—implications for the regional character of Basin and Range tectonism, 109 p.

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83-22 Menges, C. M., and Pearthree, P. A., 1983, Map of neotectonic (latest Pliocene-Quaternary) deformation in Arizona, 48 p., scale 1:500,000, 2 sheets.

85-2 Scarborough, R. B., 1985, Geologic cross sections of western Arizona Basin and Range with accompanying geologic maps and other information, 9 p., scale 1:250,000 and 1:500,000, 35 sheets.

Wilderness Act Update

by Larry D. Fellows

The Spring 1984 issue of *Fieldnotes* included an article on assessing Arizona's mineral- and energy-resource potential. During preparation of that article, which included references to publications on Arizona's mineral resources, an Arizona wilderness bill was introduced by Congressman Morris K. Udall and Senator Barry M. Goldwater. The Arizona Wilderness Act of 1984 was passed in August and was subsequently signed by President Reagan. The act added 41 areas to the wilderness system, included a portion of the Verde River in the Wild and Scenic Rivers Act, and identified 3 areas to be studied for possible wilderness designation, with recommendations about their status to be made prior to January 1, 1986. Approximately 286,270 acres of U.S. Bureau of Land Management (BLM) lands, most of which are north of the Colorado River, and 777,090 acres of U.S. Forest Service lands were designated as wilderness (Figure 1; Table 1).

During the preceding decade, the Forest Service identified and evaluated "roadless" areas, held public hearings, and recommended whether each area should be managed as wilderness or nonwilderness or studied further. Forest Service staff evaluated topography, vegetation, watershed characteristics, mineral- and energy-resource potential, grazing, wildlife, timber resources, recreational values, and special uses within and adjacent to the "roadless" areas. Congress specified that the U.S. Geological Survey (USGS) and the U.S. Bureau of Mines (USBM) were to assess the mineral- and energy-resource potential of areas that the Forest Service recommended for wilderness or further planning. The results of the assessments were to be considered in the final decision-making process.

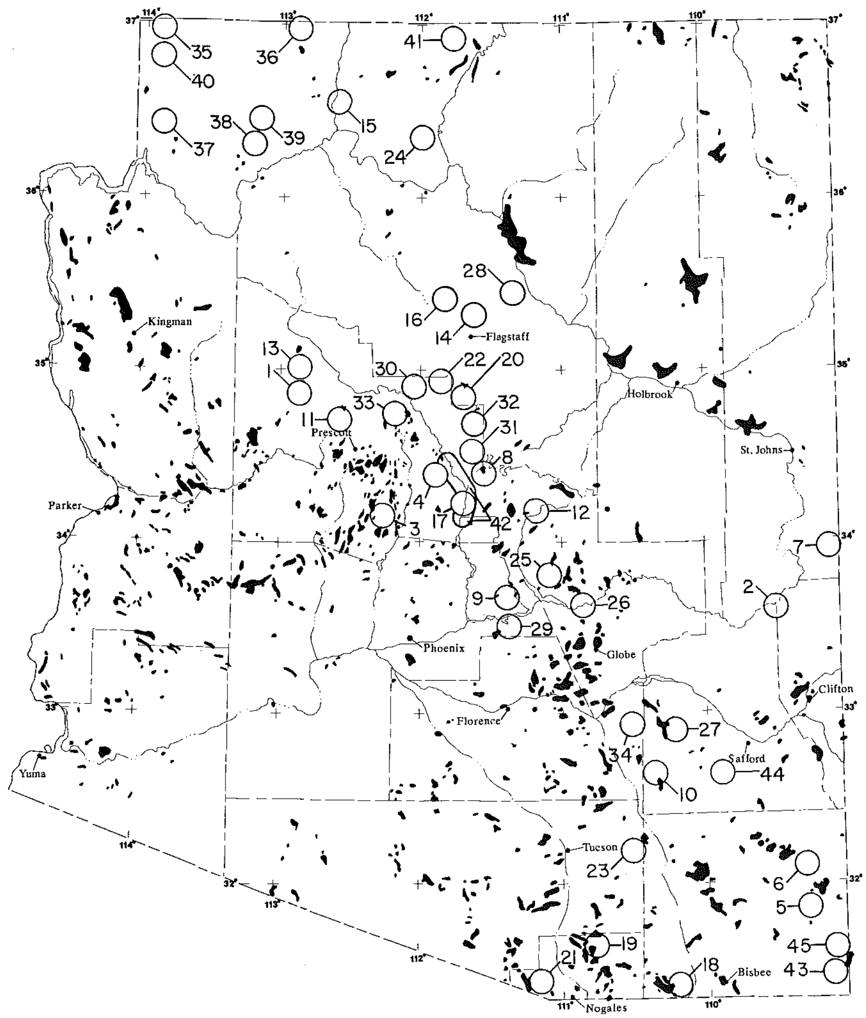


Figure 1. Areas included in the Arizona Wilderness Act of 1984. Numbers coincide with those in Table 1. Blackened areas are metallic mineral districts as defined in Metallic Mineral Districts and Production in Arizona, *Arizona Bureau of Geology and Mineral Technology Bulletin 194.*

The USGS and USBM assembled a great deal of information about the geologic framework and mineral and energy resources in the areas they studied. Guidelines to the preparation of mineral survey reports on public lands were summarized in USGS Open-File Report 84-787. Selected published references on the geology and mineral resources of Forest Service wilderness and "roadless" areas were listed in USGS Open-File Report 84-483. All Forest Service areas studied by the USGS and USBM from 1964-84 were summarized in Professional Paper 1300, a two-volume set published by the USGS in cooperation with the USBM.

Prior to passing the Arizona Wilderness Act of 1984, Congress conducted its own review of Forest Service "roadless" areas and the environmental impacts associated with management alternatives (wilderness, nonwilderness, or further planning). The act specifies that all national forest system lands reviewed by the Forest Service in the second Roadless Area Review and Evaluation (RARE II) that were not designated wilderness or wilderness-study areas by the act shall be managed for multiple use. The act also specifies that the Department of Agriculture shall not conduct further statewide RARE analyses of national forest system lands to determine their suitability for the National Wilderness Preservation System, unless Congress expressly authorizes such evaluation.

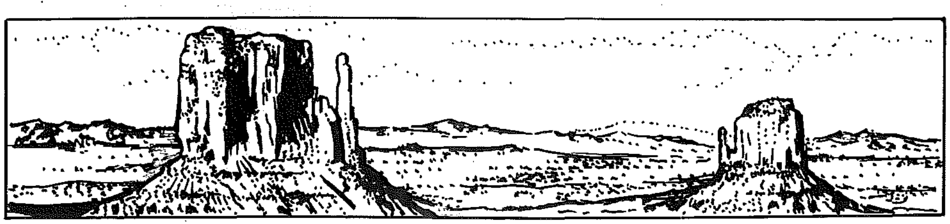
Congress also stated in the act that it does not intend that designation of wilderness areas should lead to the creation of protective perimeters or buffer zones around each area. The fact that nonwilderness activities or uses can be seen or heard within a wilderness area shall not, by itself, preclude such activities or uses adjacent to the wilderness boundary.

Of the 41 areas designated as wilderness in the Arizona Wilderness Act, 33 are administered by the Forest Service and 8 by the Bureau of Land Management. Eight of the 33 Forest Service areas were recommended as nonwilderness during the RARE II procedure; hence, no mineral assessments of these areas were required. An assessment was completed for one of the areas, however. The USGS or USBM completed mineral assessments for 15 of the remaining 25 areas that were recommended for wilderness or further planning. Mineral- and energy-resource potential was assessed in six of the eight BLM wilderness areas. Potential was not evaluated, however, in 19 of the 41 areas prior to their designation as wilderness.

Table 1. Areas included in the Arizona Wilderness Act of 1984. Numbers coincide with those on Figure 1 (index map).

Map Number	Name	Forest or District	Acres	RARE II Recommendation
	Forest Service Wilderness Areas			
1	Apache Creek	Prescott	5,420	nonwilderness
2	Bear Wallow	Apache-Sitgreaves	11,080	nonwilderness
3	Castle Creek	Prescott	26,030	wilderness
4	Cedar Bench (Arnold Mesa)	Prescott	14,950	further planning
5	Chiricahua additions	Coronado	69,700	wilderness
6	Chiricahua Monument additions (Bonita Creek)	Coronado	850	further planning
7	Escudilla Mountain	Apache-Sitgreaves	5,200	nonwilderness
8	Fossil Springs	Coconino	11,550	further planning
9	Four Peaks	Tonto	53,500	further planning
10	Galiuro additions	Coronado	23,600	further planning
11	Granite Mountain	Prescott	9,800	wilderness
12	Hells Gate	Tonto	36,780	further planning
13	Juniper Mesa	Prescott	7,600	wilderness
14	Kachina Peaks	Coconino	18,200	wilderness
15	Kanab Creek*	Kaibab	77,100	wilderness further planning
16	Kendrick Mountain	Kaibab/Coconino	6,510	wilderness
17	Mazatzal additions	Tonto	46,670	further planning
18	Miller Peak	Coronado	20,190	wilderness
19	Mount Wrightson	Coronado	25,260	wilderness
20	Munds Mountain (Rattlesnake)	Coconino	18,150	further planning
21	Pajarita	Coronado	7,420	nonwilderness
22	Red Rock—Secret Mountain	Coconino	43,950	wilderness
23	Rincon Mountain	Coronado	38,590	wilderness
24	Saddle Mountain	Kaibab	40,600	wilderness
25	Salome	Tonto	18,950	nonwilderness
26	Salt River Canyon	Tonto	32,800	nonwilderness
27	Santa Teresa	Coronado	26,780	wilderness
28	Strawberry Crater	Coconino	10,140	further planning
29	Superstition additions	Tonto	35,640	further planning
30	Sycamore Canyon additions	Prescott/Coconino	8,180	nonwilderness
31	West Clear Creek	Coconino	13,600	further planning
32	Wet Beaver	Coconino	6,700	further planning
33	Woodchute	Prescott	5,600	nonwilderness
	Bureau of Land Management Wilderness Areas			
34	Aravaipa Canyon	Safford	6,670	
35	Beaver Dam Mountains	Arizona Strip	19,600	
36	Cottonwood Point	Arizona Strip	6,500	
37	Grand Wash Cliffs	Arizona Strip	36,300	
38	Mount Logan	Arizona Strip	14,600	
39	Mount Trumbull	Arizona Strip	7,900	
40	Paiute	Arizona Strip	84,700	
41	Paria Canyon—Vermillion Cliffs	Arizona Strip	110,000	
	Wild and Scenic River Designation			
42	Verde River from the boundary between national forest and private land in T. 13 N., R. 5 E., sec. 26-27, downstream to the confluence with Red Creek.			
	Areas to be Reviewed			
43	Bunk Robinson Peak	Coronado	850	further planning
44	Mount Graham	Coronado	62,000	nonwilderness
45	Whitmire Canyon	Coronado	5,080	further planning

* Part of the Kanab Creek Wilderness Area is administered by the Bureau of Land Management.



Arizona Wilderness Dedication

With the Vermillion Cliffs as a backdrop, the Dominguez-Escalante Interpretive Site near the Arizona-Utah border was the latest scene linked to passage of the Arizona Wilderness Act of 1984. Several hundred guests and public officials gathered on April 11 to formally dedicate more than 1 million acres of BLM and Forest Service lands that were recently added to the National Wilderness Preservation System.

The wilderness dedication marked the first official visit to Arizona by Secretary of the Interior Donald Hodel. Congressman Morris Udall, who cosponsored the Arizona wilderness legislation in the House, served as master of ceremonies. Other honored guests included Congressman Robert Stump, Senator Dennis DeConcini, Congressman James Hansen of Utah, Assistant Secretary of Agriculture Peter Myers, BLM Director Robert Burford, and R. Max Peterson, Forest Service Chief. Senator Barry Goldwater, who sponsored the Senate version of the bill, was unable to attend.

Back Issues of *Fieldnotes* Available

Fieldnotes has been supplying timely articles and news briefs since its first issue appeared in March 1971. More than 50 issues have been published to date, covering all aspects of Arizona geology. Although some articles contained in early issues are now outdated, others are timeless or provide a historical overview that could be helpful in understanding current situations.

Past issues of *Fieldnotes* are available from the Bureau. For most issues, only a handling and UPS shipping fee is charged. Out-of-print issues cost an additional $1.50 per copy to cover reproduction expenses. The following issues, listed by volume and number, are out-of-print: 1-1; 1-2; 1-3; 1-4; 4-4; 5-1; 5-2; 5-3; 5-4; 6-1; 6-2; 7-3 & 4 (combined issue); 8-1 & 2 (combined issue); and 10-1. The volume and number refer to the issue's publication date (e.g., 1-2 was published in 1971 during the 2nd quarter). A list of shipping and handling charges appears below. All orders must be prepaid by check or money order made out to the Arizona Bureau of Geology and Mineral Technology.

Copies	Shipping
1-3	$.75
4-6	1.50
7-11	1.80
12-23	2.20
24-35	2.60
36-47	3.00
48-54	3.40

(Add $1.50 for each out-of-print issue.)

Recent Publications on the Geology of Arizona

The following publications were recently added to the Bureau library, where they may be examined during regular working hours. Copies may also be examined in or obtained from the respective offices:

U.S. Bureau of Mines

Bulletin: Superintendent of Documents, Washington, DC 20402

Mineral Land Assessment Reports: Intermountain Field Operations Center, Bldg. 20, Federal Center, Denver, CO 80225.

U.S. Geological Survey

Maps: Western Distribution Branch, U.S. Geological Survey, Box 25286, Federal Center, Denver, CO 80225.

Open-File Reports: Open-File Services Section, Western Distribution Branch, U.S. Geological Survey, Box 25425, Federal Center, Denver, CO 80225.

All other publications: Eastern Distribution Branch, Text Products Section, U.S. Geological Survey, 604 S. Pickett St., Alexandria, VA 22304.

Arizona Department of Mines and Mineral Resources, Mineral Bldg., Fairgrounds, Phoenix, AZ 85007; 416 W. Congress, Rm. 161, Tucson, AZ 85701.

Arizona Geological Society, c/o Helen Hauck, 4744 N. Campbell Ave., Tucson, AZ 85717.

U.S. Bureau of Mines

Bulletin

675 Mineral facts and problems, 1985, preprints: beryllium; bromine; cesium; chromium; cobalt; corundum and emery; diatomite; feldspar; ferroalloys; fluorspar; garnet; iron and steel; kyanite and related minerals; lime, calcium, and calcium compounds; lithium; mercury; mica; nickel; nitrogen (ammonia); phosphate rock; platinum-group metals; potash; pumice and pumicite; rare-earth elements and yttrium; rhenium; silicon; talc and pyrophyllite; tantalum; thallium; and tin.

Mineral Land Assessment Reports

MLA 5-85 Ryan, G. S., 1985, Mineral investigation of the Black Rock Wilderness Study Area, Graham County, Arizona, 13 p.

MLA 9-85 Ryan, G. S., 1984, Mineral investigation of the Needle's Eye Wilderness Study Area, Gila County, Arizona, 8 p.

MLA 17-85 Ryan, G. S., 1985, Mineral investigation of the Fishhooks Wilderness Study Area, Graham County, Arizona, 8 p.

U.S. Geological Survey

Maps

MF-1558-B Gerstel, W. J., 1985, Geochemical map of the Wet Beaver Roadless Area, Coconino and Yavapai Counties, Arizona, scale 1:24,000.

MF-1673 Thaden, R. E., and Zech, R. S., 1984, Preliminary structure contour map on the base of the Cretaceous Dakota Sandstone in the San Juan basin and vicinity, New Mexico, Arizona, Colorado, and Utah, scale 1:500,000.

MR-92 Hosterman, J. W., 1985, Bentonite and fuller's earth resources of the United States, scale 1:5,000,000.

Open-File Reports

84-350 Brooks, W. E., 1984, Volcanic stratigraphy of part of McLendon volcano, Anderson mine area, Yavapai County, Arizona, 42 p.

84-772 Gori, P. L., ed., 1984, Primer on improving the state of earthquake hazards mitigation and preparedness, 219 p.

85-22 Jacobson , M. L., and Rodriguez, T. R., comp., 1985, Summaries of technical reports, volume XIX, 608 p.; prepared by participants in the National Earthquake Hazards Reduction Program.

85-222 Abrams, G. A., Moss, C. K., and Schutter, T. A., 1985, Principal facts for gravity stations in the Dos Cabezas Mountains, Cochise County, Arizona, 8 p.

Professional Paper

1304 Sohl, N. F., and Kollmann, H. A., 1985, Cretaceous actaeonellid gastropods from the Western Hemisphere, 151 p.

Water-Supply Paper

2241 Aldridge, B. N., and Hales, T. A., 1984, Floods of November 1978 to March 1979 in Arizona and west-central New Mexico, 149 p.

Arizona Department of Mines and Mineral Resources

Directories

20 Jett, J. H., and Bloyd, A. W., comp., 1984, Directory of earth science clubs in Arizona, 18 p.

21 Greeley, M. N., 1984, Directory of exploration offices in Arizona, 9 p.

22 1984, Directory of active mines in Arizona, 15 p.

23 1984, Directory of State, county, and Federal agencies in Arizona concerned with mining and mineral resources, 28 p.

Four Corners Geological Society

Nations, J. D., Doss, A. K., and Ybarra, R. A., 1984, The geologic setting of oil and gas exploration in Arizona, *in* Oil and gas fields of the Four Corners area: prepublication manuscript, 32 p.

Nations, J. D., Doss, A. K., and Ybarra, R. A., 1984, Stratigraphy and oil and gas production of Arizona, 1978-1983, *in* Oil and gas fields of the Four Corners area: prepublication manuscript, 27 p.

Other Publishers

Arizona Geological Society, 1985, Geology of the Vulture and Congress mines, Maricopa and Yavapai Counties, Arizona: 1985 Spring Field Trip Guidebook, 132 p.

Johnson, K. S., and Gonzales, Serge, 1978, Salt deposits in the United States and regional geologic characteristics important for storage of radioactive waste: Earth Resource Associates, Inc., 188 p. Prepared for the Office of Waste Isolation; the Union Carbide Corporation, Nuclear Division; and the U.S. Department of Energy.

Riggs, Nancy, 1985, Geologic map of the Pajarito Mountains, Santa Cruz County, Arizona: Tucson, University of Arizona, M.S. Thesis, Figure 3, scale 1:12,000.

PROFESSIONAL MEETINGS

Basement Tectonics. Meeting and field trips, Santa Fe, New Mexico, September 16-20, 1985. Contact M. J. Aldrich, MS D462, Box 1663, Los Alamos National Laboratory, Los Alamos, NM 87545; (505) 667-1495.

Geology and Paleontology of Triassic Continental Deposits of the American Southwest, symposium, September 21 – 22, 1985; **Southwestern Geology and Paleontology,** 38th annual symposium, September 7, 1985; Flagstaff, Arizona. Contact Dept. of Geology, Museum of Northern Arizona, Rt. 4, Box 720, Flagstaff, AZ 86001; (602) 774-5211.

Management of Hazardous Chemical-Waste Sites. Symposium by the International Association of Engineering Geology and Association of Engineering Geologists, Winston-Salem, North Carolina, October 9-10, 1985. Contact Norman R. Tilford, Dept. of Geology, Texas A&M University, College Station, TX 77843; (409) 845-9682.

BUREAU PUBLICATIONS

The following publications may be purchased over the counter or by mail from the Bureau offices at 845 N. Park Ave., Tucson, AZ 85719. Orders are shipped via UPS; street address is required for fastest delivery. All orders must be prepaid by check or money order made out to the Arizona Bureau of Geology and Mineral Technology. Shipping and handling charges are listed below. If your total order is

$1.01 to $5.00, add $1.75	40.01 to 50.00, add 7.75
5.01 to 10.00, add 2.25	50.01 to 100.00, add 10.00
10.01 to 20.00, add 4.25	More than 100.00, add 10%
20.01 to 30.00, add 5.50	Foreign mail, add 40%
30.01 to 40.00, add 6.25	

Bulletins

Keith, Stanton B., 1973 (reprinted 1985), Index of mining properties in Cochise County, Arizona: Bulletin 187, 98 p.; $5.00.

Arizona has been an important mineral-producing area for more than 100 years, and many mines, ranging from major operations to small mines and prospects, have contributed to the total mineral output. The records of these operations are scattered in numerous publications of Federal and State agencies, in articles in various technical journals, in public and private reports, and in newspaper clippings. Many such sources are not readily available to individuals seeking information about these operations. This bulletin, covering notable mining properties in Cochise County, is designed to provide such information in a concise manner.

The index does not attempt to name and describe every mining property that may exist in an area. It does, however, include properties that are important because of their production records, mineral-resource potential, or special geologic or mineralogic characteristics. Because of high demand, this bulletin has been out-of-print for several years. It has now been reprinted in its entirety.

Reynolds, S. J., 1985, Geology of the South Mountains, central Arizona: Bulletin 195, 61 p., colored geologic map, scale 1:24,000; $9.50.

The geologic history of the South Mountains was briefly described in the Spring 1985 issue of *Fieldnotes*. Bulletin 195 contains an in-depth discussion of the geology of the area, including its geologic setting, geochronology, structural geology, and economic geology. The bulletin contains 68 figures and a colored 1:24,000-scale geologic map.

Bulletin 195 represents an important contribution to our understanding of the geologic framework of Arizona. The South Mountains are among the recently recognized "metamorphic core complexes" of western North America and, as such, are similar in age and origin to other core complexes in the State. Bulletin 195 describes a major, previously unrecognized, low-angle detachment fault that lies beneath Phoenix, Tempe, and Mesa. This bulletin also documents for the first time that gold, silver, and copper mineralization in the South Mountains is middle Tertiary in age, not older, as previously thought.

Reprinted here are excerpts from the abstract.

The South Mountains of central Arizona are a typical, but geologically simple, metamorphic core complex. The western half of the range is underlain by Precambrian metamorphic and granitic rocks, whereas the eastern half is primarily a composite middle Tertiary pluton. Middle Tertiary plutonism was accompanied by intense mylonitization that affected Precambrian and middle Tertiary rocks alike. Mylonitization generally produced a low-angle foliation and east-northeast-trending lineation. The attitude of mylonitic foliation defines a broad, east-northeast-trending antiform that controls the topographic axis of the range. Fabrics in all rock types indicate that mylonitization was accompanied by extension parallel to east-northeast-trending lineation and by flattening perpendicular to subhorizontal foliation. Small-scale structures indicate that most mylonitic rocks were formed by noncoaxial, east-northeast-directed shear parallel to lineation. Mylonitization occurred under conditions of elevated temperature, but relatively low to moderate confining pressure; both temperature and pressure probably decreased during successive phases of mylonitization.

Mylonitization was succeeded by more brittle deformation that produced chloritic breccia and microbreccia in the footwall of a major detachment fault that dips gently to the east. The detachment fault and underlying breccia were formed by low-angle normal faulting and brittle extension in an east-northeast direction.

Geologic and geochronologic data strongly suggest that mylonitization and detachment faulting represent a continuum of middle Tertiary shear and extension. Documentation of this continuum has important implications regarding the evolution of Cordilleran metamorphic core complexes. Specifically, the complexes may represent the ductile to brittle evolution of normal-slip shear zones of crustal proportions.

Maps

Scarborough, R. B., 1985, Map of post-15-m.y. volcanic outcrops in Arizona: Map 21, scale 1:1,000,000; $3.00.

The outcrops on Map 21 are divided according to the following major age brackets: 0 to 4 m.y.; 4 to 10.5 m.y.; and 10.5 to 15 m.y. This map is one of a series of 1:1,000,000-scale colored geologic maps depicting rock outcrops in Arizona. It was prepared during a project jointly funded by the Arizona Bureau of Geology and Mineral Technology and the U.S. Geological Survey. In addition to Map 21, the following maps of rock outcrops have been or will soon be published:

Map 19 *Keith, Stanley B., 1984, Map of outcrops of Laramide (Cretaceous-Tertiary) rocks in Arizona and adjacent regions; $3.00*

Map 20 *Scarborough, R. B., (in press), Map of mid-Tertiary (40-15 m.y.) volcanic, plutonic, and sedimentary rock outcrops in Arizona; availability and price to be announced*

Map 22 *Scarborough, R. B., Menges, C. M., and Pearthree, P. A., (in press), Map of late Pliocene-Quaternary (post-4-m.y.) faults, folds, and volcanic outcrops in Arizona; availability and price to be announced.*

Open-File Reports

Welty, J. W., Spencer, J. E., Allen, G. B., Reynolds, S. J., and Trapp, R. A., 1985, Geology and production of middle Tertiary mineral districts in Arizona: Open-File Report 85-1, 88 p.; $10.00.

This report was prepared by Bureau staff to gain a better understanding of middle Tertiary metallogenesis. Tables include the following information for all mid-Tertiary mineral districts in Arizona: geology, basis of age determination, lithotectonic association, present value of production, and historic grade.

Scarborough, R. B., 1985, Geologic cross sections of western Arizona Basin and Range with accompanying geologic maps and other information: Open-File Report 85-2, 9 p., scale 1:250,000 and 1:500,000, 35 sheets.

This report consists of a series of geologic cross sections drawn through western Arizona. The project was part of a U.S. Geological Survey (USGS) study to evaluate the geohydrologic character of the Basin and Range Province of the western United States. The final results of this study are being published by the USGS as a series of Professional Papers and Water-Resources Investigations Reports.

The cross sections are drawn to a horizontal scale of 1:250,000, with a vertical exaggeration of 10x. Two 1:500,000-scale base maps show the positions of cross-section lines. Twenty cross sections trend transversely across mountain ranges; 15 trend parallel to major valleys. Index maps list references from which outcrop information was derived. Prices for portions of this report are as follows:

Text: $1.50
Sheet 1: (to be added)
Sheets 2 & 3 (base maps; scale 1:500,000): $3.00 each
Sheets 4-17 (cross sections; scale 1:250,000): $2.50 each
Sheets 18-21 (geologic maps; scale 1:250,000): $2.50 each
Sheets 22-25 (gravity and fault maps; scale 1:250,000): $2.50 each
Sheet 26 (index of published geologic maps of western Arizona; scale 1:1,000,000): $2.50
Sheet 27 (location map of cross sections, wells with stratigraphic information, theses, and dissertations on the geology of western Arizona; scale 1:1,000,000): $2.50
Sheets 28-35 (index maps of Phoenix, Prescott, Salton Sea, Kingman, Williams, Needles, El Centro, and Ajo quadrangles; scale 1:250,000): available for inspection only.

Scarborough, R. B., 1984, Cenozoic erosion and sedimentation in Arizona: Open-File Report 85-3, 61 p.; $8.00

This report summarizes important aspects of the history of Cenozoic sedimentation and sedimentary rocks throughout Arizona. It is an expanded version of a report that will appear in a planned Arizona Geological Society publication. The Bureau open-file report contains an in-depth review of the late Cenozoic (Miocene-Pleistocene) sedimentary history of Arizona, including discussions on Pleistocene glaciation, river integration, and basin dissection. A detailed reference list documents previous work on this subject.

Pearthree, P. A., and Scarborough, R. B., 1984, Reconnaissance analysis of possible Quaternary faulting in central Arizona: Open-File Report 85-4, 39 p., 21 photographs; map, scale 1:250,000; text, including photographs: $9.00; map: $2.00.

This report summarizes the results of a reconnaissance analysis of Quaternary faulting in central Arizona, from the Verde Valley southeastward to the Superstition Mountains. The study was conducted for the U.S. Bureau of Reclamation as part of an investigation of the safety of existing and potential dam sites.

The report contains a section on seismotectonic setting, discusses landform analysis, and identifies five areas in central Arizona with evidence of probable or possible Quaternary faulting.

(text continued from page 6)

Many maps and reports were completed as part of the project. The status of those pertaining specifically to Arizona is shown in Table 1. These products present information on water resources and on recent faulting and other tectonic data, and summarize mineralized areas in the State. They are equally applicable to siting potential storage facilities for low-level radioactive, toxic, and hazardous wastes.

Arizona and other States in the Basin and Range Province seriously lack detailed maps that show the distribution of rock and unconsolidated materials at the land surface. Subsurface data are almost nonexistent. Because the geologic framework is so poorly known in large portions of the province, much new surface and subsurface information would be required before any siting decision could be made relative to disposal of radioactive, hazardous, or toxic waste.

Fieldnotes

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Assistant Director, Mineral Technology Branch .... J. Brent Hiskey
Editor .... Evelyn M. VandenDolder
Illustrators .... Joe LaVoie, Joy Mehulka

The Bureau of Geology and Mineral Technology is a division of the University of Arizona.

Arizona Bureau of Geology and Mineral Technology
845 N. Park Ave.
Tucson, AZ 85719
TEL: 602/621-7906