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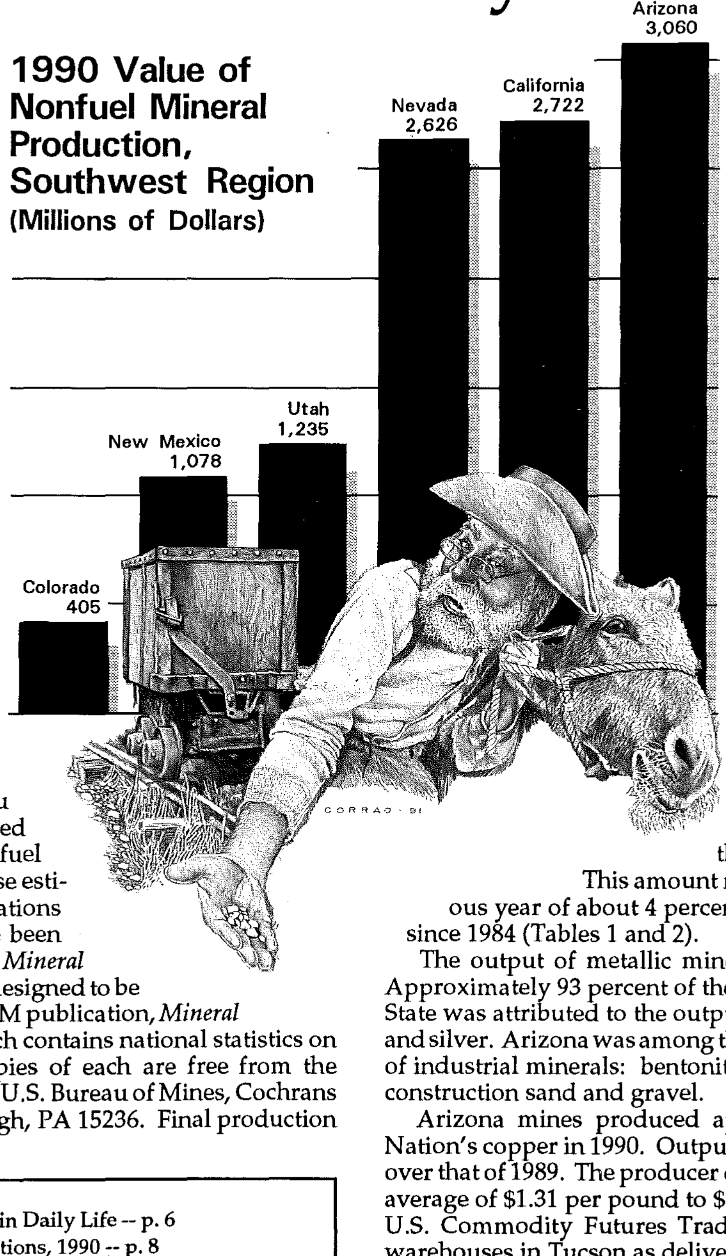
Michael N. Greeley, U.S. Bureau of Mines

The Nonfuel Mineral Industry of the Southwest: 1990 Summary

In 1990, the value of nonfuel mineral production declined slightly in the Southwest, the first downturn since 1985. Preliminary figures show that the total value of production in this region was one-third of the total production in the United States. Mines in the six southwestern states of Arizona, California, Colorado, Nevada, New Mexico, and Utah produced more than $11 billion worth of mineral products; the national total was about $33 billion (see figure at right; Table 1).



The value of mineral output in the Southwest declined less than 1 percent from 1989 to 1990. Arizona, California, and Nevada ranked first through third, respectively, in U.S. nonfuel mineral production. Arizona accounted for more than 9 percent of the Nation's total output.

These preliminary statistics were published by the U.S. Bureau of Mines (BOM), which has released individual State estimates of nonfuel mineral production for 1990. These estimates, generally yearend extrapolations based on 9 months of data, have been published in one volume: *State Mineral Summaries--1991*. This volume is designed to be a companion report to another BOM publication, *Mineral Commodity Summaries--1991*, which contains national statistics on 90 nonfuel minerals. Single copies of each are free from the Publications Distribution Section, U.S. Bureau of Mines, Cochrans Mill Rd., P.O. Box 18070, Pittsburgh, PA 15236. Final production figures for 1990 are expected to be available in August.

The State summaries were prepared by BOM State Mineral Officers, in cooperation with the State mineral agencies. Individual summaries are also published separately as State Mineral Industry Surveys. Copies are available from the respective State Mineral Officers: Fred V. Carrillo, 1605 Evans Ave., Reno, NV 89512 (California and Nevada); Michael N. Greeley, 210 E. 7th St., Tucson, AZ 85705 (Arizona, New Mexico, and Utah); and Rodney J. Minarik, East 360 Third Ave., Spokane, WA 99202 (Colorado).

ARIZONA

For the third consecutive year, Arizona mines led the Nation in the production of nonfuel minerals. Estimated figures indicate that the total value of output in the State was about $3.1 billion, or more than 9 percent of the national value. This amount reflected a decline from the previous year of about 4 percent and was the first drop in value since 1984 (Tables 1 and 2).

The output of metallic minerals was valued at $2.8 billion. Approximately 93 percent of the mineral production value in the State was attributed to the output of copper, gold, molybdenum, and silver. Arizona was among the leading states in the production of industrial minerals: bentonite, cement, gem stones, lime, and construction sand and gravel.

Arizona mines produced approximately 62 percent of the Nation's copper in 1990. Output represented a 7-percent increase over that of 1989. The producer copper price dropped from a 1989 average of $1.31 per pound to $1.23 in 1990. Late in the year, the U.S. Commodity Futures Trading Commission approved two warehouses in Tucson as delivery points for copper under Commodity Exchange (COMEX) contracts. Prior to approval, a COMEX warehouse in Deming, New Mexico was the closest storage location available to Arizona producers.

Table 1. Value of nonfuel mineral production in the Southwest, measured by mine shipments, sales, or marketable production, including consumption by producers. All figures are from the U.S. Bureau of Mines; totals for 1990 are preliminary estimates.

State	Value (thousands of dollars) 1989	1990	Percent of Total Value in 1990 Southwest	U.S.	1990 Rank in Nation	Principal Minerals
Arizona	3,159,295	3,060,218	27.5	9.2	1	copper, molybdenum, sand & gravel
California	2,854,206	2,722,343	24.5	8.1	2	sand & gravel, cement, boron
Colorado	455,164	405,315	3.6	1.2	27	sand & gravel, molybdenum, cement
Nevada	2,319,068	2,625,554	23.6	7.9	3	gold, silver, sand & gravel
New Mexico	1,121,575	1,078,038	9.7	3.2	12	copper, potash, sand & gravel
Utah	1,290,612	1,234,669	11.1	3.7	9	copper, gold, magnesium metal
SOUTHWEST	11,199,920	11,126,137	100.0	33.3	---	
U.S. TOTAL	32,315,789	33,432,164	---	100.0	---	

Two copper mines, the Johnson Camp mine in Cochise County and the Magma mine in Pinal County, were reactivated in 1990. Production from the deep Kalamazoo orebody, adjacent to the San Manuel deposit in Pinal County, also began during the year. Development of the Oracle Ridge property in Pima County continued in 1990, and at yearend a new discovery named Coronado was announced in the Morenci district of Greenlee County.

Although output of gold, molybdenum, and silver in Arizona decreased, the State was an important source of these metals in 1990. Molybdenum production, which came solely from copper mines, was the highest in the Nation. Molybdenum output, however, was 50 percent below that of 1989, despite considerably higher prices in 1990. Several copper mines were among the top 25 U.S. producers of silver.

The value of industrial mineral production was about $219 million, a drop of approximately 24 percent from that of 1989. Arizona ranked eighth in the Nation in output of construction sand and gravel, which remained the largest component of the State's industrial mineral production. Cement, lime, and crushed stone were also major contributors. Arizona mines also held their position nationally among the leading producers of naturally occurring gem stones.

The BOM continued its in situ, copper-mining research project in cooperation with the Santa Cruz Joint Venture. Hydrologic modeling of the Santa Cruz Test Site near Casa Grande was conducted using the BOM's computer program, MINEFLO. The BOM continued to investigate an area in west-central Arizona characterized by gold mineralization associated with extensional detachment faulting (see also Spencer and Reynolds, 1989). The agency also conducted extensive evaluations of known mineral occurrences in the Coconino, Coronado, and Kaibab National Forests.

The Arizona Desert Wilderness Act of 1990 incorporated about 1.1 million acres of Bureau of Land Management (BLM) land and 1.3 million acres of Fish and Wildlife Service land into the National Wilderness Preservation System (see also Bauer, 1991). The legislation also retained about 57,800 acres in Cactus Plain (La Paz County) and 4,800 acres in Baker Canyon (Cochise County) as BLM Wilderness Study Areas (WSAs). The Gila Box WSA (Graham County) received special designation as a Riparian National Conservation Area. This is the second area in the Nation to receive this management designation; Arizona's San Pedro Riparian National Conservation Area was the first.

Several bills that addressed environmental issues, especially hazardous waste and air and water pollution, were introduced during the 1990 session of the Arizona Legislature. One of the most significant bills that became law was House bill 2007, which established a civil penalty of up to $10,000 per day for each violation of air-pollution-control laws committed by anyone engaged in metalliferous mining. Attempts to increase severance taxes on minerals were defeated.

CALIFORNIA

California was the second leading State in the Nation in the value of nonfuel mineral production during 1990, accounting for more than 8 percent of the U.S. total. The value of nonfuel mineral commodities was estimated to be $2.7 billion, a 4-percent decrease from that of 1989 (Table 1). California led all states in the production of asbestos, boron minerals, portland cement, diatomite, calcined gypsum, construction sand and gravel, rare-earth concentrates, and tungsten.

Industrial mineral production appeared to reflect the leveling off of construction activity in the State, with projected declines in the production of portland cement, lime, sand and gravel, and crushed stone. Increased gold production retained California's standing as the second largest gold-producing State, despite lower precious-metal prices, which closed several of the smaller, marginal gold and silver mines.

The McLaughlin mine in Napa County produced its one-millionth ounce of gold since it began production in 1983. Operations were resumed in 1990 at the Sixteen-to-One gold mine in Sierra County. Development continued during the year at the Hayden Hill gold project in Lassen County.

Exploration activities were reported in the Kelso Dunes of San Bernardino County, where the BLM reviewed a proposal to conduct a mining operation within the WSA. Sacramento County supervisors reported evaluations of aggregate and incidental gold at Mather Air Force Base, which will become county property in 1993 after it is relinquished by the Air Force.

Nearby residents' opposition to mining continued to impede the issuing of new mining permits throughout the State, but three county referendums restricting mining in Nevada, Tuolumne, and Yolo Counties were defeated at the polls.

Two bills concerned with mining reclamation and environmental impact reports were passed in September. AB 3551 and AB 3903 require the State Mining and Geology Board, in conjunction with local agencies, to conduct inspections of and prepare

Table 2. Value of nonfuel mineral production in Arizona, measured by mine shipments, sales, or marketable production, including consumption by producers. All figures are from the U.S. Bureau of Mines; totals for 1990 are preliminary estimates.

Mineral	Value (thousands of dollars) 1989	1990
Clays	2,506	1,930
Copper[1]	2,593,292	2,633,098
Diatomite	W	W
Gem stones	2,821	2,821
Gold[1]	34,564	33,708
Lime	W	W
Iron oxide pigments (crude)	W	18
Pumice	---	---
Sand and gravel		
Construction	133,900[e]	129,200
Industrial	W	W
Silver[1]	30,186	21,059
Stone		
Crushed	28,552	13,500
Dimension	W	W
Other[2]	333,474	224,884
TOTAL	3,159,295	3,060,218

W Withheld to avoid disclosing company proprietary data; value included in "Other" figure.
[e] Estimated.
[1] Recoverable content of ores, etc.
[2] Combined value of cement, gypsum, iron oxide pigments (crude, 1989), lead (1989), molybdenum, perlite, pyrites, salt, tin (1989), and values indicated by symbol W.

environmental impact reports on all surface mining operations. These bills also require mine operators to provide financial assurance for costs associated with reclamation plans and the State Mining and Geology Board to adopt minimum, verifiable reclamation standards.

COLORADO

The estimated value of nonfuel minerals produced in Colorado was $405.3 million. This is an 11-percent decrease from that of 1989 (Table 1).

From a peak of $1.3 billion in 1980, Colorado nonfuel mineral output fell to one-third of that amount in 1982 and has since remained near that level. In 1990, Colorado ranked 27th among the 50 states with 1.2 percent of the total value of nonfuel minerals produced in the Nation.

Most of the decline from 1989 to 1990 was due to a drop in the output of molybdenum, historically Colorado's largest nonfuel mineral product. Waning demand for molybdenum reflects the decline in output of the U.S. steel industry, the major consumer of this metallic mineral. Production of copper, gold, molybdenum, silver, and vanadium also declined. Zinc output was up, although the total production value remained the same. Production of industrial minerals, including cement, gypsum, lime, construction sand and gravel, and crushed stone, increased in 1990. A dramatic increase in output of dimension stone also occurred during the year.

In May 1990, operations were resumed at the Summitville gold mine in Rio Grande County. The open-pit mine had been on standby since mid-1989. The Yule Marble quarry in Gunnison County was reopened in September, after having been shut down since 1942. Stone from this quarry was used to construct the Lincoln Memorial and the Tomb of the Unknown Soldier. In southwestern Colorado, because of depressed markets, a number of uranium-vanadium mines were idled.

The second largest gold nugget ever found in Colorado was discovered in the summer of 1990. The nugget, which weighs 8 troy ounces, was found on the alpine slopes of Pennsylvania Mountain, west of Alma (Park County). Named "The Turtle Nugget," it is 1.5 by 3 inches. Colorado's largest gold nugget, weighing 12 troy ounces and measuring 2 by 3 inches, was discovered at the same site in 1937. Both are now at the Denver Museum of Natural History's Coors Mineral Hall.

Two bills concerning the mineral industry were signed by the Governor during the spring 1990 session. House bill 1205 doubled the fee to dispose of solid waste in landfills. The new fee will increase the State's hazardous-waste emergency-response fund for use in Superfund actions. Bill 1205 also extended the fund to 1997 and prohibited funds from being used for new litigation. Senate bill 77 created a State uranium-mill-tailings remedial-action fund to serve as a source of State matching monies under the Federal Uranium Mill Tailings Remediation and Control Act. The bill also requires the Colorado Department of Health to report annually to a legislative oversight committee on the progress of cleanup activities.

NEVADA

Nevada was third among all states in the production of nonfuel minerals. The State's 1990 output was valued at $2.6 billion, an increase of 13 percent over that of 1989 (Table 1). Most of this increase is attributed to a 19-percent rise in gold production, which totaled about 184,548 kilograms (5,933,600 troy ounces). Silver production declined 4 percent to 600 metric tons (19,291,100 troy ounces). Nevada was the leading State in the Nation in the production of gold, silver, mercury, and barite; second in the production of diatomite, fluorspar, and lithium; and the sole producer of mined magnesite.

Gold production continued to rise, despite a slight drop in the average annual price to about $380 per troy ounce from the 1989 price of $383. Lower silver and gold prices resulted in closures of some marginal precious-metal operations. At the same time, however, many of the larger northern Nevada gold mines were increasing production, and new mine startups were initiated. Gold production began at the Casino (White Pine County), Elder Creek (Lander County), and Tonkin Springs (Eureka County) mines. A bio-oxidation recovery method employed at Tonkin Springs is only the second application of this technology in the world. Gold-silver production began during the year at the Ketchup Flat property in Nye County.

The Gold Bar II project (Eureka County), composed of three open-pit operations, began in 1990, as did underground mining and the startup of a sulfide circuit at the McCoy-Cove gold mine (Lander County). The first gold was poured during the year at Adelaide Crown (Humbolt County), Ivanhoe Joint Venture (Elko County), and Rabbit Creek (Humbolt County).

Silver operations at the Candelaria mine (Mineral County) were suspended because

THANK YOU, MINING COMPANIES

ASARCO, Homestake Mining Company, and Magma Copper Company have recently made contributions to support ongoing Arizona Geological Survey (AZGS) projects and activities. We sincerely appreciate their much-needed support.

Members of the Mineral Resources Advisory Committee to the AZGS recommended in January that highest priority be given to preparing regional and detailed geologic maps, including laboratory analyses to characterize alteration and mineralization; maintaining computerized geologic databases and a comprehensive library; assessing known and potential mineral resources in urban areas and remote subdivisions; participating in earth science education; studying mineral districts; and maintaining and expanding the repository of rock cores and cuttings. These recommendations were described further in the Spring 1991 issue of *Arizona Geology*.

Because of the importance of these activities to our constituents engaged in mineral exploration and mining and because of the current status of Arizona's economy, the AZGS sought assistance from mineral exploration and mining companies to help maintain the repository of rock cuttings and cores; to conduct laboratory analyses of mineralized rocks sampled during routine geologic mapping; to purchase computer equipment for the mineral-district, bibliographic, and other databases; and to pay graduate students to work on these projects.

We are pleased to announce that the mineral industry is responding. To date, the following contributions have been received:

Homestake Mining Company	$1,000
Magma Copper Company	$1,000
ASARCO	500 core boxes

We have not yet determined the best way to use the cash contributions. During fiscal year 1991, AZGS staff members will organize the core repository to make it more useful. AZGS geologists are currently mapping west-central Arizona, where substantial mineralization related to crustal extension and detachment faulting has taken place. Some funds may be used to sample and analyze rocks to determine the type and extent of alteration in the mineralized areas. AZGS staff members are also compiling a comprehensive bibliography of Arizona geology, a monumental endeavor that will take several years to complete at our present level of staffing. To date, nearly 15,000 citations have been entered into the computer, but they must still be indexed by key words. Because of the magnitude of these projects, additional support is still needed and would certainly be appreciated.

A MINERAL-RICH DIET

Did you know that every year, the United States uses 20 tons of nonfuel minerals for each American (per capita)? At this rate of consumption, the U.S. Bureau of Mines estimates that a baby born in 1991 will "need" during his or her lifetime

- 1,238,101 pounds of sand and gravel to make concrete for homes, schools, offices, factories, bridges, and roads;
- 32,700 pounds of iron to make house appliances, kitchen utensils, cars, ships, and buildings;
- 28,213 pounds of salt to make plastic products, detergents, and water softeners and to prepare foods;
- 26,550 pounds of clay to make bricks, paper, paint, glass, and pottery;
- 3,593 pounds of aluminum to make beverage cans, house siding, and aluminum foil and to use as an alloy to make pipes, steam irons, motors, cookware, ladders, furniture, aircraft, and barbed wire;
- 1,500 pounds of copper primarily to make electric motors, generators, communications equipment, and electrical wiring;
- 795 pounds of lead primarily to make car batteries, electronic components, and solder; and
- 757 pounds of zinc to make protective coatings on steel and chemical compounds for rubber and paint and to use as an alloy with copper to make brass.

of declining silver prices, which closed at the end of October at a 15-year low of $4.20. Poor market conditions were also responsible for the closure of the McDermitt mine in Humbolt County, the Nation's sole source of primary mercury.

Because the Nevada Legislature meets only during odd-numbered years, all State legislation affecting the mineral industry was held in abeyance until 1991.

NEW MEXICO

The total value of nonfuel mineral production in New Mexico was about $1.1 billion in 1990. This amount reflected a decline from the previous year of almost 4 percent and was the first drop in value since 1986 (Table 1). The State fell to twelfth place in output of nonfuel minerals.

The metals sector, including copper, gold, molybdenum, silver, and zinc, contributed nearly $750 million, or 69 percent, of the total value of nonfuel mineral production. Potash output furnished more than 21 percent of the total value. New Mexico mines also produced significant quantities of mica, perlite, sand and gravel, and stone.

New Mexico was ranked second in the Nation in copper production in 1990. During the year, the Tyrone and Chino mines in Grant County continued as the Nation's third and fourth largest copper producers, respectively. A report issued by Western New Mexico University estimated that the impending closure of the Tyrone mine would decrease annual revenues to the Silver City area by about $21 million.

Several copper deposits in the State were examined and pronouncements made concerning their possible development. In Grant County, the Continental property and a copper-oxide deposit in the Deadman Canyon area were evaluated during the year. The Copper Flat property in Sierra County, which operated briefly in 1982, was investigated for possible reopening. The deposit reportedly contains 53 million short tons of open-pit ore at an average grade of 0.45 percent copper.

Other metals that were produced in significant quantities in the State were molybdenum, gold, silver, and zinc. The Questa underground molybdenum mine in Taos County operated for a full year, following startup in late 1989. Most of New Mexico's gold and silver was produced as byproducts of base-metal production. Early in the year, the sulfide concentrator at Deming was refurbished and began concentrating copper and zinc ores shipped from the Pinos Altos underground mine in Grant County. The Hanover open-pit mine (Grant County) was reopened for zinc production, and the Midnight underground mine (Sierra County) was reopened for silver.

The value of New Mexico's industrial mineral production in 1990 was estimated to be about $329 million. Potash mined in the Carlsbad area represented more than one-fifth of the total value of nonfuel mineral production in New Mexico. Six subsurface mines increased their combined output by approximately 7 percent. Total production accounted for nearly 90 percent of all U.S. output. Representatives of the potash industry continued to urge the New Mexico Transportation Authority to create a regional transportation development district that could effectively address the industry's desire to have a shorter railroad connection to eastern markets.

Other commodities that contributed significantly to the total value of industrial mineral production were perlite, construction sand and gravel, and crushed stone. The production of perlite was the largest in the Nation. New Mexico mines also produced important quantities of mica and pumice. The sole producer of mica in the State announced plans to expand its operations at Velarde.

Most legislation introduced by the 1990 New Mexico Legislature that affected the mineral industry was generally favorable. Two tax bills (HB-428 and SB-208) that were beneficial to mining interests were passed and signed by the Governor. Mine wastes were specifically excluded from the comprehensive solid-waste management program enacted by the legislature in Senate bill 2. At the urging of the mining industry, State funds that were to be cut from the New Mexico Transportation Authority were restored.

The U.S. Congress passed legislation that protects a stretch of the East Fork of the Jemez River in Sandoval County from mining within 0.25 mile on either side of its banks. Legislation that was signed into law in June designates the river as part of the National Wild and Scenic Rivers System.

A report summarizing the impact of government policies on extractive industries in the State was issued by the Mining and Minerals Division of the New Mexico Energy, Minerals, and Natural Resources Department and by the Institute for Public Policy of the University of New Mexico. In September, a conference of panelists discussed the report and made recommendations in the principal areas of concern, including community assistance, education, marketing, regulation, and taxation. Toward yearend, these recommendations were submitted to the State legislature.

The BOM continued to investigate mineral deposits near the margin of the Great Plains in New Mexico. The study was conducted in conjunction with the New Mexico Bureau of Mines and Mineral Resources and the U.S. Geological Survey. A report on rare-earth minerals in the Laughlin Peak area (Colfax County) was completed. The BOM initiated two other studies during 1990: a mineral appraisal of the 14.5-million-acre Roswell Resource Area in southeastern New Mexico and a mineral-resource evaluation of a 100,000-acre addition to the Carson National Forest in the northern part of the State.

UTAH

The estimated value of nonfuel mineral production in Utah in 1990 was about $1.2 billion. This amount reflected a decline of about 4 percent from 1989 and was the first drop in value since 1985 (Table 1). The State fell from eighth to ninth place nationally in the output of nonfuel minerals.

Approximately 73 percent ($900 million) of the production value was attributed to the metals sector, including copper, gold, iron, magnesium, molybdenum, and silver. Utah mines also produced significant quantities of beryllium, cement, magnesium compounds, salt, sand and gravel, and vanadium.

Utah maintained its position as third in the Nation in copper output. The Bingham Canyon mine in Salt Lake County was the second largest U.S. producer. In January, the mine operator announced a $227-million project to increase copper production by 35,000 short tons per year. This expansion is expected to increase annual capacity by about 15 percent to 270,000 short tons, compared with the current level of 235,000 short tons. The output of byproduct metals would also increase by approximately 15 percent. The main component of the 2-year project will be the addition of a fourth grinding line and flotation circuit at the new Copperton concentrator.

Gold output by Utah mines was the fourth largest in the Nation. The Bingham Canyon mine, producer of byproduct gold from copper ores, was the largest producer of gold in the State. The Mercur mine in Tooele County was the largest producer of primary gold. Both the Barneys Canyon mine (Salt Lake County) and the Goldstrike mine (Washington County) produced gold as the principal commodity for a full year following startup in 1989. Potential targets for primary production that received major exploration interest during the year included the following prospects: Kings Canyon (Millard County), Long Ridge (Utah County), and Washington Dome (Washington County).

The output of molybdenum, which was produced as a byproduct of copper production at the Bingham Canyon mine, rose substantially over that of the previous year. The increase was chiefly due to improved efficiencies realized in the molybdenum circuit at the Copperton concentrator. Recovery of silver from stockpiled ore at the Escalante mine (Iron County) ceased in 1990. The mine was closed in 1988 because of depleted ore reserves.

The production of magnesium metal in Utah was the second largest in the Nation, and portland cement output continued to rise in 1990. Cement plants were operated at Leamington in Millard County and at Devil's Slide in Morgan County. Other important commodities produced in Utah were construction sand and gravel and salt. Demand for sand and gravel increased slightly during 1990 because of improved conditions in the construction industry.

Marked increases in the production of clays and magnesium compounds were reported for 1990. Most of the rise in clay production was attributed to common clays used in the rebounding construction industry. Iron ore production in the State remained relatively constant, and beryllium output increased slightly. Utah ranked fourth in the Nation for the production of iron ore; it was the only U.S. source of mined beryllium during the year. A new beryllium mining project adjacent to the existing operation in Juab County was evaluated by two joint-venture partners. Vanadium was recovered as a coproduct with uranium in the White Mesa mill at Blanding (San Juan County). The production of vanadium was slightly less than that of the previous year, and toward yearend, operations at the mill were suspended.

The Apex mine in Washington County was put into production for gallium and germanium early in the year. Because of metallurgical and operational difficulties, however, no gallium was produced, and the operation was halted in August.

A third operator began producing asphaltite (uintaite) in eastern Utah. One uintaite mine was placed on sale, as was the phosphate mine near Vernal.

The Utah Legislature in 1990 considered several bills that addressed environmental protection, taxation, and workers' compensation. Senate bill 199, which increased the severance tax on all metalliferous production to 2.6 percent, was passed into law after some modifications suggested by the mining industry. Passage of Senate bill 170 adopted Federal criminal penalties for hazardous-waste violations. The Governor's proposal to create an independent department of environmental quality was reviewed by legislative leaders and recommended for further evaluation.

At yearend, the BLM recommended that nearly 2 million acres of land in Utah be added to the National Wilderness Preservation System. The State's congressional delegation was divided on its recommendation: one faction proposed that 1.4 million acres of BLM land be designated as new wilderness; the other recommended 5.1 million acres. A report issued by the Western Economic Analysis Center asserted that restriction of the lands to wilderness use would cost the State an average of $1.4 billion (for 1.4 million acres) to $13.2 billion (for 5.1 million acres) per year for 25 years following wilderness designation.

The BOM continued a study begun in 1988 under the auspices of the Inventory of Land Use Restraints Program (ILURP). This long-term program was initiated to inventory Federal land-use restrictions to assess accurately the availability of Federal lands for mineral entry. Under ILURP in 1990, the BOM prepared a manuscript for the Utah study and completed mineral favorability maps for the State, all of which were technically reviewed by the Utah Geological and Mineral Survey.

The Utah Supreme Court issued two decisions during the year that may have significant impact on the State's mining industry. At midyear, the court ruled that State-assessed property must be taxed in essentially the same way as county-assessed property. Specifically, the court stated that the 20-percent exemption allowed county-assessed properties is discriminatory. Later in the year, the court agreed with a lower-court ruling that, in Utah, a property's mineral estate is exempted as a taxable asset. The Utah Supreme Court ruled, however, that a factual hearing must be held to determine if the actual practice of tax assessment conforms to the intent of the law or if it treats taxpayers differently and is, therefore, unconstitutional.

Utah Survey Is Renamed and Relocated

With passage of Senate Bill 189 in the 1991 Utah Legislature, the name of the Utah Geological and Mineral Survey was officially changed to the Utah Geological Survey. The office was also relocated to 2363 S. Foothill Dr., Salt Lake City, UT 84109.

REFERENCES

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Mineral Resource Information for Western States

The West is the richest and most productive mineralized region in the United States. Three western States -- Arizona, California, and Nevada -- ranked first through third, respectively, in U.S. nonfuel mineral production in 1990. Petroleum from Prudhoe Bay in Alaska contributes a major share of the Nation's oil and gas resources. A new book, *Mineral Resource Information Sources in the Western United States*, published as U.S. Geological Survey Circular 1063, lists the services available from three Federal agencies (U.S. Bureau of Land Management, U.S. Bureau of Mines, and U.S. Geological Survey) and State agencies in Alaska, Arizona, California, Colorado, Hawaii, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming. Publications, databases, libraries, and other information sources are included. To obtain a free copy of this 52-page reference, write to U.S. Geological Survey, Branch of Distribution, Books and Open-File Reports Section, Box 25425, Federal Center, Denver, CO 80225.

INDUSTRIAL MINERALS IN DAILY LIFE*

by Hal McVey
Mineral Marketing, Inc.
P.O. Box 343
Rough & Ready, CA 95975

Few of us realize the importance of industrial minerals in our everyday lives. Perhaps a trip through a normal working day will underscore our reliance upon these nonmetallic minerals. This article was written to emphasize how much our lives would change without ready and economical access to these fundamental constituents. The products that contain industrial minerals or require them in the manufacturing process are highlighted in **bold face.**

As we step out of bed in the morning, we place our feet on the **carpet**. (Calcium carbonate, or limestone, is used in the carpet backing.) We find our way to the kitchen and switch on the **electric light** and **coffee pot**, which are made of either glass or ceramics. (Both **glass** and **ceramics** are made entirely from industrial minerals: silica sand, limestone, talc, lithium, borates, soda ash, and feldspar.) As we enter the kitchen, we walk on **linoleum** (calcium carbonate, clay, and wollastonite) or **ceramic tile**.

While the coffee is brewing, we sit down to read the **newspaper**. At the same time, we remember that we have to take a trip, so we consult our **Official Airline Guide** and refer to the **Yellow Pages** of the phone book for the number of the airline. (All of these papers are filled with kaolin clay; limestone, sodium sulfate, lime, and soda ash are used to process them.)

The coffee is ready. We brown a slice of **toast** and sneak a piece of **cake** from last night's party. (Bakery items, such as **bread** and **cake icing,** contain gypsum.) The **plate** from which we are eating is composed of **glass, ceramics,** or **china,** a special form of ceramics. We might also have a full breakfast or contemplate what we'll have for lunch or dinner. All of the **food** that we eat relies on industrial minerals for its growth and production. (All **fertilizers** are composed of potash, phosphates, nitrogen, sulfur, and other minor minerals. The acidity of soils must be regulated with gypsum, limestone, or sulfur. In fact, without industrial minerals, there would be no modern agriculture.) One of the most basic **food additives** is an industrial mineral: salt. It is so basic that it was historically used as a medium of trade or payment, as implied in our word *salary*.

We now get ready for work. We brush our teeth with **toothpaste** (calcium carbonate [limestone] or sodium carbonate). Women might put on **lipstick** (calcium carbonate and talc) and **powder** (talcum); men may use **hair cream** (calcium carbonate). Other forms of **makeup** also contain industrial minerals. The **counter top** in the bathroom is **synthetic marble** or **synthetic onyx** (titanium dioxide, calcium carbonate, and alumina hydrate). Sinks, basins, toilets, and similar fixtures throughout the house are kept shiny with **cleansers** (silica, pumice, diatomite, feldspars, and limestone). Kitchen and bathroom tiles are installed and waterproofed with **putty** and **caulking compounds** (limestone and gypsum).

Before we leave, we brighten up our wardrobe with **jewelry.** (All precious and semiprecious stones -- opal, amethyst, aquamarine, topaz, garnet, diamond, etc. -- are industrial minerals.) There is a less attractive task to do at the last minute: changing the **kitty litter** (attapulgite, montmorillonite, zeolites, diatomite, pumice, or volcanic ash).

As we walk outside, we make a mental note to fix the **composite roof**. (**Fiberglass** is composed of almost the same ingredients as regular glass: silica, borates, limestone, soda ash, and feldspar. Fiberglass and asphalt, along with lesser quantities of either talc, silica sand, or limestone, make up composition roofing.) As we get in the car, we plan planting and gardening projects for the evening. In addition to **fertilizers,** we need to buy **soil amendments** and **planting mixes.** (Vermiculite, perlite, gypsum, zeolites, or peat improve plant growth.)

Once we leave for work, we are surrounded by industrial minerals. Our **car** is composed of them, starting from the ground up. **Tires** contain clays and calcium carbonate, and **mag wheels** are made from dolomite and magnesium. All of the **glass** in the car is entirely made from minerals, as is the **fiberglass body** that is becoming popular on many models. Many **components** in the car are made of **composites,** which are usually combinations of **fiberglass** and **plastics.** (Plastics are made from calcium carbonate, wollastonite, mica, talc, clays, and silica.) As we drive to work, we benefit from numerous industrial minerals in the **bumpers, dashboard, radiator cap,** and **floor mats,** among others.

The **paint** that makes our car so attractive is mostly composed of industrial minerals: titanium dioxide, kaolin clays, calcium carbonate, micas, talc, silica, wollastonite, and others. In fact, all paints that we encounter today, from that on our house to the stripe down the middle of the road to the interior of our office and other buildings, are composed of industrial minerals.

Modern transportation is almost entirely reliant upon industrial minerals, and this does not stop with the car. **Gasoline** and **lubricants** depend on industrial minerals because the **drill bit** that

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*This article was first presented at the Industrial Minerals Conference that was sponsored by the U.S. Geological Survey and California Division of Mines and Geology and held in Marina del Rey, California on February 15-16, 1989. It is reprinted here with permission from the author.

originally discovered the crude oil was faced with industrial diamonds. **Drilling fluids**, used for ease of well drilling, are almost entirely made from barite, bentonite, attapulgite, mica, perlite, and others. Clays and zeolites are used in the catalytic cracking process to refine crude petroleum and produce gasoline and lubricants.

On our way to work, we don't think about it, but we are literally riding on industrial minerals. **Concrete pavement** is composed of **cement** and **aggregates**. Aggregates are themselves industrial minerals: sand and gravel or crushed stone, such as limestone, dolomite, granite, and lava. Cement is manufactured from limestone, gypsum, iron oxide, clays, and possibly pozzolan. Even **asphaltic pavement** or **blacktop** contains industrial minerals as aggregates.

The **building** we are about to enter is made from or of industrial minerals. If it is a **concrete, stone,** or **brick** building, it is entirely made from industrial minerals. There may be **steel** structural members; the steel production process requires fluorspar for fluxing, bentonite for pelletizing, and perhaps chromite for hardening. The making of steel requires the use of high-grade **refractory bricks** and **shapes** made from bauxite, chromite, zircon, silica, graphite, kyanite, andalusite, sillimanite, and clays. **Fiberglass batts** may be used for insulation in our office building, as they are in our home.

Inside the building, we are often enclosed by **wallboard** or **sheetrock** (gypsum with fire-retardant additives, such as clays, perlite, vermiculite, alumina hydrate, and borates), joined together with **joint cement** (gypsum, mica, clays, and calcium carbonates). The **plate-glass windows** are entirely made from industrial minerals. The **floors** or **decks** between floors are probably made from **concrete** with **lightweight aggregate** (perlite, vermiculite, zeolites, or expanded shales).

To begin our work, we may pick up a **pencil** (graphite and clays) to make a list of things to do. One of our first tasks is to mail a few invoices that are backed with **self-contained carbon paper** (bentonite or other clays or zeolites). We need to order some supplies, so we pick up a **catalog** or **magazine** and note the glossy feel of the **paper**, due to a high content of kaolin clay or calcium carbonate, and the extreme whiteness of the paper, due to titanium dioxide. Almost every sheet of paper that we use was made from industrial minerals, such as talc, or contains minerals as fillers and coaters. Even some **inks** contain calcium carbonate or other fillers.

The morning has worn on and it is time for a break. In addition to drinking coffee in a **coffee cup**, which is made of industrial minerals, we eat a roll that has been heated in the microwave on a **microwavable container** (plastics filled and reinforced with talc, calcium carbonate, and titanium dioxide or clays). While on break, we ponder what to do during the weekend. **Recreational devices**, such as **golf clubs, tennis rackets, fishing rods,** and **skis**, are commonly made from graphite or a slightly "older" material, fiberglass. **Backpacking equipment**, such as **pack frames, pots,** and **pans**, are made of **aluminum**. (All aluminum, for whatever use, originates with bauxite, one of the most widely used industrial minerals.) The **mantles** in camping lanterns are also made from an industrial mineral, thorium.

Communications equipment incorporates numerous industrial minerals. The standard product of the industry for many years has been the **silicon chip**, made from quartz or silica as the name implies. **Optical fibers**, made from glass, are replacing some copper wiring. The **television screen** or **computer monitor** is made of glass, but critical **tubes** also contain phosphors made from the rare earths or lanthanides, a family of industrial minerals. Even **superconducting materials** are made from industrial minerals (yttrium, lanthanides, titanium, zirconium, and barite).

After a hard day at the office, we stop for refreshments with our friends. A glass of **fruit juice** or, for the less temperate, **wine** or **beer**, would be refreshing. All of these liquids are filtered through either perlite or diatomite during the purifying and clarifying processes. If we add **sugar** to any of our drinks, we will enjoy the benefits of industrial minerals because limestone and lime are basic to the production of **sweeteners**. Our refreshments may be served in **ceramic mugs** or **glasses**, which are composed entirely of industrial minerals.

Filtering and purification are major uses for industrial minerals. Drinking **water** is purified and clarified by filtering through limestone, lime, and salt. Wastewater-treatment plants use zeolites, soda ash, lime, and salt in the filtering process. **Vegetable oils** are filtered through clays, perlite, or diatomite. All of the minerals mentioned in this paragraph are used to filter and purify water in swimming pools.

After we return home, we may need to take **medicine** or **pharmaceuticals. Antacid pills** are essentially made from calcium carbonate. Other treatments for upset stomachs include **Milk of Magnesia** (made from magnesia or dolomite), **Kaopectate** (made from kaolin), and medicines made from clays, such as attapulgite. We ingest the **barium "cocktail,"** made from barite, prior to being X-rayed for gastrointestinal disorders. Iodine is used in **tincture of iodine** for cuts and bruises. **Lithium**, which is used to treat manic depression, is derived from an industrial mineral.

Abrasives are used for making **sandpaper** for home or workshop use, **emery boards** for our fingernails, and **polishing compounds** for our silverware and other items. Abrasives are made from pumice, diatomite, silica, garnet, corundum, and emery. **Porcelain figures** for our what-not shelves are made from silica, limestone, borates, and soda ash, and **plaster-of-paris statues** for our lawn are made from gypsum.

As a final testament to our dependence on industrial minerals, an ode to our lives will eventually be inscribed in the form of an elegy on **monumental stone**, made from marble or granite.

States Collect $481 Million for 1990 Share of Federal Mineral Revenues

The Minerals Management Service (MMS) of the U.S. Department of the Interior distributed $481.3 million to 27 States last year. This total is the States' cumulative share of 1990 revenues from mineral extractions on Federal lands located within their borders and from Federal offshore oil and gas tracts adjacent to their shores. Most States share the revenues equally with the Federal government: 50 percent to the State, 40 percent to the Reclamation Fund for water projects, and 10 percent to the U.S. Treasury. One exception, Alaska, gets a 90-percent share, as prescribed by the Alaska Statehood Act. In 1990, five States -- Wyoming, New Mexico, Colorado, Utah, and California -- received more than 83 percent of the total revenues. Arizona received $167,317.50, or 0.03 percent of the total.

Great Basin Proceedings Now Available

Proceedings of the April 1990 symposium, "Geology and Ore Deposits of the Great Basin," held in Sparks and Reno, Nevada, are now available. The 1,257-page two-volume set includes 95 papers and costs $95.00. The 1,000-page field-trip guidebook for this symposium contains 18 new and updated road logs, as well as new papers, and costs $75.00. The 140-page program with abstracts contains 139 abstracts for all oral and poster presentations and costs $10.00. All prices include shipping and handling. To obtain copies, send payment to the Geological Society of Nevada, P.O. Box 12021, Reno, NV 89510; tel: (702) 323-3500.

Theses and Dissertations, 1990

compiled by Nancy Schmidt
Arizona Geological Survey

The following list includes theses and dissertations on Arizona geology, geological engineering, hydrology, and related subjects that were awarded in 1990 by Arizona State University, Northern Arizona University, and the University of Arizona. This list, however, is not a complete compilation of theses on such topics. Theses on the geology of other States or countries that were awarded by these universities are not listed, nor are theses on the geology of Arizona that were awarded by out-of-State universities.

Most theses included here are not available in the library of the Arizona Geological Survey. Each thesis, however, may be examined at the main library of the university that awarded it. Information may also be obtained from the respective departments, which are indicated in parentheses after each citation according to the codes listed below.

Arizona State University, Tempe, AZ 85287; (602) 965-9011. (Gg-Geography; Gl-Geology)

Northern Arizona University, Flagstaff, AZ 86011; (602) 523-9011. (G-Geology)

University of Arizona, Tucson, AZ 85721; (602) 621-2211. (G-Geosciences; HWR-Hydrology and Water Resources; MGE-Mining and Geological Engineering; MSE-Materials Science and Engineering; RNR-Renewable Natural Resources; SWS-Soil and Water Science)

ARIZONA STATE UNIVERSITY

Gorey, T.L., Stream terraces of Middle Cave Creek, Maricopa County, Arizona: M.S. thesis, 96 p. (Gl).

Knoebl, Emmerich, A model of metamorphic fluid production during subduction of pelagic sediments: M.S. thesis, 86 p. (Gl).

Lehman, T.W., Copper and zinc in sediments of Whitlow Ranch Reservoir, Queen Creek, Arizona: M.A. thesis, 95 p. (Gg).

Posin, S.B., Eruptive conditions and volcano morphology: M.S. thesis, 209 p. (Gl).

NORTHERN ARIZONA UNIVERSITY

Basham, E.L., Fluvial architecture of the Wupatki and Holbrook Members of the Lower/Middle Triassic Moenkopi Formation, northeastern and north-central Arizona: M.S. thesis, 178 p. (G).

Deacon, M.W., Depositional analysis of the Sonsela Sandstone Bed, Chinle Formation, northeast Arizona and northwest New Mexico: M.S. thesis, 128 p. (G).

Labrenz, M.E., Structure of Early Proterozoic rocks and emplacement of the Young Granite, Pleasant Valley area, northern Sierra Anchas, Gila County, Arizona: M.S. thesis, 92 p. (G).

Leighty, R.S., Gravity evidence for a Proterozoic crustal boundary along the southern Shylock fault zone, central Arizona: M.S. thesis, 72 p. (G).

Martin, E.R., Structural and stratigraphic expression of late Cenozoic extensional tectonism, eastern and northern Payson basin, central Arizona: M.S. thesis, 137 p. (G).

Mayes, H.B., Cenozoic stratigraphy and depositional history of the northern Tonto basin, Gila County, Arizona: M.S. thesis, 113 p. (G).

Melis, T.S., Evaluation of flood hydrology on twelve drainage basins in the central highlands region of Arizona: An integrated approach: M.S. thesis, 135 p. (G).

Nation, M.J., Analysis of eolian architecture and depositional systems in the Jurassic Wingate Sandstone, central Colorado Plateau: M.S. thesis, 222 p. (G).

Norton, A.K., Depositional environments, diagenesis,and stratigraphic relationship of the Kaibab and San Andres Formations (Permian) of Navajo and Apache Counties, Arizona: M.S. thesis, 156 p. (G).

Sanchez, P.E., Seismicity and seismotectonics of the Verde Valley and Transition Zone of central Arizona: M.S. thesis, 108 p. (G).

Thiessen, K.R., A new reptile from the Triassic Moenkopi Formation of Arizona: M.S. thesis, 106 p. (G).

Wessels, Rick, Re-evaluation of the Slate Creek shear zone: Structure of Early Proterozoic rocks, northern Sierra Anchas, Gila County, Arizona: M.S. thesis, 81 p. (G).

Zuber, J.D., Geochemistry and sedimentology of paleosols in the Upper Petrified Forest Member, Chinle Formation, Petrified Forest National Park, Arizona: M.S. thesis, 152 p. (G).

UNIVERSITY OF ARIZONA

Al-Rawahy, K.H., Embodied consumption of U.S. copper and sulfur: Implications for intensity of use estimation and forecasting: Ph.D. dissertation, 203 p. (MGE).

Arslan, Awadis, Modeling water quality for soils containing gypsic horizons: Ph.D. dissertation, 174 p. (SWS).

Betancourt, J.L., Tucson's Santa Cruz River and the arroyo legacy: Ph.D. dissertation, 239 p. (G).

Bykerk-Kauffman, Ann, Structural evolution of the northeastern Santa Catalina Mountains, Arizona: A glimpse of the pre-extension history of the Catalina Complex: Ph.D. dissertation, 195 p. (G).

Carpenter, M.C., Earth-fissure movements associated with fluctuations in ground-water levels near Picacho Mountains, south-central Arizona, 1980-84: Ph.D. dissertation, 116 p. (HWR).

Chakraborty, Sumit, Multicomponent cation diffusion in aluminosilicate garnets: Theory, experiments, and applications: Ph.D. dissertation, 192 p. (G).

Checchio, Elizabeth, Water transfers in Arizona: Measuring effects on areas of origin: M.S. thesis, 197 p. (HWR).

Coggeshall, M.C., Hydrologic assessment and computer model application in the upper Santa Cruz River basin, Santa Cruz County, Arizona: M.S. thesis, 125 p. (HWR).

Cole, G.L., Models of plate kinematics along the western margin of the Americas: Cretaceous to present: Ph.D. dissertation, 460 p. (G).

Didi, Didace, Electrical methods surveys in southern Arizona for hydrogeological investigations: M.S. thesis, 145 p. (MGE).

Duncan, J.T., The geology and mineralization of the northern Plomosa district, La Paz County, Arizona: M.S. thesis, 135 p. (G).

Gonzalez, J.L., An evaluation of the ^{15}N values of nitrate in ground water at Quartzsite, Arizona: M.S. prepublication manuscript, 20 p. (G).

Hartman, K.A., P- and S-wave velocity structure and Poisson's ratio beneath the Colorado Plateau of central Arizona: M.S. prepublication manuscript, 22 p. (G).

Hsu, Shyh-Shyan, Laboratory shear tests on Apache Leap Tuff: M.S. thesis, 152 p. (MGE).

Jackson, G.W., Tectonic geomorphology of the Toroweap fault, northwestern Arizona: Implications for transgression of faulting on the Colorado Plateau: M.S. prepublication manuscript, 61 p. (G).

Jeton, A.E., Vegetation management and water yield on a southwestern ponderosa pine watershed: An evaluation of three hydrologic simulation models: M.S. thesis, 181 p. (RNR).

Kemna, S.P., Some geomorphic models of flood hazards on distributary flow areas in southern Arizona: M.S. thesis, 171 p. (HWR).

Lerch, M.F., Geologic mapping and isotopic studies in the Quartzsite region, west-central Arizona: Implications for Proterozoic and Mesozoic tectonics: M.S. prepublication manuscript, 65 p. (G).
Loy, K.L., Subsurface structure of the southern and central Tucson basin, Pima County, Arizona: M.S. thesis, 81 p. (G).
McCord, V.A.S., Augmenting flood frequency estimates using flood-scarred trees: Ph.D. dissertation, 182 p. (G).
McGill, J.W., Ground penetrating radar investigations with applications for southern Arizona: M.S. thesis, 261 p. (MGE).
Orr, R.C., Geology and mineralization associated with the Early Proterozoic Alder Group, the Sunflower mining district, Maricopa and Gila Counties, Arizona: M.S. thesis, 143 p. (G).
Park, Wonkyu, Development of anatomical tree-ring chronologies from southern Arizona conifers using image analysis: Ph.D. dissertation, 234 p. (RNR).
Qi, Peihao, Leaching and electrochemical behavior of gold in iodide solutions: M.S. thesis, 107 p. (MSE).
Schnell, C.W., A structural and stratigraphic interpretation of the Gaddes Basalt in the Oak Wash drainage of the Verde mining district, central Arizona: M.S. thesis, 161 p. (G).
Schwartz, K.L., A geohydrologic investigation of volcanic rocks using the gravity survey method: Galiuro Mountains, Graham, Pinal, and Cochise Counties, Arizona: M.S. thesis, 138 p. (G).
Schwartzman, P.N., A hydrogeologic resource assessment of the lower Babocomari watershed, Arizona: M.S. thesis, 212 p., scale 1:24,000, 3 sheets. (HWR).
Shenk, J.D., Economic geology of the White Cliffs diatomite deposit, Mammoth, Arizona: M.S. thesis, 157 p. (G).
Stevens, Craig, Variations of Cl/Br ratios in ground water of Tucson basin and Avra Valley, Arizona: M.S. prepublication manuscript, 29 p. (G).
Thoman, M.W., The electrical resistivity structure of the EZ-1 breccia pipe with geologic correlation: M.S. thesis, 298 p. (G).
Van Metre, P.C., Flow and water quality relations between surface water and ground water in the Puerco River basin near Chambers, Arizona: M.S thesis (HWR).
Williams, C.A., Numerical modeling of fault formation and the dynamics of existing faults: Ph.D. dissertation, 282 p. (G).
Woodward, J.A., The role of lithology and non-tectonic base level change on the development of three pediment levels, southwestern Santa Catalina Mountains, Arizona: M.S. prepublication manuscript, 27 p. (G).
Zhang, Renduo, Soil variability and geostatistical applications: Ph.D. dissertation, 281 p. (SWS).

Frank Kottlowski Retires From NMBMMR

Dr. Frank E. Kottlowski retired from the New Mexico Bureau of Mines and Mineral Resources (NMBMMR) in April, after having served as director for 17 years. Kottlowski began working at the NMBMMR in July 1951, immediately after receiving a Ph.D. degree in geology from Indiana University. He has written numerous papers on New Mexico geology, served on countless committees, and participated in the activities of professional societies. He was a member of the Association of American State Geologists (AASG) and served as its president from 1984 to 1985. At their annual meeting in May, AASG members elected Kottlowski as an honorary member. His retirement plans include carrying out the necessary field work to complete his geologic projects that were delayed because of his administrative responsibilities. Kottlowski is succeeded by Dr. Charles E. Chapin, who has been employed at the NMBMMR as a research geologist for the past 20 years and is an adjunct professor in the Department of Geoscience at the New Mexico Institute of Mining and Technology.

Peter Kresan Receives Distinguished Teaching Award

Peter L. Kresan, adjunct lecturer in the Department of Geosciences at the University of Arizona (U of A), is the 1991 recipient of the Five Star Faculty Award. About 100 teachers were nominated for the award, which is sponsored by the Honors Student Planning Board and is based on evaluations, classroom observations, and interviews. Kresan has been a presence on the U of A campus since 1981, when he worked as a research assistant and adjunct instructor. He won the Outstanding Teacher award in 1981 and Faculty of Science Innovation in Teaching award in 1989 and received previous nominations for the Five Star Faculty Award. Kresan is a member of the Arizona Geological Survey's advisory committee on earth science education and has contributed several articles and photographs to *Arizona Geology* and its predecessor, *Fieldnotes*.

TED EYDE ELECTED SME PRESIDENT

Ted H. Eyde is the 1991 president of the Society for Mining, Metallurgy, and Exploration (SME), a professional society with a worldwide membership of 20,000 engineers and geologists. A resident of Tucson since 1959, Eyde is president of GSA Resources, Inc., a company that owns, manages, and participates in ventures that explore for and produce specialty industrial minerals. The company owns and operates the Grace chabazite mine near Bowie, the Lyles hectorite deposit near Kirkland, the East and West Burro Creek saponite deposits, and the Cheto No. 1 bentonite deposit at Sanders. All of these mines are in Arizona.

Eyde's major priorities as SME president are to encourage the SME to take positions on government policies that would affect the orderly development and production of the Earth's mineral resources, to increase membership, and to continue improving the scope and quality of *Mining Engineering* magazine.

A registered geologist with 35 years of mineral exploration and mining experience, Eyde received his bachelor's and master's degrees in geological engineering from the Montana School of Mines. He is past president of the Mining and Exploration Division of SME, has served on the SME Board of Directors, is a Distinguished Member of the SME, is past president of the Arizona section of the American Institute of Professional Geologists, serves on the exam committee of the Arizona State Board of Technical Registration, and is a member of the American Institute of Mining and Metallurgical Engineering and the Arizona, New Mexico, and West Texas Geological Societies. We are especially pleased that he is also a member of the Arizona Geological Survey's advisory committee on mineral resources.

Resource Materials for Earth Science Teachers

Energy Resources of Arizona, by John Duncan and Frank Mancini, is the first publication to be released in the Arizona Geological Survey's (AZGS) new Down-to-Earth Series. This series was established to address geologic concepts and perspectives in a "down-to-earth" manner, i.e., through the use of relatively few technical terms. This publication describes Arizona's renewable and nonrenewable energy resources, including coal, hydroelectric power, uranium and nuclear power, oil and gas, geothermal energy, solar energy, wind power, and biomass energy. Each chapter describes the nature of a resource, outlines the locations, geologic settings, and size or importance of the resource in Arizona, and specifies the extent of development, markets, uses, and potential for future development. Separate chapters at the end of the report list the State and Federal agencies with energy-related responsibilities. Important energy production, processing, and transportation facilities are identified on an accompanying 1:1,000,000-scale map of Arizona.

This 17-page nontechnical summary is suitable for high-school earth-science students, as well as adults who want to learn more about the resources that fuel modern civilization. The result of a cooperative project between the AZGS and the Energy Office of the Arizona Department of Commerce, the report may be purchased for $10.50 (shipping included) from the Arizona Geological Survey, 845 N. Park Ave., #100, Tucson, AZ 85719; tel: (602) 882-4795.

Earth Science Education Receives Boost From Scientific Community

On December 5, 1990, the Council of Scientific Society Presidents provided written evidence of their support for earth science education by adopting a resolution recommending that geoscience be incorporated into the precollege curriculum and accepted as a laboratory science for college admission. The interdisciplinary council is composed of officers from 57 physical, mathematical, and life science societies in the United States. Their resolution is as follows:

Whereas an understanding of the earth's land, water, and atmospheric systems that control our environment and supplies of resources is important to all citizens; and

Whereas the distribution, development, and use of energy and mineral resources around the world have a significant influence on the economy of the United States and our foreign policy; and

Whereas the inhabitability of our cities and coasts, and the productivity of our agricultural lands and oceans may be strongly influenced by global climatic change, the disposal of wastes, and the protection of our water supplies; and

Whereas the United States must attract a much larger number of students into scientific careers, and the study of geoscience can provide an effective way to demonstrate the relevance of science to issues that interest and are of concern to students;

Therefore be it resolved that the Council of Scientific Society Presidents strongly recommends that substantial study of the geosciences (e.g., soil science, geology, meteorology, oceanography, astronomy) be made a part of the pre-college curriculum in the United States middle and high schools and that its status as a laboratory science be acceptable for college admission along with biology, chemistry, and physics.

Be it further resolved that geoscience shall be one of the themes for the teaching of science in the elementary schools in our country.

Janice VanCleave's Earth Science for Every Kid: 101 Easy Experiments That Really Work includes experiments that can be safely, easily, and cheaply performed at home or in the classroom. Each experiment specifies its purpose, a list of materials, step-by-step instructions, expected results, and a scientific explanation in terms that elementary school children can understand. The experiments have been "child tested" by the author's own students. This 231-page science-activity book includes a glossary and index and is available for $10.95 from John Wiley & Sons, Inc., Order Dept., 1 Wiley Dr., Somerset, NJ 08875-1272; tel: (908) 469-4400, ext. 2499.

Science in a Nanosecond: Illustrated Answers to 100 Basic Science Questions, by James A. Haught, provides answers to deceptively simple questions, such as these: Why is the sky blue? Why are there seasons? How fast does the Earth rotate? What holds an airplane in the sky? What causes earthquakes? This 110-page, easy-to-read, illustrated text explains important scientific ideas in physics, astronomy, and geology. Suitable for parents and teachers as well as elementary school children (ages 10 and up), it is available for $12.95 plus shipping ($3.00 for first book; $1.50 for each additional book; $9.00 maximum) from Prometheus Books, Warehouse and Fulfillment Center, 59 John Glenn Dr., Amherst, NY 14228-2197; tel: (716) 691-0133 or (800) 421-0351.

Water in Your Hands, a children's introduction to the problems of water quality and management, uses cartoon characters to explain the basic issues. A teacher's guide that includes classroom activities and additional information is also available. Single copies of the 16-page booklet are $0.75; single copies of the teacher's guide are $2.00; bulk orders are discounted. Write to the Soil and Water Conservation Society, 7515 N.E. Ankeny Rd., Ankeny, IA 50021-9764; or call (515) 289-2331 or (800) THE-SOIL.

"Inside Hawaiian Volcanoes," a recent 25-minute film coproduced by the Smithsonian Institution and U.S. Geological Survey, uses spectacular eruption footage and computer-generated animation to illustrate features of eruptions and the underground workings of Hawaiian volcanoes. Scenes include lava fountains, scientists monitoring eruptions, and cutaway underground views. The 16-mm film may be borrowed from Modern Talking Picture Service, Inc., 5000 Park Street North, St. Petersburg, FL 33709; tel: (813) 541-7571. It may also be purchased in VHS format for $20.00 from the Smithsonian Institution, Dept. of Mineral Sciences, NHB-119, Washington, DC 20560; Attn: Richard S. Fiske. A teacher's guide to the film includes questions that a teacher might pose to students after they have viewed the film, as well as lab exercises that illustrate how scientists can better understand the underground workings of a volcano and attempt to forecast eruptions. The 20-page teacher's guide, published as Open-File Report 89-685, may be purchased for $3.50 from the U.S. Geological Survey, Books and Open-File Reports Section, Box 25425, Denver, CO 80225.

"Out of the Rock," a new video produced by the U.S. Bureau of Mines (BOM), focuses on the importance of minerals, environmental issues associated with mining, and new technologies. One of many videos in the BOM's Mineral Resource series, "Out of the Rock" is available in 1/2" VHS and 3/4" U-Matic videocassette formats. BOM films and videos may be borrowed for free, except for return postage. For a free catalog or loan copy of the video, write to Audiovisual Library, U.S. Bureau of Mines, Cochrans Mill Rd., P.O. Box 18070, Pittsburgh, PA 15236. Include your phone number and preferred showing dates. Copies of the video may also be purchased from Ernie Aschenbach, Video Transfer Inc., 5710 Arundel Ave., Rockville, MD 20852; tel: (301) 881-0270.

New AZGS Publications

The following publications may be purchased from the Arizona Geological Survey (AZGS), 845 N. Park Ave., #100, Tucson, AZ 85719. Orders are shipped by UPS; a street address is required for delivery. All orders must be prepaid by check or money order payable in U.S. dollars to the Arizona Geological Survey. Add shipping and handling charges, listed below, to your total order:

In the United States:	20.01 - 30.00, add 5.75	50.01 - 100.00, add 10.25
$1.01 - $5.00, add $2.00	30.01 - 40.00, add 6.50	Over 100.00, add 12%
5.01 - 10.00, add 2.50	40.01 - 50.00, add 8.00	Other countries: Request price quotation.
10.01 - 20.00, add 4.50		

Duncan, J.T., and Mancini, F.P., 1991, Energy resources of Arizona: Down-to-Earth Series 1, 17 p., scale 1:1,000,000. $8.00

See description under "Resource Materials for Earth Science Teachers" on page 10.

Doorn, P.L., and Péwé, T.L., 1991, Geologic and gravimetric investigations of the Carefree Basin, Maricopa County, Arizona: Special Paper 8, 187 p., scale 1:24,000 and 1:48,000, 10 sheets. $25.00

The Carefree Basin just north of Phoenix, like many other areas near major cities, is experiencing rapid population growth. Construction of roads, buildings, and other structures is influenced by the type and character of the rocks and surficial materials on which they are built. Construction of other urban facilities, such as water-supply and waste-disposal plants, requires an understanding of subsurface geologic and hydrologic conditions as well. Information contained in this report should assist those responsible for the stewardship of the Carefree Basin area. The report describes the geologic framework of the area, characterizes the major rock units and surficial materials, and includes information and interpretations about subsurface geologic conditions. The report and accompanying maps, three of which are in color, are based on P.L. Doorn's master's thesis, as well as other theses and reports, and were published in cooperation with several other State agencies, town councils, and private organizations.

Duncan, J.T., and Spencer, J.E., 1991, A survey of uranium concentrations in rocks and soils in populated areas of Arizona -- Methods: Open-File Report 91-2, 9 p. $1.50

Uranium in rock and soil is the ultimate source of indoor radon gas, which is considered to be a potential geologic hazard. Higher levels of uranium are associated with higher levels of indoor radon. The U.S. Environmental Protection Agency provided funds, channelled through the Arizona Radiation Regulatory Agency, to the Arizona Geological Survey for a survey of uranium levels in populated and population-growth areas of Arizona. A gamma-ray spectrometer was purchased for the survey. This report describes spectrometer calibration and routine operation, data collection and reduction, and determination of regional uranium levels for common, nonanomalous rocks and soils.

Duncan, J.T., and Spencer, J.E., 1991, Uranium-bearing rocks of Verde Valley, Coconino and Yavapai Counties, Arizona, and implications for indoor radon gas: Open-File Report 91-3, 11 p., scale 1:32,000, 2 sheets. $4.75

The Verde Formation is widely exposed in Verde Valley and includes two units. The lower unit largely consists of carbonate-rich mudstone; the upper unit largely consists of white limestone, with minor amounts of carbonate-rich mudstone. The mudstone commonly contains elevated uranium concentrations and could be a significant source of radon gas. This report outlines the extent of the uraniferous rocks and presents data on their uranium levels.

Lehman, N.E., 1978, Geologic map and cross sections of the Washington Camp--Duquesne mining district, Patagonia Mountains, Santa Cruz County, Arizona: Contributed Map CM-91-A, scale 1:4,800, 3 sheets. $5.00

These three maps are based on investigations that the author conducted in partial fulfillment of a Ph.D. degree.

Gray, I.B., and Ciesiel, Robert, 1991, Geologic maps of the underground workings of the Black Rock and Sally uranium mines, Navajo County, Arizona, with a text by W.L. Chenoweth: Contributed Report CR-91-A, 6 p., scale 1:171. $4.00

Exploration for uranium in 1955 resulted in the establishment of several mines in a remnant channel deposit in the Triassic Chinle Formation. The host rocks for the Black Rock and Sally mines are massive sandstones and conglomerates, which filled a scour in the underlying Moenkopi Formation. Although samples from both mines contained favorable percentages of uranium and vanadium, neither mine was economically successful. These maps, which are from the archives of the U.S. Atomic Energy Commission (AEC), show the underground mine workings of both mines. The text describes their location, geologic history, and production.

Chenoweth, W.L., 1991, The geology and production history of the Bluestone No. 1 uranium-vanadium mine, Garnet Ridge, Apache County, Arizona, with notes on the U.S. Atomic Energy Commission's drilling project: Contributed Report CR-91-B, 9 p. $1.50

During the uranium boom of the mid-1950's, some 53 tons of uranium-vanadium ore was produced from the Bluestone No. 1 mine on Garnet Ridge. The host rock for this ore deposit was the Jurassic Navajo Sandstone where it was in contact with a Tertiary serpentine rubble dike. This report includes a location map and lithologic logs of four core holes drilled in 1951 and 1952, describes the geologic setting, and provides production statistics. Most of the information is from the AEC archives.

STAFF NOTES

Thomas G. McGarvin gave a talk, "Invisible Importance: No Rocks, No Ice Cream," to approximately 50 Boy Scouts at their Camporee in the Buenos Aires National Wildlife Refuge on March 23. On April 6, he gave a talk, "Geologic Setting of the Phoenix Region," to more than 50 adults and children during the "DesertFest" at Phoenix's Desert Botanical Garden. At the Desert Gold Diggers' monthly meeting in Tucson on May 7, McGarvin spoke to 75 members about "Geological Processes and Results: Observing the Obvious." The Tucson Public Library's Summer Programs for Children included a talk by McGarvin on June 8, entitled "Rock Riddles and Mineral Mysteries." On June 18, he gave the presentation, "Looking Down Before You Can Look Up: Geology and Aerospace," to 35 teachers who attended the Embry-Riddle Aeronautical University's Aerospace Education for Teachers program in Prescott.

At the annual conference of the Association of State Floodplain Managers, held in Denver June 10-12, **Philip A. Pearthree** summarized his research in "Detailed Reconstruction of a Recent Alluvial-Fan Flood: Implications for Management of Flood Hazards in Piedmont Areas of Arizona." At the June 27-28 meeting of the Arizona Floodplain Management Association held in Payson, Pearthree critically assessed the methodology used by the Federal Emergency Management Agency to set flood-insurance rates for areas that are potentially subject to alluvial-fan flooding.

Stephen J. Reynolds led a field trip on May 3 to the Santa Catalina Mountains near Tucson for geologists from the U.S. Geological Survey and University of Arizona.

PROFESSIONAL MEETINGS

Survival in the Desert: Water Quality and Quantity Issues into the 21st Century. Annual symposium, Arizona Hydrological Society, September 12-14, Casa Grande, Ariz. Contact Todd Rasmussen, Dept. of Hydrology and Water Resources, University of Arizona, Tucson, AZ 85721; tel: (602) 621-6216.

Our Future is Now: Accepting the Environmental Challenge. Annual environmental education conference, Arizona Association for Learning In and About the Environment (AALE), September 27-29, Prescott, Ariz. Contact AALE, 179 W. Kent Dr., Chandler, AZ 85224 or call John Stair (602-621-7269) or Lorna Taylor (602-742-7184).

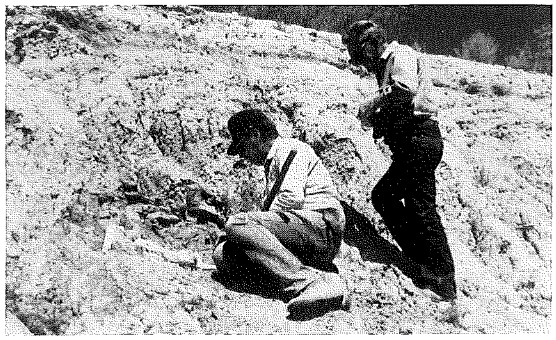
Arizona Science Teachers Association. Annual convention, October 3-4, Phoenix, Ariz. Contact David Byrum, 3301 E. Fort Lowell Rd., Tucson, AZ 85716; tel: (602) 795-2928.

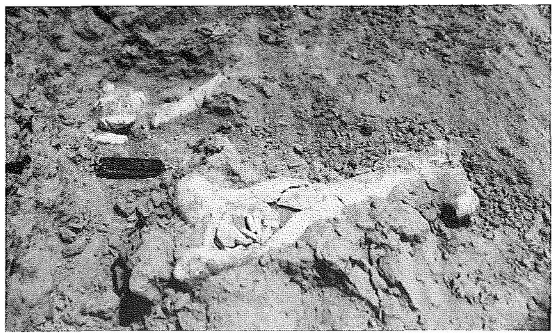
Geological Society of America (GSA). Annual meeting, October 21-24, San Diego, Calif. Contact GSA Meetings, P.O. Box 9140, Boulder, CO 80301; tel: (303) 447-2020 or 1-800-472-1988.

Riparian Issues and Interdisciplinary Symposium on Arizona's In-Stream Flows. Seminar sponsored by the Tucson chapter of the Arizona Hydrological Society and the Arizona chapter of the Soil and Water Conservation Society, November 15-16, Tucson, Ariz. Contact Placido Dos Santos, Arizona Dept. of Water Resources, 310 S. Meyer, Tucson, AZ 85701; tel: (602) 628-5858.

American Geophysical Union (AGU). Fall meeting, December 9-13, San Francisco, Calif. Contact AGU, 2000 Florida Ave., N.W., Washington, DC 20009; tel: (202) 462-6900.

VESTIGES OF AN EARLIER AGE





Dr. Everett Lindsay (top left) and Howard Schwalb (top right) examine an outcrop containing Pliocene-Pleistocene sediments (approximately 1 to 3 million years old). Schwalb discovered fossilized bone fragments of a horse (*Equus*), including a portion of a jaw, at this eastern Pima County location and brought them to the Arizona Geological Survey. The fossils were given to Lindsay, Professor of Geology at the University of Arizona, for identification. Schwalb led Lindsay and Tom McGarvin of the Arizona Geological Survey to the fossil locality. Several other fossilized bones and bone fragments were discovered and carefully removed by Lindsay for study, including the semi-articulated hind leg (femur) of a horse (bottom), toe bones and neck vertebrae of a llama (*Hemiauchenia*), and shell fragments of a pond turtle (*Kinosternon*).

THANK YOU

The Arizona Geological Survey (AZGS) extends special thanks to Mrs. Norman Lehman for donating geologic maps of the Washington Camp and Duquesne areas. Norm, her late husband, prepared the maps as part of his Ph.D. dissertation. The maps will be on file in the AZGS library and are available for sale or public inspection (see "New AZGS Publications" on page 11). The AZGS seeks high-quality mylars of geologic maps of areas in Arizona, compiled from original research. Contact the AZGS (602-882-4795) for more information.

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Director & State Geologist: Larry D. Fellows
Editor: Evelyn M. VandenDolder
Editorial Assistant: Nancy Schmidt
Illustrator: Peter F. Corrao
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Arizona Geological Survey
845 N. Park Ave., Suite 100
Tucson, AZ 85719
Tel: (602) 882-4795