

### WHAT'S UP DOWN THERE?

by  
H. Wesley Peirce

#### PROBING ARIZONA'S DEPTHS

Exploration activities that probe Arizona's third dimension are a source of geologic data vital to the continuing development of an understanding of its geologic framework. Drilling, a direct method for determining something about what is under foot, is motivated by the desire for discovery. The search may be for substances of direct economic value (metals, nonmetals, fuels and helium) or simply for basic information necessary for the evaluation of an engineering endeavor (underground storage projects, evaluation of subsurface water producing potential, etc.).

#### DATA ACQUISITION

The Bureau, continually seeking geologic understanding, is interested in all drilling activity, past, present, and future. Not having regulatory or enforcement powers we rely on the willingness of others to share information derived from drilling. As an example, the Arizona Oil and Gas Conservation Commission requires that one set of samples from all holes drilled within its jurisdiction be sent to the Arizona Bureau of Mines. Also, water well samples collected by the United States Geological Survey, Groundwater Branch, are stored by the Bureau. Many mining companies and others with exploration interests occasionally make core descriptions, logs, and/or samples available. Once in Bureau facilities, samples are available for study by any responsible party whether from government, industry, or education. In this way, maximum benefit can be derived from costly drilling.

Because there are more studies to be made than there are people to make them, and because techniques change, the same sample may be restudied many times. These factors encourage allowance for sample storage. The Bureau maintains a storage facility of limited capacity. It is hoped that in the future, for the best interests of Arizona, means will be provided to enable the continued acquisition and storage of small, but potentially vital, pieces of what's down in Arizona.

### FROM THE ACTING DIRECTOR

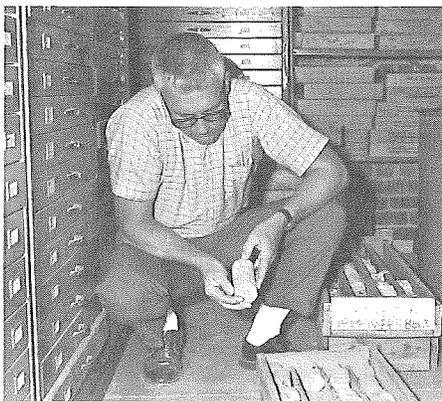
Many of you may not know that Dr. J.D. Forrester, our Director of the Arizona Bureau of Mines since 1956, retired last August. A new Director has not yet been appointed and I am acting in that capacity in the meantime.

It was Dr. Forrester's retirement, in part, which brought us to realize that a publication like this was really needed in order to get information out about Bureau affairs. We plan not only to do that on a periodic basis with this newsletter, but we also plan to have it serve as a clearing house, generally, for items of interest in the field of earth resources. We invite your participation in this effort.

At this time, it is our intention to carry on all of the activities performed under Dr. Forrester's direction. As in the past, we will be re-evaluating our programs constantly in order to add to and increase our capability to serve in the most appropriate way. The Arizona Bureau of Mines offices are located in the Geology-Mines building on the campus of the University of Arizona. Any member of the staff of the Bureau is available for discussion of matters of mutual interest, and we all would welcome the opportunity to have a visit with you.

I hope you enjoy this newsletter and will let us have your thoughts on how it might better serve you. We will also welcome additional names and addresses for our mailing list.

R.M. Edwards  
Acting Director



Typical of the many samples contained in the Arizona Bureau of Mines sample library, is this core from northwestern Arizona being examined by Dr. Peirce.

in each well. These same data also are shown graphically in plates. Most of the holes were drilled in connection with exploration for oil, gas, or helium and are distributed in 12 of the State's 14 counties. As a follow up to this initial effort a bulletin is being prepared that is to present additional geologic and engineering data about these and subsequent holes, especially the tops of important geologic units. This fundamental contribution will, among other things, make possible the construction of geologic illustrations that will help to provide additional insight into the State's geologic framework which, in turn, controls the occurrence of all of its earth material resources.

#### SOME DRILLING ADVENTURES - ARIZONA SALT

The status of saline resources of Arizona was summarized in 1969 in Arizona Bureau of Mines Bulletin No. 180: "Mineral and Water Resources of Arizona," pp. 417-424. At that time Arizona salt resources were not being utilized although potential uses were noted. Also, a proposed exploration effort near Phoenix was mentioned (p. 421). The two principal subsurface salt occurrences then known were in Mohave County near Red

*Continued on page 2*

#### DATA DISTRIBUTION AND PREPARATION

The Bureau, in cooperation with the Arizona Oil and Gas Conservation Commission, has been compiling well data for public distribution. An initial effort is presented in Arizona Bureau of Mines Bulletin No. 182: "Coal, Oil, Natural Gas, Helium, and Uranium in Arizona," in which 681 drill holes, through 1969, are recorded in table form. It indicates the oldest (deepest) geologic unit penetrated

**WHATS UP (continued)**

Lake playa north of Kingman, and in southern Navajo and Apache counties in the Holbrook region.

Subsequently, a subsurface storage project for liquid petroleum gas (lpg) was initiated at Holbrook. Storage will be in cavities washed from a salt horizon high in the Permian Supai Formation. In Mohave County, a hole drilled in connection with exploration for a site at which to develop underground storage for natural gas, penetrated over 4,000 feet of halite in the approximate interval 1800'-5850', the hole bottoming in halite. The Arizona Salt Company exploration effort northwest of Phoenix resulted in the penetration of 3,600 feet of halite, in the approximate interval 900'-4500', the hole bottoming in halite. Arizona Salt Company has constructed seven sealed evaporating ponds and contingent upon the successful completion of a production well, should be in production during the 1971 thermal season. The resulting cavity also may eventually be utilized for underground storage.

The constructive utilization of Arizona's apparently prolific salt resources has been initiated. In addition to the direct and indirect economic aspects of this valuable resource are the fascinating geologic questions that are being raised. Both of these aspects are subjects of continued Bureau study.

**1970 DRILLING ACTIVITY**

According to the records of the Oil and Gas Conservation Commission 20 holes were permitted and drilled in Arizona during 1970. Five, representing 16,568 feet of drilling, were drilled during salt exploration or development and fifteen, representing 45,414 feet of drilling, were drilled in exploration for oil - gas - helium. All told about 62,062 feet of drilling was done averaging close to 2,100 feet per hole.

Six holes were drilled in the Basin and Range province, three being related to salt exploration or development. Fourteen holes were drilled on the Plateau province of northeastern Arizona, two of which involved a salt storage project.

The Ivan Tenney No. 3 State in Sec. 36, T9S, R27E, Graham County, was drilled to about 3,500 feet and is the deepest test within a radius of more than 20 miles. The hole bottomed in an alternating shale-sulfate (gypsum and/or anhydrite) sequence of probable Tertiary age.

**GEOLOGY AT ARIZONA UNIVERSITIES****NORTHERN ARIZONA UNIVERSITY**

One function of this newsletter is to disseminate more widely information about the activities and accomplishments of the various geology departments in the State. These departments are dynamic and contribute input into the geological mix from which material is sifted that influences conceptual development. We received a nice reply from Dr. Augustus S. Cotera, Chairman of the Department of Geology at Northern Arizona University at Flagstaff (86001), summarizing the current status of his department.

Quite naturally the brochure describing the department is headlined "Geology in the Grand Canyon Country". An accompanying summary of graduate students includes the question "Where else can the student photograph the internal structure of a dissected cinder cone, sample olivine-rich basalts, and measure and describe different facies of Cambrian sedimentary deposits during one weekend in the field?" In addition the claim is made that visitors are "greeted with the cleanest air, purest water, and the most magnificent scenery in the United States!"

NAU offers the BS and MS degrees in Geology, BS degree in Geophysics, and BS and MA degrees in the teaching of Earth Science. The staff consists of nine PhD's and as of January 1971 there were over 100 geology majors including about 25 MS degree candidates.

The staff is actively involved in research which can be summarized as follows: *Barnes*—structural geology of the Gray mountain monocline; *Beus*—recently completed studies of the Devonian of northern Arizona; *Cotera*—Cambrian sandstone studies in northern Arizona; *Eastwood & Holm*—initiating an investigation of the geochronology and petrology of volcanic rocks in the San Francisco Peaks area; *Montgomery*—beginning investigation of certain aspects of ground and surficial waters of Black Mesa area and also a geophysical study of volcanic domes in the San Francisco Volcanic field; *Nations*—paleoecology of the Verde Formation; *Rawson*—stratigraphic study of the Beta Member of the Toroweap Formation, Grand Canyon.

We note from Dr. Cotera's report that the respective departments from ASU and NAU have initiated joint meetings. Such interchange is heartily encouraged and we hope that our newsletter can act as a servant of interchange and wider communication.

**VOLCANIC AND GLACIAL HISTORY OF SAN FRANCISCO PEAKS**

The geology of the famous San Francisco Peaks area near Flagstaff is the subject of the Fall 1970 issue of the Museum of Northern Arizona's "Plateau" magazine. Troy L. Pewe and Randall G. Updike of Northern Arizona State University, Tempe, combined to summarize the volcanic and glacial geology of this picturesque region. The publication is divided into a text and a geology field trip section, the latter including 40 stops. Numerous excellent diagrams, maps and photographs are included. The Museum address is P. O. Box 1389, Flagstaff, Arizona 86001.

**EVOLUTION OF THE CALIFORNIA DIVISION OF MINES AND GEOLOGY**

A review of the history of the California Division of Mines and Geology is provided in the February 1971 issue of "California Geology," formerly known as the "Mineral Information Service."

A "California State Mining Bureau" was created in 1880. Subsequently this organization has had the following name changes: "Division of Mines and Mining", 1927, "Division of Mines", 1929, and "Division of Mines and Geology", 1961. Gordon B. Oakeshott, Deputy Chief, states that these name changes reflect the fact that "official recognition of the basic geologic function of the State Mining Bureau has come slowly through the years." The Chief was known as the State Mineralogist until 1961 at which time the title was changed to "State Geologist."

Dr. Olaf P. Jenkins, a geologist with the Arizona Bureau of Mines in the early 20's went to California and in 1929 became "Chief (and only!) Geologist, heading the Geologic Branch . . . of the Division in which geology finally came to receive equal emphasis with mining engineering."

The Division is divided into three District offices located at Sacramento, San Francisco, and Los Angeles. Also, local field offices are set up to serve projects widely removed from the Districts. Greater authority is now delegated to district offices to provide more effective supervision of, and logistical support to, field activities. Many studies are conducted in cooperation with local governments to gather basic data for long range planning purposes.

## ARIZONA CONTRIBUTES NEW MINERALS TO WORLD

Minerals new to the world continue to be identified by mineralogists working in the State. Hemihedrite was identified and named by Dr. Sidney A. Williams of the Phelps Dodge Corporation, and Dr. John W. Anthony of the University of Arizona, from materials first collected by R. W. Thomssen of Tucson. The mineral is an oxide of silicon, zinc, fluorine, lead, and chromium and is now known to occur at a mine in the Tortilla Mountains in Pinal County and near Wickenburg, Maricopa County. It is described in the July-August, 1970, issue of the *American Mineralogist*.

Kinoite, a hydrous copper calcium silicate, was named for Fr. Kino, a Jesuit missionary prominent in early Arizona history. The material was encountered in core taken by the Anaconda Company in the Santa Rita Mountains of Pima County. The core was submitted by G. A. Barber of the Company to Dr. John W. Anthony of the University, for study. The results are recorded by Dr. Anthony and Robert B. Laughon, NASA, Geology Branch, Manned Spacecraft Center, Houston, in the May-June, 1970, issue of the *American Mineralogist*.

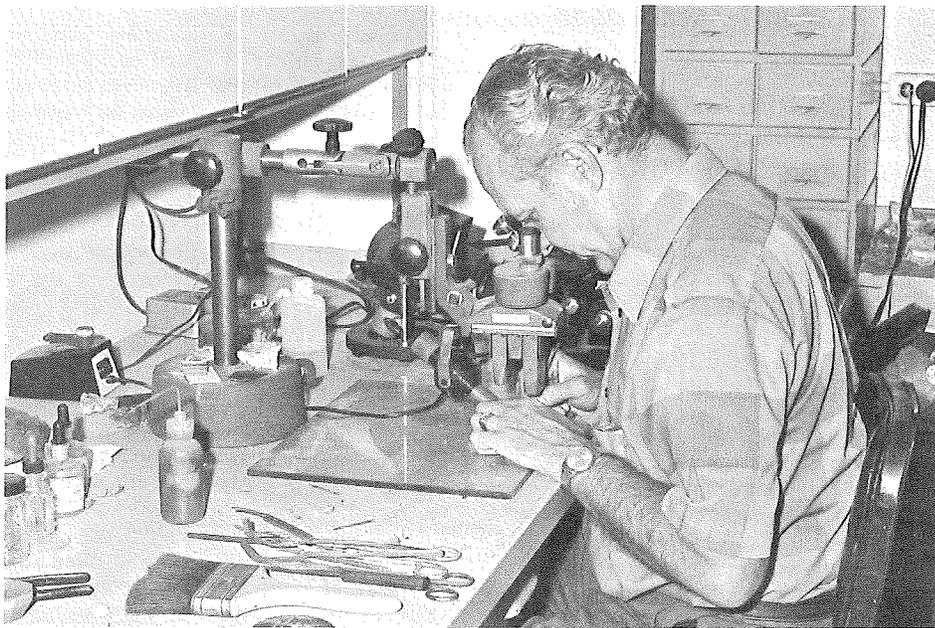
Two minerals new to Arizona, tilasite and cornetite, are described in the new magazine, the *Mineralogical Record*, which is mentioned elsewhere in this newsletter.

## NEW MINERAL MAGAZINE

The "*Mineralogical Record*" is a new publication initiated in the spring of 1970. John S. White, Jr., editor and publisher, is with the Division of Mineralogy at the Smithsonian Institution and is a graduate of the University of Arizona. Richard A. Bideaux of Tucson, likewise a University of Arizona graduate, is a member of the four man editorial board.

The publication is conceived to fill a large void between the overly simplified and the extremely technical. Three issues have been published and from this sampling it appears as though the publication will indeed fill a void on the book shelves of serious mineral collectors and hobbyists. However, the excellent and detailed photography provides a dimension that can be appreciated and enjoyed by anyone who is sensitive to the world's natural mysteries and beauties.

The "*Mineralogical Record*" is published bimonthly by the *Mineralogical Record, Inc.*, P. O. Box 783, Bowie, Maryland, the subscription rate being \$6.00 per year in the United States.



The examination and identification of rocks and minerals (top), an important part of mineralogist Robert O'Haire's workday. A routine flotation test (bottom), one of over 1500 ore tests performed in the Bureau's labs by George Roseveare, Bureau Metallurgist.

## BUREAU LOOKS AT THOUSANDS OF ROCKS, MINERALS AND ORES

Since the Bureau became a State agency in 1915, it has included services designed to identify and evaluate rocks and their constituent minerals. Services range from free qualitative rock and mineral identifications to quantitative studies made in connection with determining appropriate milling and extraction procedures to use on a particular ore type.

Robert T. O'Haire, Associate Mineralogist, reports that the mineralogy section has examined over 85,000 rock and mineral samples while George H. Roseveare, Metallurgist, reports that since 1941 the metallurgy section has conducted over 1500 ore beneficiation tests. Between them these men represent 43 years of experience in dealing with Arizona rocks, minerals, and ores.

## ATTENTION

### COUNSELORS AND STUDENTS— MINING INDUSTRY EMPLOYMENT OPPORTUNITIES

Mrs. Jan Wilt of the Bureau staff, a former physical science teacher at Pueblo High in Tucson, asked Mr. Dave Smith, coordinator of science study in School District One, what we might include in our newsletter that might be of use to counselors and students. He suggested a listing of jobs associated with our local mining industry. Mrs. Wilt enlisted the services of J.C. Dotson, Professor in the Department of Mining and Geological Engineering, and he obtained a list from the personnel department of the relatively new Twin Buttes open pit mine. We thank the Anaconda Company for the following list:

#### SALARY AND HOURLY OCCUPATIONS AT THE ANACONDA COMPANY

##### HOURLY

###### *Mechanics.*

**MILL**—repairs rods, motors, pumps and belts associated with light weight equipment. There is also plenty of heavy duty equipment at the mill requiring repair, alignment and replacement.

**CONVEYOR**—maintains and repairs six miles of rollers on conveyor system.

**CRUSHER**—repairs the metal plates, motors and moving parts, which wear routinely. Keeps a watchful eye on the equipment which needs repair.

**PLANT**—involves himself with refrigeration, heating, general housekeeping, and carpentry.

**AUTO**—replaces and repairs engines and transmissions. Distributors, carburetors, points, plugs, starters, brakes, ignition wiring and steering are just a few items an auto mechanic must know how to replace and repair.

**HEAVY EQUIPMENT**—repairs quad-tracks, scrapers, end dump trucks, cranes, shovels and track equipment.

###### *Heavy Equipment Operators*

Operates shovels, graders, scrapers, dozers, quadtracks and trucks.

###### *Powdermen and Drillers*

Blasts and drills rock which is then moved by shovels and trucks.

###### *Welders*

Welds and repairs in any department where services are needed.

###### *Warehouseman*

Stocks, issues and codes materials that are used at our operation.

###### *Laborer and Helpers*

Cleans up facilities and trains for journeyman positions. Each department has assigned helpers to assist the journeymen.

###### *Electricians*

Wires plant for electricity and high voltage powerlines that connect to shovel equipment. The electrician's job involves all equipment that requires electrical upkeep.

###### *Lubrication Man*

Keeps equipment greased and oiled so as to prevent unnecessary wear and to save cost of upkeep. Replaces batteries, filters and fuel equipment as needed.

###### *Carpenters*

Constructs concrete slabs, partitions and any other materials that are required. Also, have cabinet makers who make directional signs, shelves and office cabinets.

###### *Plumbers*

Concerns himself with internal and external water lines already on the property. Repairs and maintains same.

###### *Pipe Fitters*

Involves himself with new installations, layout, and modifications. Similar to plumber's job but usually involves new additions.

###### *Crane Operators*

Goes anywhere on the property where the services of the crane are needed. They also are operators in other types of equipment.

Within our hourly positions we have a line of progression in each department. A person who begins as a laborer may progress to a journeyman in a minimum period of time. Within each step there involves a pay increase and promotion. Apprenticeship programs are also available to employees to learn skilled trades in the mechanical and electrical fields.

##### SALARY

###### *Departmental Clerks and Secretaries*

Duties are filing, coding, typing, record keeping, researching, and general clerical work which is necessary in each department.

###### *Draftsmen*

Designs new systems and sees that old ones are maintained at a progressive level.

###### *Accountants*

Calculates payroll, governmental taxes, finance, and production control, and miscellaneous accounting procedures.

###### *Geologists*

Gives direction on where to mine and the best available methods to use in our unique operation.

###### *Surveyors*

Charts claims, drilling areas, ore and waste areas and some road surveying within operations.

###### *Mining Engineers*

Calculates and executes mining procedures that are the safest and most effective available.

###### *IBM and Keypunch Operators*

Programs the accounting procedures used to maintain records of production, inventory control, and miscellaneous accounting unique to our operation.

Salary personnel are usually hired because of their qualifications. The training involved is learning the uniqueness of our individual operation. If an opening comes up, we first go within our operation to fill such an opening, although extensive external recruiting is utilized. At our Twin Buttes operation we employ approximately 1,400 personnel.

In addition to the Anaconda Company other companies operating large mines in the immediate Tucson area are: Duval Corporation, American Smelting & Refining Company, and the Pima Mining Company.

#### TEN MILLIONTH BARREL OF OIL PRODUCED IN ARIZONA

In May 1970, 16 years after its first barrel was produced in 1954, Arizona gave up its 10 millionth barrel of oil. In comparison a like amount is produced in Texas every three days, every sixteen days in Oklahoma, and every month in New Mexico. The Arizona production was unequally distributed among 44 wells located in northern Apache County on the Navajo Indian Reservation, most of it having been produced since 1967 when the relatively prolific Dineh-bi-Keyah field was discovered by the Kerr-McGee Corporation.

## ENVIRONMENTAL CORNER

### Forrester heads up PD Environmental Division

Dr. James D. Forrester, former Dean of the College of Mines and Director of the Arizona Bureau of Mines, has become head of the Phelps Dodge Corporation's newly established Division of Environmental Engineering and Research. The division's main office is in Tucson in the Tucson Federal Savings Building.

Although the division is concerned with the total environment, one of its first projects will be intensified air quality monitoring programs and meteorological studies. Air sampling studies will be conducted in Phoenix and Tucson and the data collected will be made available to all interested agencies and individuals.

### Atmospheric Analysis Laboratory

The Arizona Mining Association, composed of thirteen major mining companies, has granted the University of Arizona in excess of half a million dollars in support of an Atmospheric Analysis Laboratory. The initial project, to be supervised by the analytical division of the UA Chemistry Department, will last for three years. William J. Rundle, president of the Association, points out three basic questions: What is in the air? How did it get there? What are the processes now at work to cleanse the air? Answers to such questions have been hindered by the unavailability of precise techniques for both sampling and analysis. Also, little is known about the interaction of components of the atmosphere with sunlight and with each other.

Much research is needed if understanding is to be gained and this grant will make Arizona one of the first states to have a comprehensive air monitoring and analysis program.

### Getting the Lead Out

Much has been said about getting the lead out of gasoline. The situation seems to be that lead needs to come out in order for new smog control devices on future cars to work effectively. In the meantime evidence suggests that burning low lead gas in conventional cars actually increases polluting emissions. This comes about because of compounds added in place of lead in order to maintain performance. According to Metals Week

(Nov. 30, 1970) John L. Kimberley of the Lead Industries Association told the Arizona State Board of Health about the recent experiences of Tokyo, Japan involving the worst smog crisis in its history. It was attributed to reactive emissions that created a city-wide photo chemical smog when the spring rain clouds passed and let the sun hit the gaseous automobile emissions of nitrogen oxides and unburned hydrocarbons. This happened four weeks after low lead fuel went on sale which was a result of a government campaign for lead-free gasoline. According to Kimberley the government had been warned that if lead was removed petroleum companies would have to increase the level of hydrocarbons to produce normal performance.

### Win or Lose

H. P. Doan, President of Dow Chemical Company, talking to a Manufacturing Chemists Association meeting in New York, made the following comments:

"I'm sure individual plants and even individual companies will be in trouble with tough environmental requirements placed on them, but shifts in demand, in values, in any number of ways, have always required major readjustments—and there has never been any guarantee that the race would be won by all. If we believe in competitive processes, we have to remember some people have to lose if others are going to win." He said he'd like to feel that industry is so committed to profits that it will see the profit opportunity in cleaning up the environment. Also, "the fact that we don't have all the technology needed simply means that there are new opportunities for invention. The profit-minded company will stop handwringing and start thinking."

### Producers and Users are Polluters

In the preface to the Proceedings of the conference on "Mining and Ecology in the Arid Environment", W. C. Peters, Editor and Professor in the College of Mines, points out that the March 22 to 27, 1970 conference was unusual because it brought together (in a discussion sense) leaders in mining, ecology, and public administration. Dr. Peters says:

*"Miners, having spearheaded the industrial revolution and having provided the raw materials for the nuclear age, will continue to be the providers. The providers as well as the users will be listed among the polluters. The users will not permit the miners to stop providing, but will certainly ask the miners to provide under conditions of the very least damage to the environment."*

## GEOTHERMAL ENERGY

A recent Department of the Interior news release entitled "Briefs on Geothermal Energy from the U. S. Geological Survey" includes the following generalizations:

*"The earth is a tremendous reservoir of heat, and its surface displays 'hot spots' that generally occur near areas of 'recent' volcanic activity. In the western United States, particularly along the Pacific Coast, widespread and intense volcanic activity has occurred during the past 10 million years; thus, the western States hold promise for geothermal power development. Over 5 percent of the world's resources of geothermal energy are in the United States, most of it stored in rocks in the upper 6 miles of the crust.*

and . . .

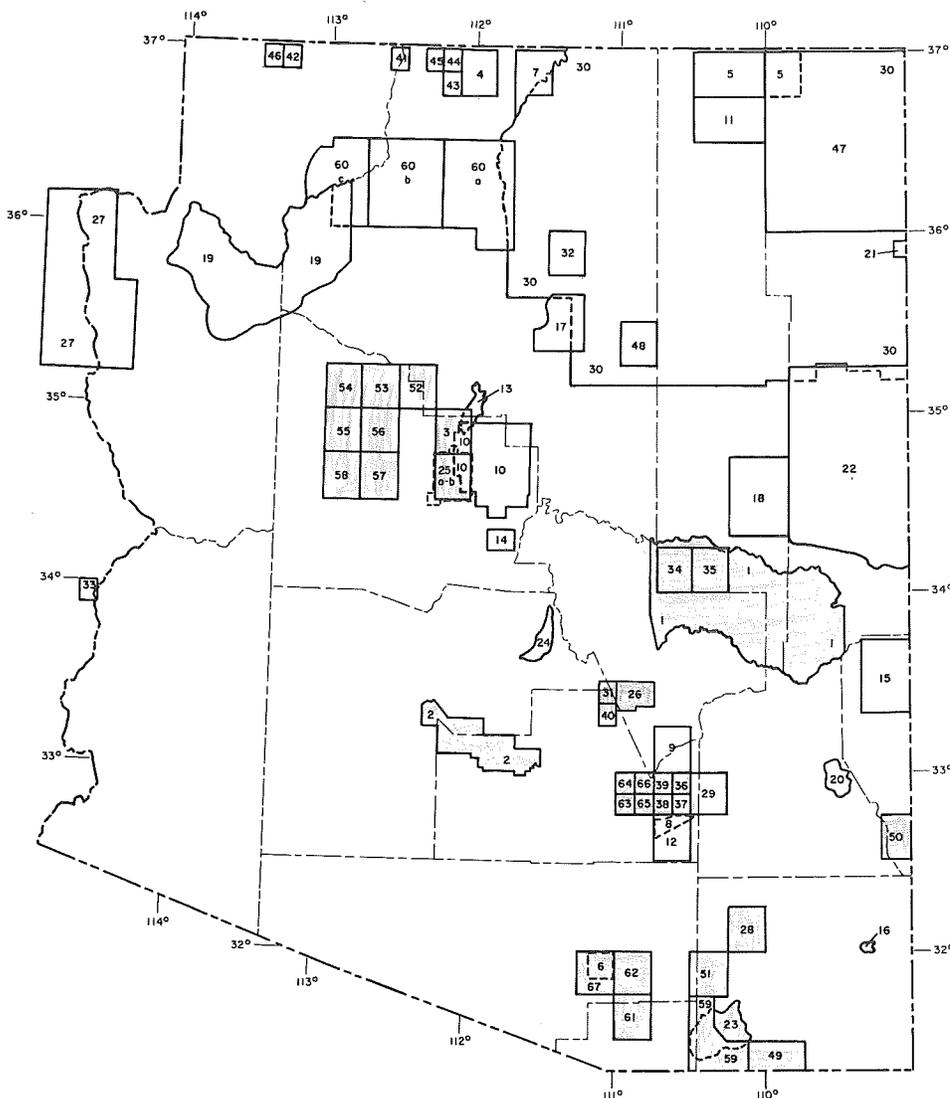
*"Locating a promising geothermal system is often a difficult problem. A system is apparent only when it is defective—when it is 'leaking' hot water or steam to the surface. These areas of hot springs and geysers are currently being explored, but experts have said that the state of our knowledge regarding geothermal resources is comparable to that regarding petroleum resources at the turn of the century. Current exploration, based on modern geologic, geochemical and geophysical methods, is likely to discover new fields. The recent discovery of a new field at Monte Amiata, Italy—where there were only meager surface manifestations of geothermal energy—was based on the use of such methods."*

Some of the known Arizona "hot spots" are listed by L. B. Haigler of the U. S. Geological Survey in Arizona Bureau of Mines Bulletin No. 180, "Mineral and Water Resources of Arizona". The hottest surface water issues from Gillard Hot Springs, in Greenlee County, at a temperature of about 180 degrees F. Nine other springs are listed that have temperatures of about 100 degrees F. In addition, six wells are shown to have water temperatures above 100 degrees F, the hottest being 161 degrees in a Pinal County well.

The volcanic history of Arizona is complex because there have been many separate igneous episodes spread unequally through the State. The most recent, the eruption of Sunset Crater near Flagstaff, is believed to have occurred in 1064 A.D., less than one thousand years ago.

Although steam is not known to be reaching the surface anywhere in Arizona, a careful check of water temperatures in all types of wells should be encouraged. Only in this way will it be possible to learn the areas of abnormally high thermal gradients.

## GEOLOGIC MAP INDEX OF ARIZONA



The U.S. Geological Survey has not issued a Geologic Map Index of Arizona since 1957. Joseph R. LaVoie of the Bureau staff has assembled a record of the various types of Arizona geologic maps published since the 1957 USGS index map and his record is presented here.

### KEY TO MAP

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3. 1958. Lehner, R.E., Geology of the Clarkdale Quadrangle, Arizona: U.S.G.S. Bull. 1021-N, p. 511-592, Plate 45, Geologic Map 1:48,000.

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29. 1964. Simons, F.S., Geology of the Klondyke Quadrangle, Graham and Pinal Counties, Arizona: U.S. G.S. Prof. Paper 461, p. 173, Plate 1, Geologic Map 1:62,500.
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MAPS, GQ SERIES*

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53. 1967. Krieger, M.H., Reconnaissance geologic map of the Picacho Butte Quadrangle, Yavapai and Coconino Counties, Arizona: I-500, 1:62,500.
54. 1967. Krieger, M.H., Reconnaissance geologic map of the Turkey Canyon Quadrangle, Yavapai County, Arizona: I-501, 1:62,500.

## MAP INDEX (continued)

- ✓ 55. 1967. Krieger, M.H., Reconnaissance geologic map of the Camp Wood Quadrangle, Yavapai County, Arizona: I-502, 1:62,500.
- ✓ 56. 1967. Krieger, M.H., Reconnaissance geologic map of the Simmons Quadrangle, Yavapai County, Arizona: I-503, 1:62,500.
- ✓ 57. 1967. Krieger, M.H., Reconnaissance geologic map of the Iron Springs Quadrangle, Yavapai County, Arizona: I-504, 1:62,500.
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- ✓ 59. 1968. Hayes, P.T., and Raup, R.B., Geologic map of the Huachuca and Mustang Mountains Southeastern Arizona: I-509, 1:48,000.
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  - 60-a Eastern (1967)
  - 60-b Central (1969)
  - 60-c Western (1969)

## MAPS ON OPEN FILE

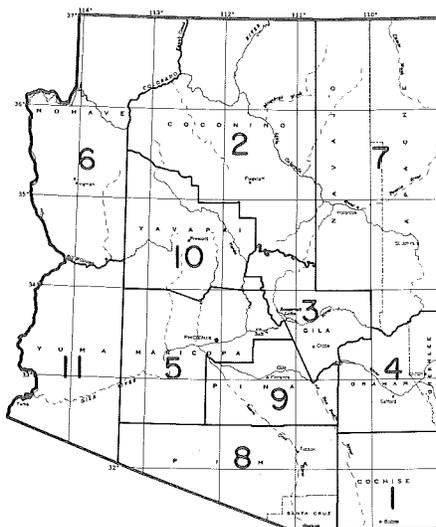
- ✓ 61. 1966. Drewes, H., Preliminary geologic map of the Mount Wrightson Quadrangle, Santa Cruz and Pima Counties, Arizona: Open File, 1:62,500.
- ✓ 62. 1968. Drewes, H., Preliminary geologic map of the Sahuarita Quadrangle, Pima County, Arizona: Open File, 1:48,000.
- ✓ 63. 1968. Krieger, M.H., Geologic map of the Black Mountain Quadrangle, Arizona: Open File, 1:24,000.
- ✓ 64. 1968. Krieger, M.H., Geologic map of the Crozier Peak Quadrangle, Arizona: Open File, 1:24,000.
- ✓ 65. 1968. Krieger, M.H., Geologic map of the Putnam Wash Quadrangle, Arizona: Open File, 1:24,000.
- ✓ 66. 1968. Kreiger, M.H. Geologic map of the Winkelman Quadrangle, Arizona: Open File, 1:24,000.
- ✓ 67. 1970. Cooper, J.R., Preliminary geologic map of the Twin Buttes Quadrangle, Pima County, Arizona: Open File, 1:48,000.

The Geologic Map of the State of Arizona is on a scale of 1:500,000 and is available (folded by mail) for \$2.50 from the Arizona Bureau of Mines, University of Arizona, Tucson, Arizona and the United States Geological Survey, Denver Distribution Section, Denver Federal Cen-

ter, Building 41, Denver, Colorado, 80225.

The Arizona Bureau of Mines County Geologic Map Series of Arizona on a scale of 1:375,000 is available for purchase from the Arizona Bureau of Mines, University of Arizona, Tucson, Arizona, 85721.

## INDEX TO COUNTY GEOLOGIC MAPS OF ARIZONA



1. 1959. Cochise County.
2. 1960. Coconino County.
3. 1959. Gila County.
4. 1958. Graham-Greenlee Counties.
5. 1957. Maricopa County.
6. 1959. Mohave County.
7. 1960. Navajo-Apache Counties
8. 1960. Pima-Santa Cruz Counties.
9. 1959. Pinal County.
10. 1958. Yavapai County.
11. 1960. Yuma County.

## PUBLICATIONS

This continuing section of the newsletter will list bibliographic material ranging from recent theses to popular paperback editions dealing with earth science. The inclusion of an item is a report of existence and not a recommendation of merit. Mrs. Jan Wilt, Assistant Geologist, is currently engaged in bibliographic compilation.

### THESES

This listing of recent and imminent theses represents contributions from the geology-geosciences departments of the advanced degree granting institutions in Arizona for the year 1970-71, with the exception of Northern Arizona Univer-

sity. In the latter case because of the newness of the graduate program all completed theses are listed.

#### *Arizona State University*

- BROWN, Ronald G. (1970-MS) Geochemical survey of the Oracle vicinity of Arizona: 50 p.
- CLARY, Thomas A. (1970-MS) Geology of the Schultze Granite and related copper mineralization: 37 p.
- McCURRY, Wilson G. (1971-MS) Mineralogy and paragenesis of the ores, Christmas Mine, Gila County, Arizona
- MERRILL, Robert K. (1970-MS) The glacial geology of the Mount Baldy area, Apache County, Arizona: 118 p.
- THROOP, Allen H. (1970-MS) The nature and origin of black chrysocolla at the Inspiration Mine, Arizona: 56 p.

#### *Northern Arizona University*

- BENFER, J. Alan (1971-MS) The petrology of the eastern phase of the Toroweap Formation, Walnut Canyon, Coconino County, Arizona.
- BILLINGSLEY, George H. (1970-MS) General geology of Tuckup Canyon, central Grand Canyon, Mohave County, Arizona
- PETTENGILL, James G. (1970-MS) Structural analysis of Coconino Point Coconino County, Arizona
- SHOLTZ, Judith F. (1968-MS) Geology of the Woods Canyon drainage basin, Coconino County, Arizona
- THOMPSON, John R. Jr. (1968-MS) Geology of Wet Beaver Creek Canyon, Yavapai County, Arizona.

#### *University of Arizona*

- COLEMAN, Dennis D. (1970-MS) Investigation of a method for determining the rate of strontium diffusion in a potassium feldspar: 66 p.
- KNIGHT, Louis H. Jr. (1970-PhD) Structure and mineralization of the Oro Blanco mining district, Santa Cruz County, Arizona: 172 p.
- LAUGHON, Robert B. (1970-PhD) The crystal structure of a new hydrous calcium copper silicate mineral: 43 p.
- LIVINGSTON, Donald E. (1970-PhD) Geochronology of Older Precambrian rocks in Gila County, Arizona: 224 p.
- LODEWICK, Richard E. (1970-PhD) The petrology and stratigraphy of the Earp Formation, Pima and Cochise Counties, Arizona: 194 p.
- MATIS, John P. (1970-MS) Hydrogeology of the Sells area, Papago Indian Reservation, Arizona: 59 p.
- WEST, Robert E. (1970-MS) Analysis of gravity data from the Avra Valley area, Pima County, Arizona: 73 p.



"...and a good time was had by all" — A stop on one of the mine tours sponsored by the Arizona Mining Association for a group of Tucson teachers.

## MINE TOURS

The Arizona Mining Association reports that a relatively new educational program by the copper mining industry in Arizona is showing good results.

The Association has been offering mine tours for teachers, some students, and special groups, such as associations of retired people since 1967. During the 1970 calendar year, these tours attracted some 2,185 people. This was from 36 full-day bus tours involving 421 teachers, 1,188 students and 576 others.

Tours have been offered by a number of the individual mining companies in Arizona in years past, but it has been on pretty much of an informal basis with little effort to seek out visitors to the mines.

In 1967 during Tucson Copper Days the Arizona Mining Association issued an open invitation to all teachers in the Tucson area to go on a bus tour of the mines. There was a good response, with two to three bus loads on each of four Saturdays preceeding the week long event. In 1969, during the Third Tucson Copper Days, a similar invitation was issued and an even greater response was received.

It was decided that similar tours should be offered to teachers from the Phoenix area. No effort had been made

previously to try to reach anybody from the major population center of Arizona.

Accordingly, an invitation was sent to all schools—elementary, secondary, public and private—in the greater Phoenix area. Tours were begun in September, 1969, and the response was gratifying, with some 250 teachers (and their husbands or wives) taking the tour in September, October and November.

It was decided to offer the tours on Saturday in six of the nine school months, skipping December, March and May because of holidays and other events.

Cost of the tours is approximately \$5 per person for bus rental and lunch. In return they receive some five or six hours concentrated education-information about the mines, their problems and possible solutions.

Subjects discussed during the tours include, besides the actual mining-refining process, such things as career opportunities in the mining industry, history and economics of the mining industry, use of the public lands, water conservation, solid waste disposal, air pollution, and other environmental matters. All the questions from students or teachers are answered as completely as possible.

Most of the tours were conducted to Inspiration Consolidated Copper Company's mine, leaching plant, electrolytic

refinery, smelter and rod plant. A few were taken to Kennecott's Ray Mines Division and this year a few more have been taken to Phelps Dodge's New Cornelia Mine at Ajo.

The tours leave at approximately 8 a.m., arrive at the property at 10 a.m., tour until 12, eat lunch, finish the tour, depart at about 2 p.m. and arrive back in Phoenix at 4 to 4:30 p.m.

For additional information or comments contact the Arizona Mining Association, Arizona Title Building, Phoenix, Arizona 85003.

## WHY?

### WHY HUNT FOR COPPER IN ARIZONA

If you ask this question of an exploration geologist he'll say that if you want to hunt elephants you should go to elephant country, and where copper is concerned, Arizona is "elephant" country. Actually, only a portion of Arizona is involved because the large mines are restricted to the Basin and Range topographic province which forms the southwestern half of the State. The principal area of active mining can be restricted even further. Of the 18 currently active large mines, 15 are in just four of Arizona's counties: Pima (7), Gila (4), Pinal (3), and Greenlee (1). Whereas in 1969 about 52% of the copper produced in the Nation came from Arizona, over 43% of the national production and 84% of the State total came from these four counties.

George B. Munroe, president of Phelps Dodge Corporation, has recently pointed out that Arizona produces more copper than any *nation* in the Free World. Chile is second to Arizona and Zambia is third. These data suggest that southeastern Arizona constitutes the heart of "big game" country. This conclusion is further substantiated by the fact that past and present exploration efforts have outlined about ten additional large copper ore-bodies within this geographic region, deposits that are in various stages of evaluation.

The U. S. Bureau of Mines has projected U.S. metal production to the year 2000. The data for copper suggests a 3 to 5 fold increase in domestic output which means that Arizona, if it is expected to continue its proportional share, must expand its copper output a like amount over the next 30 years. Can it be done? According to a recent list of mining and exploration companies published by the Department of Mineral Resources, Phoenix, as of January 1971 there were 60

*Continued on page 10*

**WHY? (continued)**

companies in Arizona, 41 of which were Tucson based. Some of the Nation's future requirements will be fulfilled by mine expansion and the development of already known ore deposits but the biggest increase for a demanding populace must come from deposits yet to be discovered. Southeastern Arizona will continue to be "elephant" country. This means that there will be strong competition amongst the hunters, especially competition for ideas as to why copper is where it is, geological ideas.

That there will be future conflicts over land and water use is certain. However, it should not be difficult to understand why there is a growing copper industry in southern Arizona. The geological fact is that much of the Nation's known copper reserve and potential is here, in just seven counties. In spite of the size of the industry as a whole it is dispersed in such a way that a large percentage of the Arizona population seems hardly aware of its magnitude. The decentralization of a principal basic industry away from urban centers is surely an environmental plus.

## **EARTH MATERIALS AND LIFE STYLE**

According to Metals Week (Vol. 41, No. 40, p. 29, Oct. 5, 1970), President Nixon has authorized the creation of a National Industrial Materials Commission to study the nation's mineral resources on a long-range basis. These resources were last assessed in 1950 when the President's Materials Policy Commission (the Paley commission) covered material requirements through 1975. The present study, to be completed in about 14 months, will project requirements, sources, and available supplies through the year 2000. An evaluation of related environmental problem areas is to be included.

Commerce Secretary Stans, speaking before the American Mining Congress Convention in Denver, acknowledged that tight supply conditions exist with such commodities as nickel and copper and that the U. S. is dependent on imports of basic materials such as tin, chromite, and manganese. Furthermore, he said that if the U. S. is pre-empted from the use of key resources, our society can be jeopardized in many ways and he then made the point that "the fact is that we have a serious lack of knowledge of what we have, what we need, and even what we use."

Although Secretary Stans was speaking of the Nation it seems quite possible that even as individuals we have little comprehension of the material requirements that

are associated with one day of routine living. Continuing to live in a style to which we have become accustomed would appear to demand an expanded rate of earth resources study, development and utilization.

Destruction and construction, like cause and effect, are inseparable in that one cannot exist without the other. Regarding environmental destruction that results from the mining and processing of raw materials used for constructive purposes, Stans told the mining industry, "The most that you can hope for is that you will be given sufficient time to carry out firm environmental quality improvement programs which are technically feasible and economically tolerable—and, of course, that you will be able to recover the added costs in your prices."

World society has many dependencies but it is wedded to earth resources—mineral, water, and air. Discriminating between needs and wants, that is a problem. Let's get on with it!

## **COCHISE COUNTY VISIT**

In December, 1970, Arizona Oil & Gas Conservation Commission geologists Conley, Koester, and Scurlock made a brief geologic highlight tour of extreme southeastern Arizona with Dr. Jerome Wright of the Department of Geosciences at the U of A and Dr. H. W. Peirce of the Bureau staff. Frank Moore, a native of the region and a Commission member, completed the contingent. A day was spent in general reconnaissance of the San Bernardino and Sulphur Spring valleys.

The San Bernardino Valley region, comprising an area of about 250 square miles, is intriguing both generally and geologically. Relatively young volcanics blanket the region except for two small islands of probable Permian limestones. The distribution and arrangement of the thick unexplored Paleozoic marine strata that should underlie the region can best be interpreted by geophysical studies. Apparently, a geophysical crew recently has been active in the region which suggests that southeastern Arizona continues to receive some attention from oil and gas explorationists.

## **BUREAU'S MAP SALES**

In 1957 the Arizona Bureau of Mines published the first (Maricopa) and in 1960 the last (Navajo-Apache) in a County Geologic Map series consisting of eleven maps covering the 14 counties. To date we have sold in excess of 41,000 of the individual maps. In addition, other maps and geologic cross-sections have since been published, their sales totalling over 21,000 sheets. Altogether a total of over 62,000 sheets have been sold since 1957.

## **NEWS FROM AND ABOUT OTHERS**

### **ARIZONA ATOMIC ENERGY COMMISSION**

According to the annual report of the Arizona Atomic Energy Commission there are 202 radioactive material licenses in Arizona. The Commission is studying the feasibility of Arizona as a site for a nuclear fuels reprocessing plant. Many aspects are being considered but one, nuclear waste disposal, would appear to be geologically related. Arizona is now a member of the Western Interstate Nuclear Compact which represents eleven western states and the Board has selected radioactive waste management in the west as its number one study project for the coming year.

### **KENNECOTT COPPER CORPORATION**

The third quarter (1970) news release to stockholders indicates that Peabody Coal Company's Black Mesa mine in northern Arizona has started to produce and that the first coal was successfully delivered through the new 275 mile pipeline to the Mohave generating plant near Davis Dam, Nevada. Crushed coal is carried as a slurry, the water being derived from wells in the Mesozoic Navajo Sandstone which underlies the coal producing property.

Regarding air quality control, Kennecott indicates that it supports appropriate ambient air quality standards which meet public health requirements but opposes emission standards which have been proposed in a number of instances. Kennecott continues to test and evaluate different methods designed to remove SO<sub>2</sub> emissions from smelter stacks

### **ARIZONA DEPARTMENT OF MINERAL RESOURCES**

Frank P. Knight, Director of the Department for the period 1957-1970, was succeeded in October, 1970, by John H. Jett, age 53. John is a mining engineer graduate of the University of Arizona (B.S., 1950) and has had a wide and varied experience in the mining industry.

Today, the Arizona Department of Mineral Resources, Mineral Building, State Fairgrounds, Phoenix, Arizona, 85007 (Phone 622-0075), serves to provide statistical and historical data on the mining industry of Arizona, projects the future mineral needs of the State, and offers assistance to the mineral industry in political, economic, and technical matters.

The present Department staff consists of the Director, three Field Engineers—Gerald W. Irvin (Southwest District), Fremont T. Johnson (Northern District),

*Continued on page 11*

**NEWS FROM OTHERS** (continued)

Glen Walker (Central District)—an Administrative Assistant, Mrs. Pare, and three secretaries, Mrs. Halloren, Mrs. Sparks, and Miss Bible. Frank Knight is a Consultant to the Department.

The Department continues to operate under a five man board of governors appointed by the Governor of the State. Originally, the bill to establish the Department was sponsored by the Arizona Small Mine Operators Association (ASM-OA), a continuing Arizona organization that publishes the popular and informative monthly mining magazine, "Pay Dirt".

The Director and staff of the Arizona Bureau of Mines welcome Mr. John Jett.

**OIL AND GAS CONSERVATION COMMISSION**

The Arizona Oil and Gas Conservation Commission, 4515 North 7th Avenue, Phoenix, 85013, in addition to filling the Director of Enforcement vacancy, has added two new geologists to their professional staff. The Commission, originated in 1959, is administered by Executive Secretary Mr. John Bannister.

In 1970 the Commission proposed to engage more directly in fundamental geologic studies related to oil, gas, and helium possibilities in Arizona. To facilitate study it arranged for the transfer of all well samples stored in the facilities of the Museum of Northern Arizona, Flagstaff. Samples are being augmented by the acquisition of selected sets of samples held at the Arizona Bureau of Mines repository.

Joining Jim Scurlock, Commission geologist since 1964, are Edward A. Koester and Jack N. Conley. Ed is 64 and his 41 years of experience has embraced petroleum exploration, development, and production, not only in the U. S. but in Italy, Turkey, Israel, and Jamaica. Besides belonging to numerous geological organizations Ed was President of the American Association of Petroleum Geologists in 1954-55. For the Commission he will, among other things, be bringing together data pertaining to the southern portion of the State.

Jack, 60, likewise has had a wide ranging professional life. He has worked for numerous companies among which are Amerada Petroleum Corporation (7 years), and Seaboard Oil Company (14 years). He was a district geologist for Southern Minerals Corporation during which time he worked in west Texas, New Mexico, the Rocky Mountain states, and Canada. He was Vice-President and Exploration Manager for the Kilroy Company of Texas, Inc., with activities in Texas, Louisiana, and the Rocky Moun-

tain states. In addition to other jobs Jack was a petroleum consultant in the United States, Canada, New Zealand, and Australia. For the Commission he is organizing the sample repository and will concentrate on the petroleum possibilities of the plateau portion of northern Arizona.

William E. Allen, 52, is the new Director of Enforcement and will be active in the application of the Commission's rules and regulations. Bill is widely experienced in the engineering aspects of drilling and production. He was a drilling foreman with Continental Oil Company and later a District Manager with the same company, a production foreman with Creole Petroleum Corporation in Venezuela, and was self-employed in Farmington, New Mexico, in oil field construction.

The Bureau takes pleasure in welcoming these new men to Arizona and congratulates the Commission for their efforts in bringing such talent to Arizona.

**U. S. BUREAU OF MINES**

The U. S. Bureau of Mines has opened a liaison office in Phoenix under the direction of Mr. Floyd D. Everett, liaison officer. Mr. Everett comes to Arizona after heading the U. S. Bureau of Mines Office of Mineral Resources in Bartlesville, Oklahoma. Mr. Everett is a mining engineer having received his formal education from the University of Utah. He has worked as a miner and as an engineer with mining firms and has been with the U. S. Bureau of Mines since 1942. We thank Mr. Everett for sending us the following report:

Arizona was ranked fifth in the nation in value of mineral production for 1970, according to preliminary estimates published January 1. Arizona ranked 10th in 1968 and 8th in 1969. States ranked higher than Arizona were: Texas, Louisiana, California and West Virginia. Arizona's value of mineral production for 1970 exceeded \$1,160 million.

Following several weeks of testing, the experimental operation of the San Manuel sodium citrate absorbent method of SO<sub>2</sub> removal from smelter gases began in October. Although 24-hour continuous testing has not yet been attempted, excellent SO<sub>2</sub> removal efficiencies have been demonstrated in operating periods of 6 to 10 hours. In these tests, 90 to 99 percent removal of the SO<sub>2</sub> was achieved at gas flows of 100 to 180 cfm and solution flows of 5 gallons per minute.

Experimental work continues at the Salt Lake City Metallurgical Research Center on recovery of copper from open-pit mine waste from the Mineral Park property near Kingman and on copper silicate ore from the Lake Shore property

near Casa Grande. Work also continues on a project of hydrometallurgical research designed to extract copper from sulfide ores.

The College Park Maryland Metallurgical Research Center plans to study ion exchange properties of some zeolites from Arizona deposits.

The Denver Mining Research Center is continuing cooperative investigations at the San Manuel property on caving systems and at the Twin Buttes property on slope stability.

Director Osborn has established, within the Bureau of Mines, an Office of University Relations. The function will enable the Bureau to more effectively evaluate and direct the impact of the Bureau's activities on the entire state of mineral science and technology and, specifically, to work closer with universities and other educational institutions to fulfill common needs. Mr. Alvin Van Valkenburg, formerly with the National Science Foundation, will head the office in Washington, D. C.

**U. S. GEOLOGICAL SURVEY**

The extent of geologic effort expended in Arizona by the Geologic Division of the United States Geological Survey is reflected by Mr. Harold L. James in a letter to the Arizona Bureau of Mines dated October 13, 1970. Mr. James lists twenty-one projects in varying stages of completion and, in addition, lists forty-one reports that were published between April, 1969, and August, 1970, and fifteen more that were approved for publication. The magnitude and content of this activity is a reflection of the many and varied geologic questions being asked about Arizona's mineral resources and general geologic environment.

According to a Department of the Interior news release (Feb. 5, 1971) the U. S. Geological Survey estimated budget for fiscal 1972 will be about 121 million dollars, a gross increase of nearly 10 million dollars over the current year. Dr. William T. Pecora, USGS Director, stated that "strong emphasis will be placed on obtaining the kind of earth science knowledge that can provide a foundation for coping with burgeoning problems that reflect the dilemma of our times—the need, on one hand, for vast amounts of natural resources, while, at the same time, the need to avoid environmental degradation."

According to Pecora more emphasis is to be given to the impact of growth and technology on the urban environment. He suggests that "by gathering earth science knowledge, the urban community can solve land and water use problems before

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If you wish to receive future editions of this news letter please fill in and return to the Arizona Bureau of Mines.

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(Business or Professional Affiliation)

NEWS FROM OTHERS (continued)

they get out of hand." The Phoenix-Tucson corridor is included in a list of localities for which feasibility and program design studies are presently under way. These preliminary studies will be used in selecting areas for more intensive investigation.

United States Geological Survey publications are available for reference in the Arizona Bureau of Mines library located in the Geology building, Room 324, University of Arizona, Tucson.

NEWS LETTER

State of Arizona  
Governor . . . . . Hon. Jack Williams  
University of Arizona  
President . . . . . Richard A. Harvill  
Arizona Bureau of Mines  
Acting Director . . . Richard M. Edwards  
Editor . . . . . H. Wesley Peirce

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