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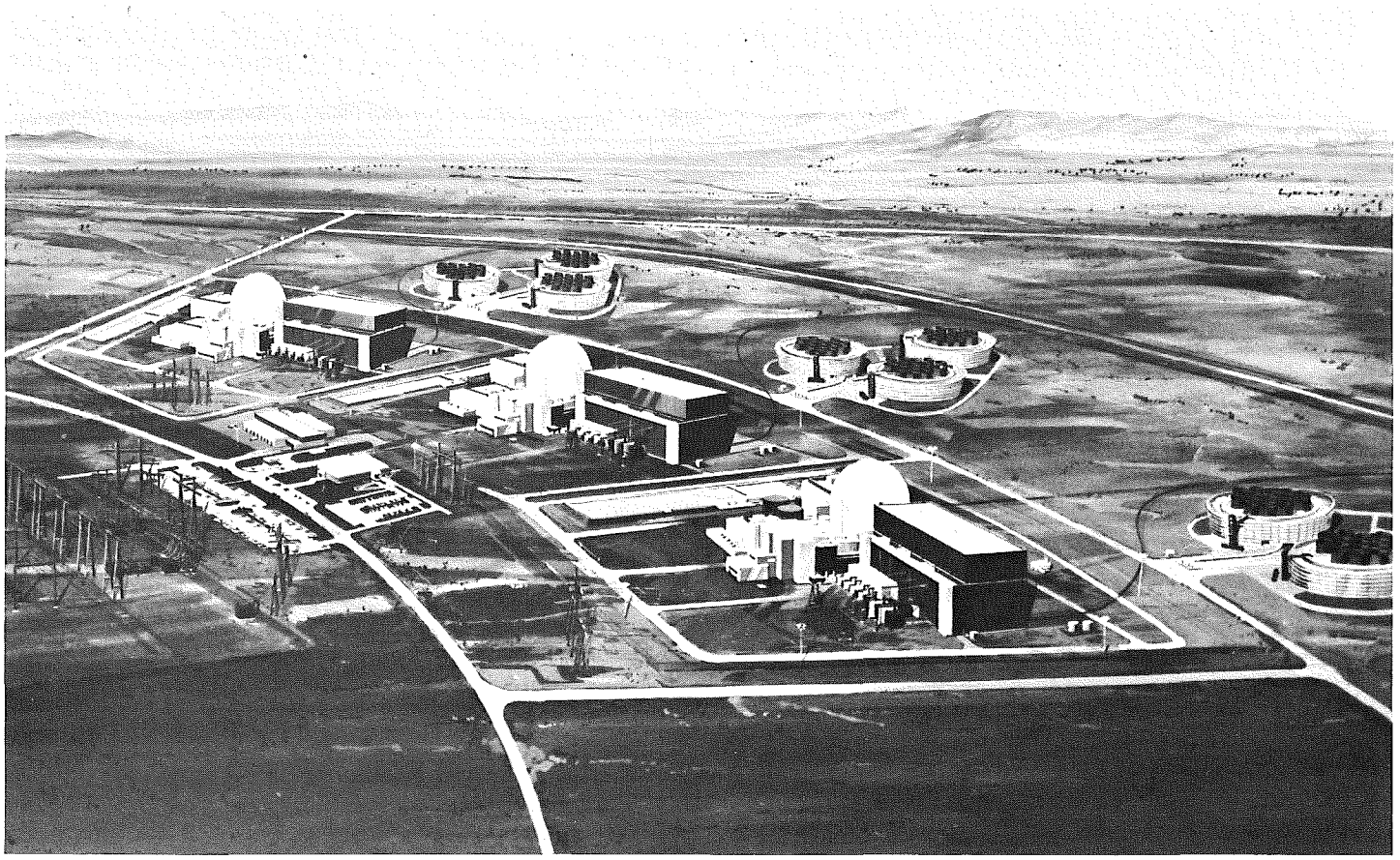
# The Palo Verde Nuclear Power Station

## Geotechnical Considerations in Site Selection



by John D. Scott and Richard T. Moore

### Introduction

The Palo Verde Nuclear Generating Station, Arizona's first nuclear power plant, is presently under construction near Wintersburg, about 36 miles west of Phoenix. Three 1,270 megawatt (electrical) net units are proposed to go on line (one each in 1982, 1984, and 1986), and current construction is meeting that schedule. The excavations were begun in June 1976, and Unit 1 is now to maximum grade (about 60 feet below ground surface). Unit 2 excavation is planned for completion by June 1977, and Unit 3 excavation will not begin until 1978.

Considering the recent publicity on the nation's commitment to nuclear power and the initiative propositions about tighter controls, it is wise that Arizonans should ask about the safety aspects that were considered in the siting of the Palo Verde Nuclear Generating Station. Geotechnical considerations from a geologic, hydrologic, seismologic and foundation engineering point of view were critical factors in the selection and evaluation of the Palo Verde site. The fact that the Palo Verde plant has been licensed and is under construction is well known to the public; however, the degree of effort and great expense required

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### *Also in this issue:*

Arizona's Interagency Energy Planning Office
Coal Comes to Southern Arizona
Arizona Bureau of Mines' Annual Report, 1975-76
Another View of Arizona's Water Problems
Commentary: Geology and Environmental Statements

to confirm Palo Verde as a viable site is not widely known. It is the purpose of this paper to generally describe the geotechnical criteria for siting nuclear power facilities, the methods used to evaluate the Palo Verde site and its region, the geotechnical conditions encountered at the site, and the continuing investigation during the construction phases.

## Background

The siting, licensing, construction and operating of nuclear power plants in the United States is controlled by the Nuclear Regulatory Commission (NRC) which was formerly a part of the Atomic Energy Commission. In addition to this agency, the State of Arizona exercises its authority through the Arizona Power Plant and Transmission Line Siting Committee, which acts and reviews the environmental aspects of the site and transmission line independently. The Arizona Bureau of Mines, Geological Survey Branch, has been working with the NRC on the evaluation of the geologic aspects of the site. In addition, local zoning requirements are followed.

To assist in its review, the NRC has set up a set of rigid criteria which are designed to cover all factors related to the safety of the plant and site. Basically, the NRC requires the utility to support its application for a construction permit by filing an Environmental Report containing sufficient information about the facility, site, and environs to permit the NRC to assess the environmental impact. The NRC also requires that the Environmental Report include evaluations of various site alternatives and justifications made by the utility including the rationale for selection of the prime site. The guidelines require that the selection of the preferred site from among viable alternatives be documented.

The Environmental Report is followed by a Preliminary Safety Analysis Report (PSAR), which is a comprehensive study on all site conditions related to safe design, construction, and operation of the plant. Both of these documents become public records at the time of submittal. To give some idea of the comprehensive nature of these reports, the PSAR for the Palo Verde Nuclear Generating Station consists of 17 volumes, each volume twice the

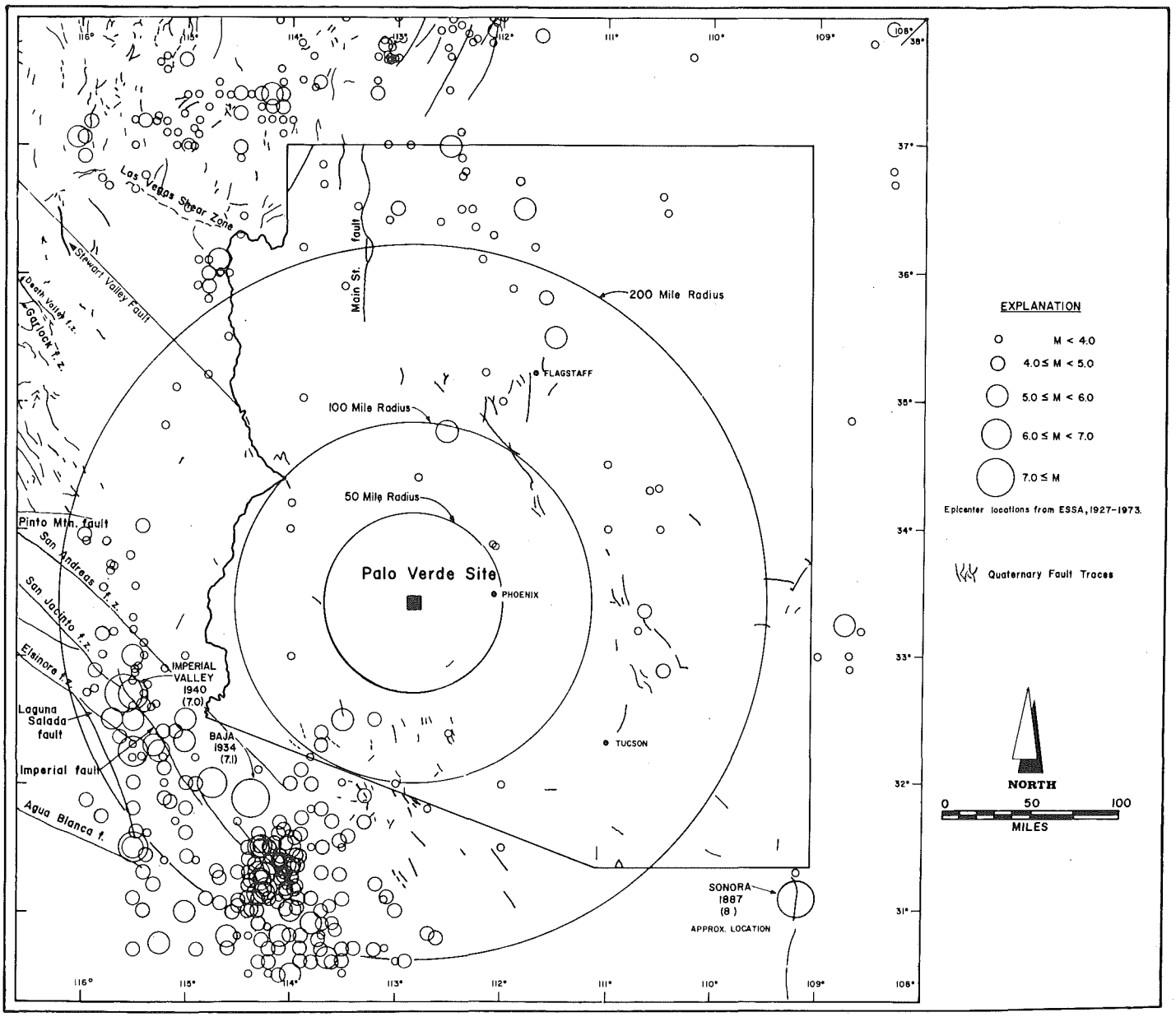


FIGURE 1 EPICENTER AND FAULT LOCATION MAP

thickness of a normal metropolitan telephone book. Of this total, 10 volumes are related to geology, hydrology, seismology and foundation engineering. The Environmental Report for Palo Verde consists of seven volumes of similar thickness to the PSAR. Time required from inception of regional screening studies (November 1972) to granting of construction permit (May 1976) was 3½ years and represents over 60 man-years of investigation devoted to geotechnical factors. This work involved the efforts of over 40 specialists in the earth sciences at a cost in excess of $3.5 million.

**Regional Site Selection Process**

Past experience in the United States and abroad has shown that geologic and seismic factors can have a controlling influence on the identification of feasible nuclear power plant sites. This is especially true in parts of the western United States where earthquakes are known to occur or where geologic evidence indicates faults have displaced the ground surface in recent time. Even in Arizona, which has relatively low seismicity compared to neighboring states and northern Mexico, the potential for earthquakes and faults must be carefully considered in any site selection study.

In basic terms, the geotechnical factors that most seriously affect the feasibility of a site are the potential for ground rupturing along faults, the maximum level of earthquakes shaking judged to affect the site, and the potential for liquefaction or other types of failure of the foundation soils during an earthquake.

Experience has shown that the most effective way of identifying one or a number of nuclear power plant sites is the systematic examination of a large region. This method provides the greatest effectiveness and flexibility in selecting optimum sites relative to all criteria critical to safety. This type of regional approach was utilized in the Palo Verde site selection and involved a screening, in distinct phases, of the entire state of Arizona. Each phase reduced the area under consideration using selected geologic, hydrologic, environmental and land-use criteria.

The first phase consisted of regional studies which divided the state in terms of seismotectonic characteristics based on selected geologic and seismologic criteria such as: physiographic provinces, natural geologic and structural provinces, complexity of geologic structure, distribution of Tertiary and Quaternary volcanic rocks, major tectonic lineaments, distribution of Quaternary faults, and distribution of historic and instrumented earthquake epicenters. In general, this regional screening showed that the most seismically active and geologically complex parts of Arizona for nuclear siting were (1) in the Southwest corner of the state, near Yuma, which is within the influence of the active San Andreas fault zone, and (2) a broad band coinciding roughly with the central mountains or Transition Zone, which extends diagonally across the state from near the Grand Canyon to Bisbee (Figure 1). In addition to identifying the most restrictive area for siting, the regional study rated all the major areas in the state in terms of potential for satisfying the stringent NRC criteria. The most satisfactory areas for demonstrating a suitable site were in the region west of Phoenix and a limited area on the Colorado Plateau. Since land access and availability were severely restricted on the Colorado Plateau, the area west of Phoenix was selected for the more detailed Phase II and III investigations, and eleven candidate valleys were identified for the second phase study.

Phase II of the screening studies evaluated and ranked the eleven candidate valleys using geotechnical and environmental criteria. Of prime consideration were (1) presence of sufficient quantities of water for plant operation, (2) absence of Quaternary faults or lineaments which might be considered capable of generating earthquakes and/or ground displacements, (3) presence of suitable topographic and foundation conditions, (4) presence of stratigraphic units of Quaternary or late Tertiary age at or near ground surface which would be useful in evaluating the longterm geologic stability of the site and site area. In geologically complex regions such as the western United States, the Quaternary (most recent) stratigraphy becomes critically important to any effort to document conclusively that a site has been tectonically stable for a considerable length of time. Phase II investigations relied on extensive literature search, aerial reconnaissance, and studies of satellite imagery and aerial photography, and consultation with experts in local geology. At the conclusion of this phase, three basic candidate valleys were identified with 28 potential siting areas divided among them.

Phase III screening reduced the three valleys and 28 candidate site areas to a number of top-rated site areas for further consideration. The prime objective was to have enough potential sites to identify a prime and alternate site having a high likelihood of satisfying the NRC criteria. The geologic criteria used in the Phase III screening were similar to Phase II; however, the ranking criteria were quantified in more detail based on extensive literature search, detailed air photo analysis, ground and aerial reconnaissance, and analysis of all available subsurface and water well data. The ability to age-date the late Tertiary and Quaternary stratigraphic units at the site areas was also an important consideration at this phase.

A limited amount of surface and subsurface exploration was performed in the highest-rated candidate sites in order to confirm the suitable geotechnical characteristics. Typical investigations included: reconnaissance geologic mapping on specially-flown, low-level stereo aerial photographs; seismic refraction and gravity surveys; several borings to 500 feet with samples for geologic and engineering analysis; age-dating of subsurface materials (where possible); backhoe trenches across lineations or faults. As a result of these limited confirmatory investigations, several sites were removed from further consideration; however, it also became apparent that the Palo Verde site had superior geologic characteristics to satisfy the NRC siting criteria.

**NRC Criteria**

The NRC has developed specific geologic and seismologic siting criteria (10 CFR Part 100, Appendix A), which require, in general terms:

1. Establishment of the maximum level of earthquake shaking that might conceivably be experienced by the plant;
2. Determination of the potential for surface faulting within 5 miles of the site;
3. Effect of shaking or loading on the performance of foundation soils;
4. Impact of any other geologic hazards near the site (subsidence, fissuring, and collapse).

The maximum level of earthquake shaking that could conceivably be expected at the site is called the Safe Shutdown Earthquake (SSE). The plant is designed to withstand at least this level of shaking and still be able to shut down operation without an accident. The SSE is a maximum credible seismic event that is conservatively determined after a complete study is made of the seismology, structural geology and tectonics within a 200-mile radius of the site.

The NRC criteria require that the potential for surface faulting be precluded within a 5-mile radius of the site. To accomplish this, any faults within a 5-mile radius must be demonstrated to:

a. have not moved once within the last 35,000 years, or
b. have no multiple movements within the last 500,000 years, or
c. have no logical connection to a fault beyond the 5-mile radius which might be considered capable of movement, and
d. have no demonstration of active seismicity.

As a result, it becomes highly important that a potential nuclear site have consistent Quaternary stratigraphy relatively close to ground surface in order to determine minimum age on faults within the 5-mile radius and, in some cases, even beyond.

A comprehensive analysis of the foundation soils is required by the NRC for Preliminary Safety Analysis Studies to preclude the

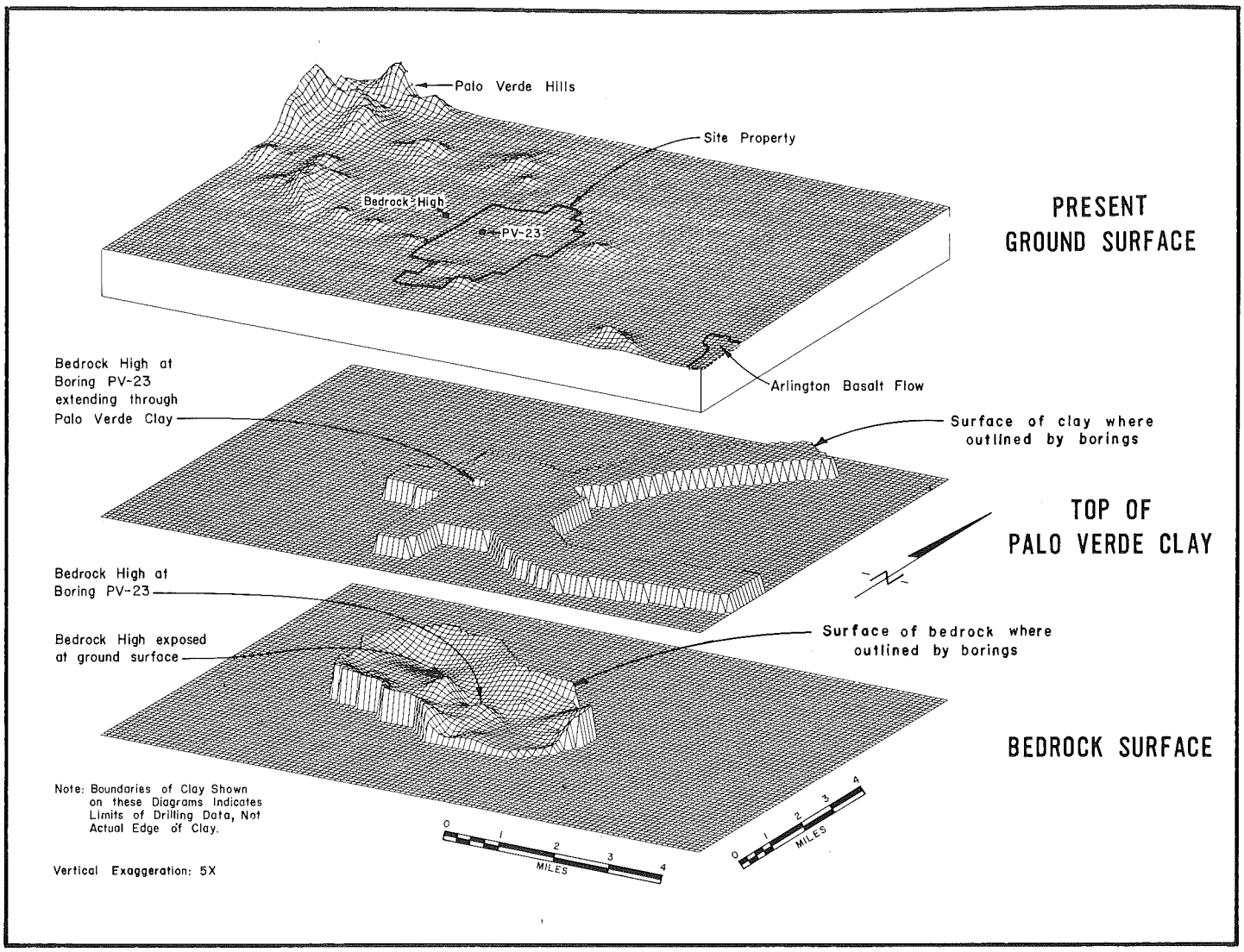


FIGURE 2 ISOMETRIC BLOCK DIAGRAM OF SURFACE AND SUBSURFACE CONTOURS AT PALO VERDE NUCLEAR GENERATING STATION SITE

possibility of differential settlements, excessive consolidation, liquefaction during the Safe Shutdown Earthquake, or any other foundation phenomena that might endanger the integrity of the plant. The foundation studies also include such considerations as subsidence due to decreases in ground-water level, collapse of soils, and the effects of man-made hazards such as mining or withdrawal of oil. Besides immediate impacts of such conditions, all of these investigations must also consider possible long-term changes over the projected 40-year life of the plant.

## Geotechnical Investigation of Palo Verde

As a result of Phase III, the Palo Verde site was confirmed as feasible. However, a detailed site-specific geotechnical investigation was required in order to determine final design considerations and to prepare the PSAR. This detailed investigation required about one year to complete and included the following activities:

– reconnaissance and detailed geologic mapping of an area encompassed within a 25-mile radius and 5-mile radius of the site;
– Over 9 miles of seismic refraction geophysical surveys;
– reconnaissance and detailed gravity and magnetic geophysical surveys covering an area within a 10-mile radius of the site;
– 2000 feet of exploratory backhoe trenches;
– drilling of more than 200 exploratory borings to depths ranging from 50 to 721 feet (in total about 10 miles of borings were drilled for geologic and foundation engineering analysis);
– high-resolution downhole geophysical logging of nearly all exploratory borings for stratigraphic correlation;
– potassium-argon age dating of 34 rock samples;
– analysis of approximately 550 samples of basin sediments for paleomagnetic polarity;
– static and dynamic engineering tests on core and drive samples;
– detailed ground-water analysis;
– complete research of all pertinent geologic, seismologic, and hydrologic data.

In addition, there were seven specialists from the University of Arizona and Arizona State University who were consulted on specific aspects of the project, such as geohydrology, stratigraphy, structural geology, petrology, clay mineralogy, palynology and geophysics.

## Geology of the Palo Verde Site

The Palo Verde Nuclear Generating Station site is within the Basin and Range physiographic and structural province of southwestern Arizona. The physiography within a 25-mile radius of the site is characterized by mountain ranges, relatively short and irregular, which stand sharply above broad alluvium-filled basins (Figure 2). The rocks of these mountains vary from deformed crystalline rocks of Precambrian age to volcanic and sedimentary rocks of middle Tertiary age. Alluvium and volcanic rocks in the broad basins range from Miocene to Holocene in age, based on potassium-argon age dates of basalt interbeds.

The Palo Verde Hills site area, which comprises approximately 25 square miles surrounding the 3,900 acre site, consists of a broad valley or basin surrounded by a series of intermittent, low hills having maximum relief of 250 feet. The basin floor slopes very gently toward the Gila River, about 10 miles to the south.

The rocks of the Palo Verde Hills can be divided into three groups: (1) Precambrian metamorphic and granitic basement rocks, (2) Miocene volcanic and interbedded sedimentary rocks, and (3) Miocene to Holocene basin sediments consisting of alluvial fan, lacustrine and basin-fill deposits, with local interbeds of volcanic rocks.

The crystalline basement rocks are not exposed at the ground surface in the site area but they have been encountered at a depth of several hundred feet in a number of exploratory borings. The buried granitic surface is undulatory with a general slope toward the northeast (Figure 3).

Miocene volcanic rocks, which unconformably overlie the crystalline basement rocks, are exposed in the Palo Verde Hills. These rocks represent massive flows, plugs, dikes and flow breccia, with scattered, discontinuous interbeds of tuff and tuffaceous sandstone. The rocks of flow origin range in composition from hornblende andesite, which is relatively rare, to pyroxene andesite, basalt, and basanite. The pyroclastic rocks consist of welded hornblende biotite tuff. Whole-rock potassium-argon ages on basalt samples from seven localitites range from 17.9 to 19.9 million years old. The many basalt dikes and plugs indicate numerous local sources for the volcanic rocks throughout the area.

Lithified and unlithified alluvial sediments overlying the basement and volcanic rocks cover the site and contain up to six distinctive stratigraphic units. These sediments are nearly horizontal and have an average thickness of approximately 320 feet, with a variation of thickness in the site area of approximately 100 feet. The stratigraphic units within this alluvial sequence extend across the Palo Verde site and are generally continuous for at least several miles beyond the site boundaries.

At the base of the basin sediments is a Tertiary fanglomerate which contains rounded to angular clasts of predominantly andesite and basalt set in a well-cemented matrix of sand, silt, and occasionally, tuffaceous sand. The fanglomerate is exposed along the lower slopes of the Palo Verde Hills and unconformably overlies the volcanic bedrock. The fanglomerate has been traced into the subsurface where it commonly fills bedrock depressions and is absent on buried bedrock highs. A basalt interbed within the fanglomerate has been dated by potassium-argon techniques at 16.7 million years old, indicating a middle Miocene age.

Near the top of the basin sediment sequence, another series of potassium-argon age dates was obtained from the Arlington basalt flow about 5 miles southeast of the Palo Verde site (Figure 2). The Arlington basalt is well exposed at the ground surface and clearly overlies basin-fill sediments in a roadcut of old U.S. 80 near the town of Arlington. An average age of about 2 million years was obtained from seven samples of the Arlington basalt flow.

The stratigraphic and age correlation between the basin sediments at the site to those underlying the Arlington basalt flow 5 miles southeast was accomplished by tracing a distinctive clay stratum, named the Palo Verde Clay for this study, in relatively closely-spaced borings (Figure 4). This clay unit is a lacustrine or lake deposit, about 200 feet below the ground surface, that averages between 80 and 100 feet in thickness, and has a known maximum thickness of at least 136 feet. The Palo Verde Clay displays a remarkably distinct signature in borehole geophysical logs, particularly those logs measuring natural gamma radiation. In addition, the clay was recognizable in lithologic cores because of its characteristic reddish-brown color and high clay content which contrasted to the coarser units stratigraphical-

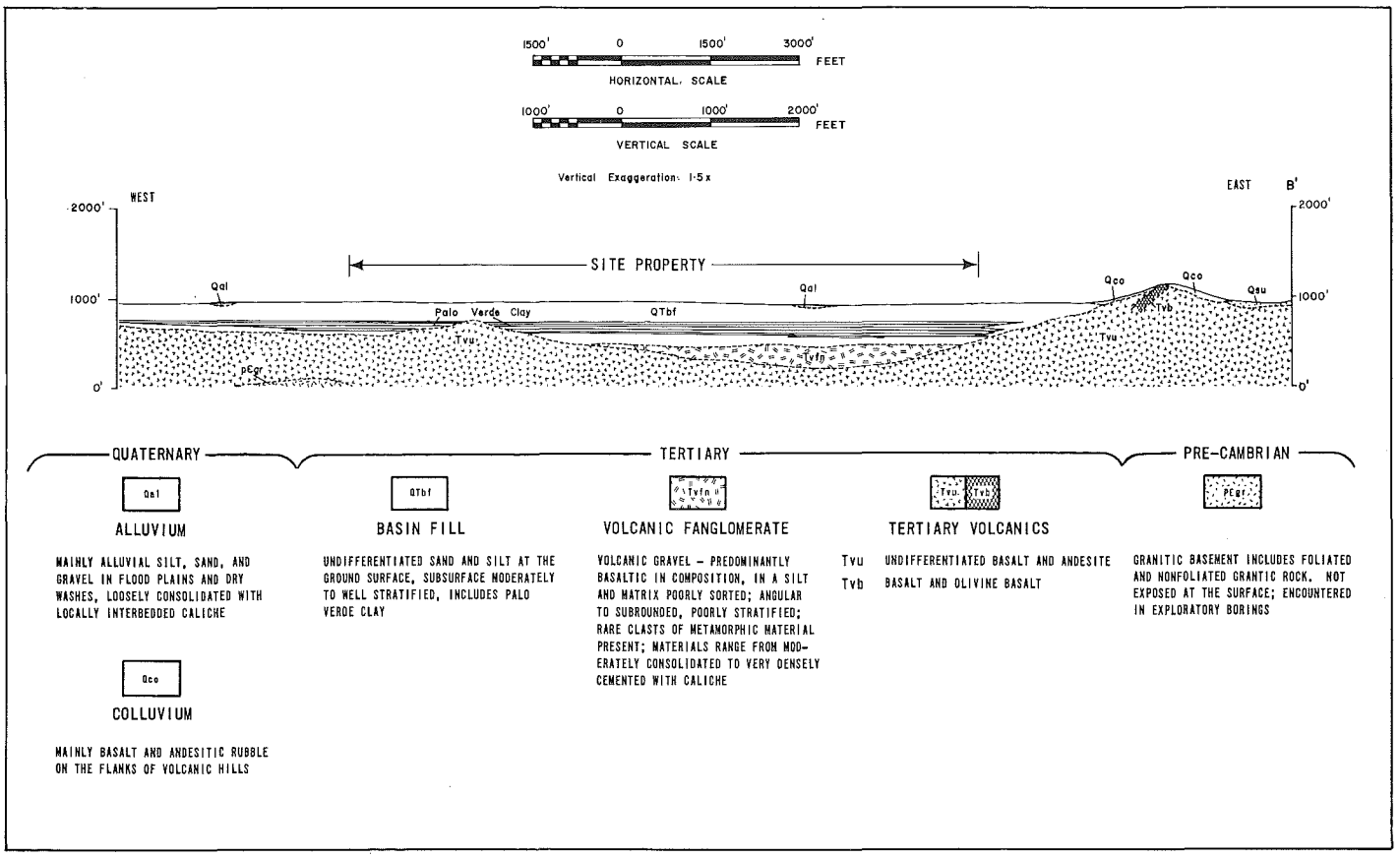


FIGURE 3 EAST-WEST GEOLOGIC SECTION THROUGH THE PALO VERDE NUCLEAR GENERATING STATION SITE

ly above and below. Because the upper surface of the Palo Verde Clay represented a broad lake bottom, the correlations are nearly horizontal and show stratigraphic and structural continuity for the entire five miles between the site and the Arlington basalt flow. To assure that the clay was stratigraphically below the basalt, two borings were drilled through the Arlington flow into the Palo Verde Clay, thereby confirming that the clay was older than 2 million years. To further refine the age of the clay, a paleomagnetic analysis was made on 550 samples of the alluvial sediments taken from locations between the site and the Arlington basalt. Results showed two prominent and continuous magnetic reversals which may correspond to worldwide reversals conservatively estimated to have occurred 2.4 and 2.8 million years ago.

The presence, extent, and continuity of the Palo Verde Clay are of great significance to the Palo Verde site for several reasons:
1. the clay continuously underlies the site and the site area to at least 5 miles southeast and northeast;
2. the clay is relatively old (estimated to be at least 2.7 million years on the upper surface) and is not deformed or faulted, indicating long-term geologic stability of the area.

The only structural folding and faulting observed in the site area have been restricted to the Miocene volcanic rocks in the Palo Verde Hills. Stratification within the Miocene volcanic bedrock sequence is indistinct, but detailed geologic mapping has shown that the dominant structure of the Palo Verde Hills area is a homocline with the volcanic flowbedding striking approximately N40°W and dipping from 15° to 23° southwest. Attitudes and areal extent indicate the volcanic sequence to be nearly 6,500 feet in thickness across the site area. Detailed mapping and trenching revealed no faulting except at one locality in the Palo Verde Hills, about 3 miles west of the site. This fault displaces Miocene volcanic rocks, trends northwest, and is approximately 2,000 feet long. The fault was exposed using closely spaced backhoe trenches, and traced to a point where it is overlain by Tertiary fanglomerate. Since the fanglomerate was not displaced and was of Miocene age (16.7 million years based on a basalt interbed), the fault was pre-fanglomerate in age and not considered a safety hazard by stringent NRC criteria.

## Seismicity

Historic seismicity in Arizona has been moderate in a few parts of the State and almost non-existent in other parts (Figure 1). Of the recorded epicenters withing the State, the three largest have been between magnitude 5.0 and 5.9 and were in the north-central part of Arizona between Flagstaff and Utah. More epicenters have been located for earthquakes less than magnitude 5.0, and these smaller earthquakes form loose concentrations along the Central Mountains Province, trending diagonally northwest across the State, and at the southwest corner near Yuma.

The most notable of strong earthquakes felt in Arizona, but originating outside the State, occurred in 1887 in Sonora, Mexico. The estimated magnitude was 8 and shaking was felt as far north as Prescott and as far south as Mexico City – a radius of about 400 miles from the assumed epicenter. Surface ruptures were reported for 35 miles along north-trending faults on the east and west sides of the Sierra Teras Mountains. The rupturing reportedly has a maximum vertical displacement of 26 feet and extended to within 10 miles of the Arizona border.

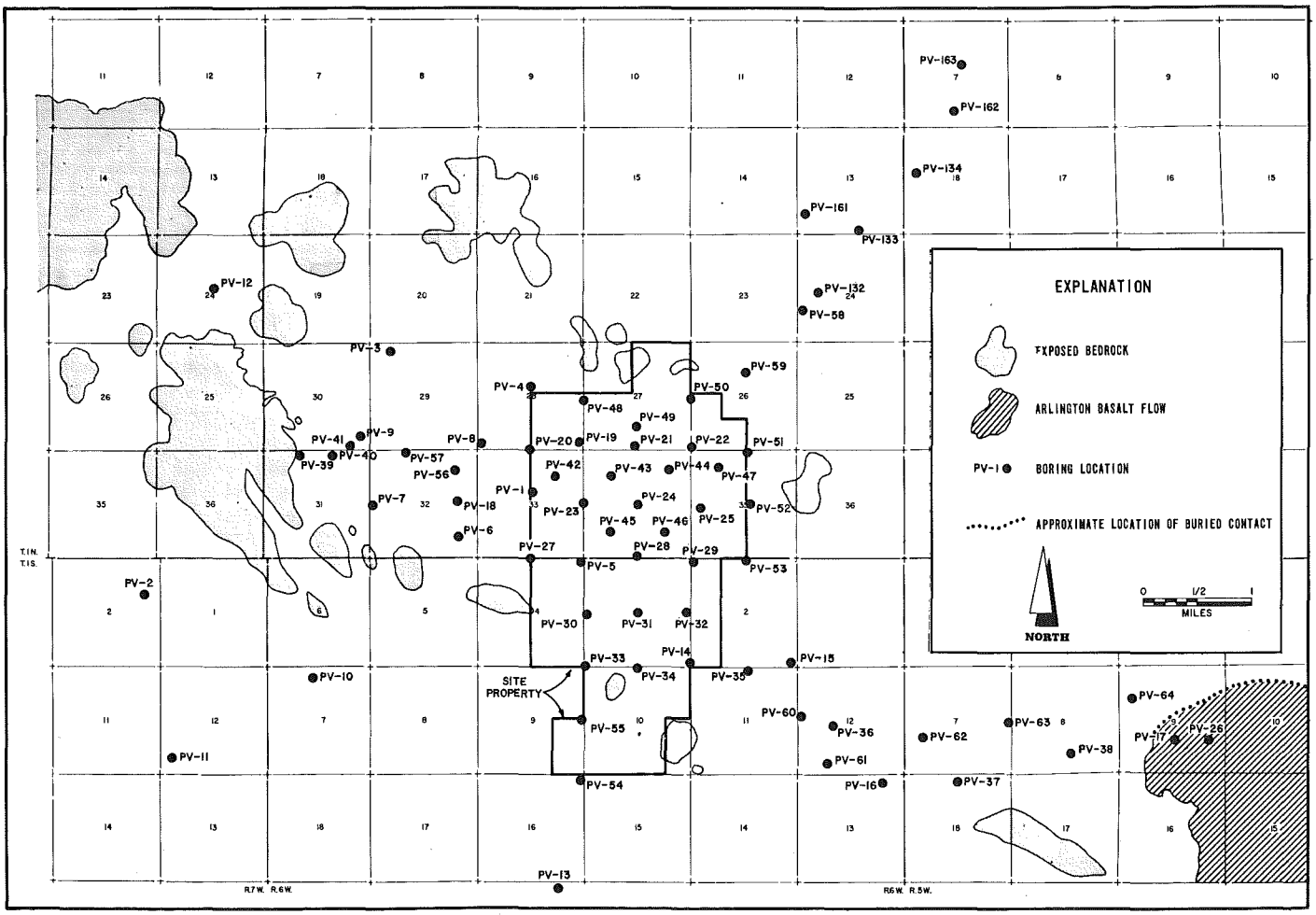


FIGURE 4 LOCATION OF BORINGS AND ROCK OUTCROPS AT PALO VERDE NUCLEAR GENERATING STATION SITE

In terms of the Safe Shutdown Earthquake, the maximum level of earthquake shaking was postulated using the 1887 Sonora earthquake (magnitude 8), relocated to a distance of 72 miles from the Palo Verde site. This conservative estimation was based on a hypothetical relocation of the epicenter from Sonora, Mexico, to a point about 250 miles northwest along major fault and mountain systems in the Transition Zone province. The closest approach of mapped Quaternary faults to the site is in the Transition Zone about 72 miles east of the site. This relocated earthquake is larger than any Arizona historical event and is a conservative representation of the maximum level of shaking that the plant might experience within its design life.

**Continuing Geologic Activities**

As excavations are developed at Palo Verde, detailed geologic inspections are being made of all exposures for any type of facility, including utility trenches. These trenches and other excavations form an extensive network of exposures that are valuable for geologic analysis. At least one wall of all pertinent exposures is photographed as a permanent record, and geologic contacts, with lithologic descriptions, are logged at scales of ten feet to the inch. For Category 1 excavations (Category 1 includes the most important facilities in terms of safety), detailed geologic logs are made at scales of 10 feet and 5 feet to the inch and a detailed geologic map is constructed at a scale of 10 feet to the inch. The purpose of such detailed inspection and logging is to analyze the site geology in as much detail as possible to:

– document the subsurface conditions at the site;

– confirm that design considerations made during earlier investigations still are appropriate for the site conditions.

During these investigations the geologists are constantly alert to detect signs of warping, shearing, faulting, cracking, or other signs of geologic instability that might affect plant design. To date there has been no indication of any such features and, moreover, the geology exposed in the excavations shows positive evidence of long-term geologic stability. One of the best demonstrations of this is provided by the detailed logs which show the precise locations of geologic strata throughout the excavations. Because the excavations are relatively shallow, all exposures are within the basin sediments, which contain distinctive, relatively continuous, and nearly horizontal strata of sand, silt, and clay. By carefully tracing a number of these layers around the excavation and establishing their location with survey points, the strata can be documented to be in place and undisturbed. Occasionally one or more of these strata will pinch out or interfinger with another sedimentary unit. These areas are carefully inspected and other strata are traced across any pinch-out or normal sedimentary structure to confirm continuity and therefore absence of any disturbance. Periodically, representatives of the NRC, U.S. Geological Survey, and Arizona Bureau of make detailed inspections of these excavations and check the pertinent parts of the detailed logging. Once such inspection was completed in September, 1976. All the logs and other pertinent information will be assembled into a final report at the conlcusion of grading and will be submitted to the NRC as a part of the Final Safety Analysis Report, which becomes a public document.

**Conclusion**

The process by which the Palo Verde Nuclear Generating Station site was selected represents a state-of-the-art systematic approach to a complex problem. All the primary safety considerations, geotechnical and environmental, were input on a statewide scale to identify the most promising areas for further study. This was a long, rigorous, and expensive investigation, but has been rewarded by the establishment of the Palo Verde Nuclear Generating Station site and the identification of some viable alternative sites, which also seem to have all the necessary characteristics to demonstrate their suitability. The public should be aware of the difficulty, expense, and time required to identify and license viable nuclear sites in the western United States. The stringent safety criteria for siting are so restrictive that a demonstrably viable nuclear site is an important and rare find that cannot be randomly or capriciously relocated. As a result, viable nuclear sites should be regarded as a form of natural resource to be wisely used for the power needs of this and future generations.

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# Grand Canyon Publications Updated

A new geologic map of the Grand Canyon and a companion book have been published by the Museum of Northern Arizona and the Grand Canyon Natural History Association.

*The Geological Map of the Grand Canyon,* at a scale of 1:48,000, replaces the out-of-print map by John Maxson.

*Geology of the Grand Canyon,* second edition, contains articles covering the Canyon's geological history from Precambrian to Cenozoic times.

The map was compiled under the direction of Bill Breed, Curator of Geology at the Museum of Northern Arizona, and is the result of combined efforts by the Museum, the GCNHA, Western Washington State at Bellingham, the University of Wyoming, and the University of Liecester in England.

Mail orders will be accepted, and should be addressed to the Grand Canyon Natural History Association, c/o Museum of Northern Arizona, Route 4, Box 720, Flagstaff, AZ 86001. The book costs $5.00 plus 50¢ for postage, and the map, rolled in a mailing tube, costs $3.95 plus $1.00 for postage.

# Energy Program Coordination in Arizona

# *The Interagency Energy Planning Office*

by Brent W. Brown

**Introduction**

Traditionally, energy-related activities in Arizona have been uncoordinated and fragmented. Energy programs have been dispersed among some twenty agencies of state government. Such a fragmented structure was not designed to cope with the overwhelming energy crisis which first generated widespread public concern in the 1970s and which is expected to continue for several decades. While some coordination of energy programs undoubtedly did occur among the various agencies, the existing structure did little to encourage it.

In August of 1975, Governor Castro responded to this problem, and established the Interagency Energy Planning Office (IEPO) by executive order. Twenty state agencies are participating members of IEPO, and agency representatives are from the top policy-making levels.

**IEPO – Structure and Function**

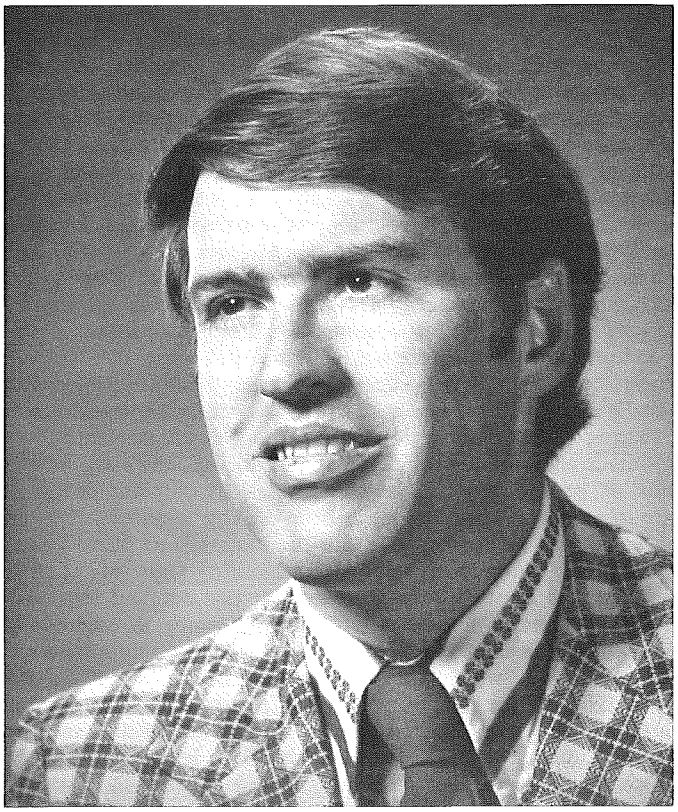
In terms of structure, IEPO has four working subcommittees. An Energy Sources subcommittee, chaired by Jim Warnock of the Solar Energy Research Commission, considers problems of supply and demand. Tom Clark of the Water Commission chairs a subcommittee concerned with the interrelationships between Energy and the Environment. A subcommittee on Energy Conservation and Public Information is chaired by Oscar Lyon of the Department of Transportation, and I chair the subcommittee on Governmental Policy and Administration.

The primary function of IEPO is to provide for the coordination of energy programs and activities among state agencies that either have a primary energy responsibility or, at least, an indirect relationship to energy programs or problems. Another important function is to serve as a major point of contact between state and federal energy agencies. In order for Arizona to compete successfully for its fair share of federal energy expenditures, it is vital that coordination exist at the state level.

Effective and efficient energy decision-making requires many ingredients. One basic requirement is a central repository for the collection of energy data; another is the capability for analyzing energy trends and assessing their socio-environmental impacts. Essential components of a state energy policy must include the development of contingency plans to cope with possible energy shortages and the creation of an energy resources conservation program. Without a legislative mandate to buttress the Governor's executive order which established IEPO, it has not been possible to effectively accomplish such tasks. Nevertheless, IEPO has been able to get the processes started.

**IEPO Activity Since its Creation**

Typical energy-related problems and opportunities require concerted action by state agencies. For example, attracting a 10 megawatt solar electric generating plant to Arizona involves such entities as the Corporation Commission, the Arizona Power Authority, and the Solar Energy Research Commission. IEPO has provided a valuable mechanism for exposing the commonalities of energy interests, expertise, and experience that exist within the member agencies, and has provided a useful vehicle for uniting them for a common purpose.



Dr. Brown is Executive Director of the Governor's Office of Economic Planning and Development, Acting Director of the Arizona Solar Energy Research Commission, and Chairman of the Interagency Energy Planning Office.

From its inception, IEPO meetings have been coordinated with those of the Citizens Energy Task Force which also was established by Governor Castro in August, 1975. The purpose of the task force is to advise the Governor on matters relating to Arizona's energy problems and opportunities. The President Pro Tem of the Senate and the Speaker of the House are members, and the membership of the task force includes a broad spectrum of interests and perspectives.

IEPO has met monthly since its formation and has considered a number of energy policy issues. Information exchange and program coordination among member agencies has been stressed.

"Round table discussions" among the IEPO participants have ranged over such topics as the Palo Verde nuclear plant, the Kaiparowitz electric generating plant, the Alaskan natural gas and crude oil developments, and the Montezuma pump storage project.

Arizona's efforts and strategies in the solar energy area have been major topics of discussion for IEPO members. The Solar Energy Research Commission, which was created by Governor Castro in June of 1975, has taken numerous initiatives in the field, including: a heating/cooling feasibility study for state and public buildings, heating/cooling demonstration programs, solar energy education programs, a solar climatological inventory, agricultural pumping, and an on-going effort to establish an Arizona Solar Energy Research Institute. The Commission also consummated the first memorandum of understanding with the Energy and Research Development Administration (ERDA) in the solar field. This agreement should lead to significant contracts and awards to the state of Arizona in the area of solar energy.

IEPO members also examined the proposal to reverse the flow in the El Paso natural gas line that crosses northern Arizona and to convert it to the transport of crude oil from the Alaskan north slope by SOHIO. IEPO deliberations led to a policy decision to support the El Paso/SOHIO project. The crude oil pipeline, when completed, will transport 500,000 barrels of crude oil daily through Arizona, which raises the possibility for construction of an Arizona oil refinery. SOHIO's president has indicated to Governor Castro a willingness to provide a supply of crude oil to an Arizona refinery, when and if one is built.

IEPO members have been involved in the development of a state energy conservation plan. The overall goal is to accomplish a five percent reduction in the total amount of energy consumed in the state by 1980. Most recently, IEPO participants have evaluated the ERDA plan, "Creating Energy Choices for the Future," and its subsequent revision. Besides dealing with the development of nuclear and solar energy, sections of the plan deal with coal development in the Western states and water use demands. IEPO members are able to assess energy related impacts from the perspective of their agencies. By pooling their perspectives, a relatively comprehensive statewide vision emerges.

### The Immediate Future

The Interagency Energy Planning Office will continue to coordinate energy programs among state agencies for the foreseeable future. Federal/state energy conservation guidelines are on the immediate agenda for IEPO members. Nevertheless, in a larger sense the need still exists for a more permanent, legislatively sanctioned energy agency to effectively and adequately meet the state's future energy problems and needs. The consolidation of various energy activities into a single administrative unit would enable Arizona to accomplish its vital energy functions more efficiently and effectively. Pending the creation of such an agency, IEPO will continue to play an important role in energy matters by coordinating relevant state agency activities.

*The twenty member agencies of IEPO are: Arizona Solar Energy Research Commission, Arizona Power Authority, Attorney General's Office, Arizona Resources Information System, Arizona Water Commission, Arizona Atomic Energy Commission, Arizona Corporation Commission, Division of Emergency Services, Department of Transportation, State Land Department, Oil and Gas Conservation Commission, Department of Mineral Resources, Department of Administration, Arizona Bureau of Mines, Arizona Board of Regents, Department of Health Services, Department of Economic Security, Department of Education, Department of Revenue, and the Office of Economic Planning and Development.*

# Some Views on Arizona Water Problems

**Sol Resnick is the Director of the Water Resources Research Center at the University of Arizona, and a Professor of Hydrology and Water Resources. The following comments were excerpted from a talk he gave September 23, 1976 at a College of Earth Sciences Research Symposium on the UA campus.**

Three problems that I think are the most pertinent are: the water supply; the need for water conservation, or the more efficient use of water; and the need for state laws that encourage water conservation – which is *not* required at the present time.

### The Water Supply

Needless to say, we know we have a serious problem throughout the state. Our ground water levels are dropping – 3 to 4 feet annually in the Tucson area, and as much as 10 feet in the Phoenix area. In places like Beardsley (where they're pumping very intensively for irrigated agriculture) the ground water levels are dropping as much as 20 feet per year. We're using waters that were laid down a long time ago – we're depleting our ground water reserves.

What do we do? We're dealing with a limited water supply that will run out with time. Of course, you *can* import water. The CAP (Central Arizona Project) would do exactly that with the Colorado River waters. People have argued that the CAP is a wild scheme, but if you look at some of the schemes that are being proposed under the Reclamation Act of 1903, CAP isn't wild at all. For example, cotton is grown up on the high plains of Texas and New Mexico where the growers knew there was a very limited ground water supply at the time they started irrigating. They're running out of water. What do they want the U.S. government to do but bring water from the Mississippi River, lift it 4,000 feet, pump it 700 miles . . . to grow cotton! When you look at the economics of that plan, the CAP doesn't look bad at all.

One of the arguments against the CAP is that there isn't enough water in the Colorado River to supply all the needs of the Colorado River Basin. It's true that in 1922 when they broke the flow down, there were 7½ million acre feet on an average per year for the upper basin and 7½ million for the lower basin, which adds up to 15 million. In 1948, some smart Texas senator convinced the government to give Texas the 1½ million acre feet of Rio Grande water that was going to Mexico. In exchange, Mexico received an equal amount of Colorado River water that was being used in the United States. How the guys in the Colorado River Basin could sit around and let that get by is hard to understand.

Now they're talking about another million acre feet of water needed in the Colorado River Basin for energy development – oil shale and coal gassification. Where's this going to come from?

O.K. There's 150 million acre feet of Columbia River water flowing into the Pacific every year. Senator Jackson put a 10-year moratorium on even looking at that water as far as using it for another area. When we're developing petroleum products, but Jackson says we're not going to get any water, I think we ought to tell him he's not going to get any oil or gasoline. If that's the way they want us to play the game, fine, but I don't think it's going to happen.

I think the government's going to have to worry about that million acre feet for energy development; they're going to have to worry about the 1½ million for Mexico; they're going to have to do something like go to the Columbia River.

Other things are also happening that the people arguing against the CAP are probably not aware of. For example, it looks as though cloud seeding might work in certain places, in certain times. Lucky for us, it looks like one of these places (in the winter season) is the western slope area of the Rocky Mountains. About 95 percent of the flow of the Colorado River comes from that area. If they could increase snow pack by about 15 percent, which they think is possible, they're talking about probably 1½ million acre feet of water. This is more than we're talking about for the CAP.

Further, 20 years ago a plan was proposed to bring icebergs from the Antartica. Everyone laughed. Now they're not laughing any more. It looks as though we could take 10 icebergs, each about 1 mile long, 1 mile wide, and 900 feet thick, rope them together, put a propeller on the head iceberg (which becomes the "locomotive"), run an atomic-powered ship alongside this locomotive, and send extra energy over to the propeller. The ship would guide the icebergs into the ocean currents. These icebergs could be parked 10 miles off the coast of Los Angeles. Chop them into pieces, run a line along the bottom of the ocean to the city, and the chunks of ice would melt by the time they arrived in Los Angeles. When ice freezes, brine separates from the ice, so you wind up with ice-cold, pure water – at a cost of about $30 per acre foot.

Right now we're paying $50-60 per acre foot for Colorado River water, which, as you know, is high in salts. Surely, if Southern California could get pure water for $30 per acre foot, they're not going to opt for Colorado River water. A chain of ten icebergs is estimated to contain 9 million acre feet of pure water – about 75 percent of the flow of the Colorado River, which is now estimated to be 13½ million acre feet per year. If San Diego and California were satisfied with the icebergs, perhaps they could free their share of the Colorado River for the CAP to extend as far as Tucson. Admittedly, it would take the federal government to bring the icebergs to the California coast.

Another alternative being offered is desalting water (which is expensive; right now $1.25 per thousand gallons at the location of the water).

### Conservation

Eighty-nine percent of the water used in this state is used by irrigated agriculture – about 7 million acre feet of water per year. The farmers are operating at 50 percent efficiency. However, you can go to Israel, where they use drip irrigation (especially with a crop like citrus) and the most efficient methods they can find – they're up to a 90 percent efficiency in water use! You can do it – *if* you want to.

*Harvesting water.* In a desert area, less than 3 percent of the water, on the average, runs off. The other 97 percent soaks in – but not very far. The sun comes out, the water returns to the surface, and you've lost it by evaporation and transpiration. Of the waters that do run off, that do reach the river channels, about 75 percent finally reach the ground water tables and replenish them.

In water harvesting, you attain as much as 85 percent runoff instead of 3 percent. You cover the ground with plastic, then the plastic with a protective cover of gravel, and lead the water into lined tanks to prevent seepage. You can also cover the tanks with floating rafts to prevent evaporation. You've got enough water, even in a year of the poorest rainfall, for 100 head (one unit) of cattle by using only one-half acre of ground.

The city of Williams, Arizona, hauls their water by tanker at a cost of $2,000 per acre foot – poor quality water, by the time they receive it. A system was designed for them using 200 acres of plastic covered with gravel. The water would run into a tank that would be lined and not covered, so the residents could use it for water recreation. The water would be treated, and there could be the water supply for the city of Williams.

Water harvesting has a tremendous potential.

*Water can be reused.* Tucson, which is screaming about conserving water, is putting 37,000 acre feet per year into the river below the Roger Road sewage treatment plant. They're taking credit for this – they say it's recharged. About 90 percent is recharged – along with a lot of nutrient matter. I don't think it's the kind of water a city like Tucson should be dropping in the river and taking credit for. It's good water for some purposes, though.

Some University of Arizona people came up with the scheme to use gravity to get this water to Avra Valley (an agricultural area west of Tucson). The waters are full of nitrates and phosphates and must have $7-8 of nutrient value per acre foot. It's too rich to use continually, but it can be cut half and half. Trade two acre feet of Avra Valley water for four we could pump to the farmers; bring it to Tucson through the existing pipeline; use it and put it through the treatment plant again; then by gravity, it can go back to Avra Valley.

*Urban hydrology.* When you urbanize a desert region, you increase the quantity of runoff about six-fold. You also decrease the quality of the water – it picks up a large amount of bacteria. A multi-disciplinary study of this situation came up with a method of using this runoff for irrigation and maintenance of greenbelts and parks.

When Tucson built Randolph Park, a wash went right through the park. Someone decided to divert the wash around the park. 2,000 years before Christ, people were diverting water from washes and watering lands alongside the washes. It's not new! If the wash were not diverted away from Randolph Park, the park could be irrigated essentially with storm runoff during the summer.

### Water Laws

We are practically the only state in the Union without any water laws.

In New Mexico, if a farmer is irrigating inefficiently, Steve Reynolds, the State Engineer, can tap him on the shoulder and say, "You've got six months to get an efficient irrigation system or I shut your water off." If six months goes by and he hasn't put in an efficient system, Steve turns his water off. Even if the farmer takes him to court, Steve Reynolds wins every time because he has laws to back him up.

If Wes Steiner (of the Arizona Water Commission) went to Sandy Mesa, where they're using 12 acre feet of water per acre every year to grow citrus (as compared to Isreal where with the same climate and soil the use is 2½ acre feet), and told the farmer to become more efficient or else – they'll tell Wes Steiner to get lost *if* they're feeling *good* that day! There are no laws! You get into ridiculous situations, like the following example.

The water that is inefficiently irrigated on the Sandy Mesa goes down into the valley below; the ground water in the valley comes to the surface in a hurry. The residents of the valley run to the federal government for help, and the federal government takes *our* money, puts in a 14-million dollar concrete-lined

*Continued on page 16*

# ANNUAL REPORT:

# Arizona Bureau of Mines, 1975-76

The main objectives of the Arizona Bureau of Mines, as set forth by law, are to collect and make available to the people of the State information on the geology and mineral resources of Arizona, and to investigate various metallurgical and mining processes in order to determine those most effective for the treatment of Arizona ore deposits.

The Bureau was created in 1915 by an act of the State legislature and placed under the authority of the Arizona Board of Regents. Under the enabling legislation, the Bureau actively engages in research and provides service in the fields of geology, metallurgy, and mining in response to both public inquiries and the requirements of other State agencies. In order to carry out these diverse functions, two basic divisions have been established in the Bureau: the Geological Survey Branch and the Mineral Technology Branch.

## Geological Survey Branch

The Survey is charged with the responsibility of acquiring, disseminating, and applying basic geologic data that are designed to (a) enhance our understanding of Arizona's general geologic history in order to assist in determining the short and long-range influence it may have on human activity and the relative merits of alternative land uses; and (b) assist in developing an understanding of the controls influencing the location of both metallic and nonmetallic mineral resources and mineral fuels in Arizona.

During this year, the Bureau accomplished a long-standing goal with the consolidation of the Survey's professional and support staff into a unified suite of offices and laboratories. In August, 1975, the University of Arizona made available to the Survey new quarters, located at 845 North Park Avenue, on the west edge of the campus.

The Survey's new offices, which include space for the sale of Bureau publications, are more accessible to the public. Additionally, our library facilities are larger and more convenient to researchers, as can be verified by the great increase in use. Visitor traffic has also increased substantially.

The cadre staff consists of four full-time career geologists and one graduate research assistant who serves on a 10-month appointment. During fiscal 1975-76, four additional geologists were employed on temporary status to assist on specific projects supported by non-state funds. Support personnel consist of three laboratory technicians one secretary, and one part-time clerical assistant.

During the year, five research projects were underway, two of which were supported with State funds and three under federal grants.

Geologist Stanton Keith has continued his state-funded project of preparing a series of bulletins that index historic and present mining operations on a county basis. These bulletins contain valuable information that is useful in land-use planning and mineral potential evaluation. During fiscal 1975-76 the third book in this series, "Index of Mining Properties in Santa Cruz County," (bulletin 191) was released and Mr. Keith began working on the manuscript for Yuma County.

John Vuich, Assistant Geologist, completed a field study of the geology, mineral resources, and geologic hazards of the South Tucson Mountain area. The results of this study are scheduled to be published in fiscal 76-77 as a bulletin entitled "Geology and Land-Use Planning." This project also was funded with state monies.

A field and laboratory study of uranium occurrences of the Mogollon Rim and Slope region of Central Arizona, which was funded by a grant from the U.S. Geological Survey, was completed by Geologist H. Wesley Peirce. Field geologists Nile Jones and Ralph Rogers assisted Dr. Peirce, who was Principal Investigator on this project, during the first part of fiscal 1975-76. The final report was released into open file in February, 1976, and will be published during the present fiscal year as a Bureau circular.

An eighteen-month coal sampling project, funded by the U.S. Geological Survey, was begun during fiscal year 1975-76, with Principal Geologist Richard T. Moore the chief investigator and Charles Kiven the assistant field geologist. During the course of the project, samples were taken from the active faces at both of the mines operated by Peabody Coal Company on Black Mesa (which are leased from the Navajo and Hopi Tribes), and from selected sites in the inactive Deer Creek coal field in southern Arizona. A total of approximately 40 samples was sent to the U.S. Geological Survey laboratories for testing for composition and trace element content. The results of the study will be released as an Arizona Bureau of Mines circular early in 1977.

In July 1975, the U.S. Geological Survey funded a two-year project, which is under the direction of R.T. Moore, to define and delineate geologic hazards occurring in an area of approximately 1,240 square miles situated north of Tucson and extending to the latitude of Picacho. A map showing slope stability in the area has been completed and will be published by the U.S.G.S. A second map, showing erosional hazards, is being completed and considerable information has been obtained on the engineering properties of the soils in the area. These data should become available for review in mid-1977. Assistant field geologist Bruce Murphy, a graduate geological engineer from the College of Mines, University of Arizona, has been employed fulltime on the project.

During the fiscal year, Robert Varga held the Bureau appointment as Graduate Research Assistant. His project involved the mapping of a portion of the western Harquahala Mountains and a study of the geologic structure of the area. A copy of his thesis, "Stratigraphy and superposed deformation of a Paleozoic and Mesozoic sedimentary sequence in the Harquahala Mountains, Arizona," is on file in the Bureau's library.

In addition to the scientific studies being undertaken, members of the Geological Survey Branch represent the Bureau at meetings of the Governor's Interagency Engery Planning Office, and prepare the Bureau's response to State Clearinghouse Documents on mining, geological, and environmental issues. At the request of the Nuclear Regulatory Commission, Bureau geologists were involved in the review of the geologic analysis that was an important part of the safety analysis made of the Palo Verde Nuclear Power site, and they are involved on a continuing basis in the ongoing monitoring of geologic conditions as exposed in the various excavations being made for the complex.

All members of the professional staff were called upon to respond to the many inquiries received from industry and members of the public, and individual

staff members were involved in several diverse activities. Dr. Peirce authored and co-authored several papers that appeared in various technical journals; Moore served as Collaborator in Seismology for the National Oceanic and Atmospheric Administration; Dr. Dresher, the Director of the Arizona Bureau of Mines, represented the Association of American State Geologists (AASG) at hearings before the Department of the Interior Task Force on Mineral Lands Availability in Salt Lake City, and before the National Commission on Supplies and Shortages in Washington, D.C.; and Dresher and Moore represented the Bureau at the Annual Meeting of the AASG. Individual staff members were also available for lectures requested by civic and service organizations and a number of public schools and community colleges.

During fiscal 1975-76, steps were taken to expand the geologic publication program of the Bureau and cooperative agreements were made to publish selected materials authored by faculty members at Arizona State University, Tempe. It is planned that this program will be expanded to include other state agencies and universities which are in a position to contribute to the knowledge of Arizona's geologic environment.

**Mineral Technology Branch**

This division of the Bureau has a staff consisting of one mineralogist, two metallurgists, and a mining engineer. Research assistants and laboratory technicians are employed on a temporary basis, when needed.

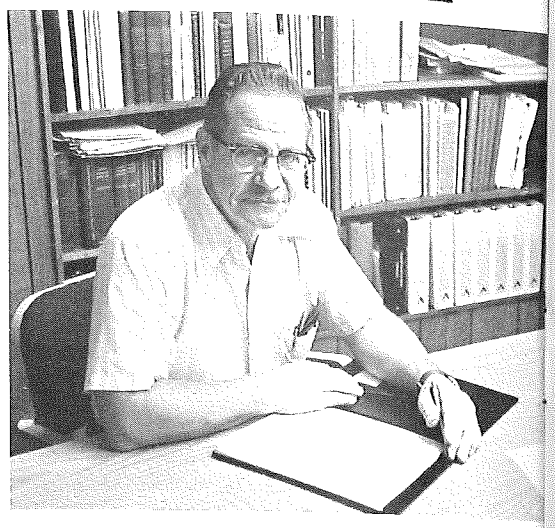
As with the Geological Survey Branch, the mission of this unit is two-fold, including both research and service. The branch conducts research and investigations into, and provides information about, the development of Arizona's mineral resources, including the mining, metallurgical processing, and utilization of metallic and nonmetallic mineral deposits. These activities are directed toward the efficient recovery of Arizona's mineral resources as well as insuring that the recovery methods will be compatible with the environmental aspects of the state.

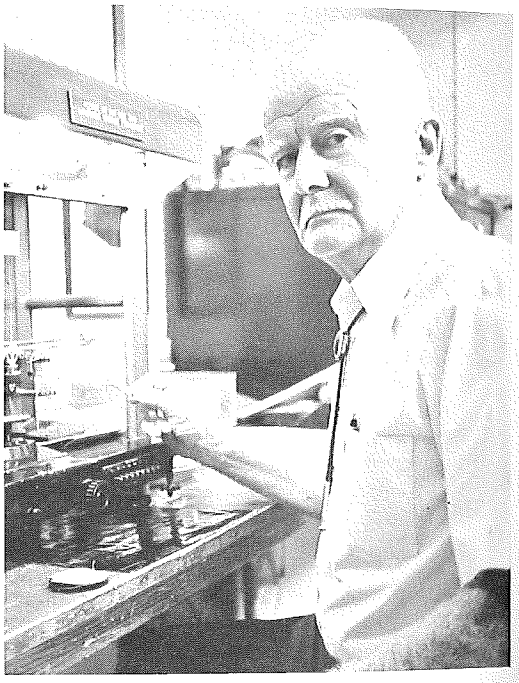
During fiscal year 1975-76, Assistant Metallurgist Walter Fisher completed research to determine the feasibility of using secondary-treated sewage effluent in copper sulfide milling operations. The results of the study were published as Bureau Circular 17. Sam Rudy, Assistant Metallurgist, assisted Dr. Fisher with his research and co-authored the circular.

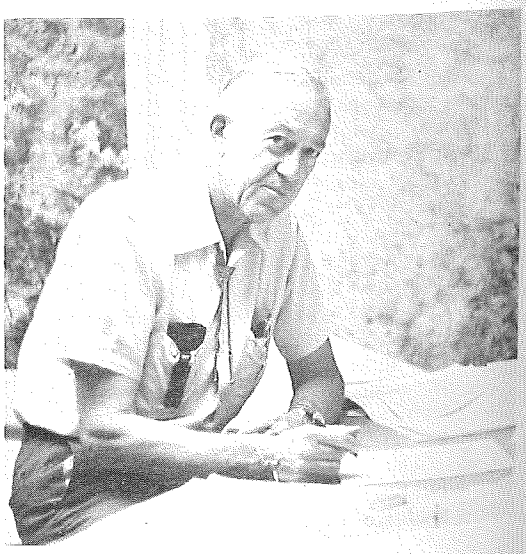
The objectives of this investigation were to (1) determine what effects might be encountered if sewage effluent were substituted for the normal water supply in a copper sulfide milling operation, and (2) examine conventional water treatment techniques for improving water quality. Sewage effluent was found to be detrimental to froth flotation recovery of copper and molybdenum sulfides, causing a severe foaming problem and a significant loss of copper and molybdenum. Various conventional water treatment techniques were found to improve the quality of sewage effluent to an acceptable level for flotation recovery. Additional research is being performed by the Bureau to isolate and identify the constituents of sewage effluent detrimental to copper flotation.

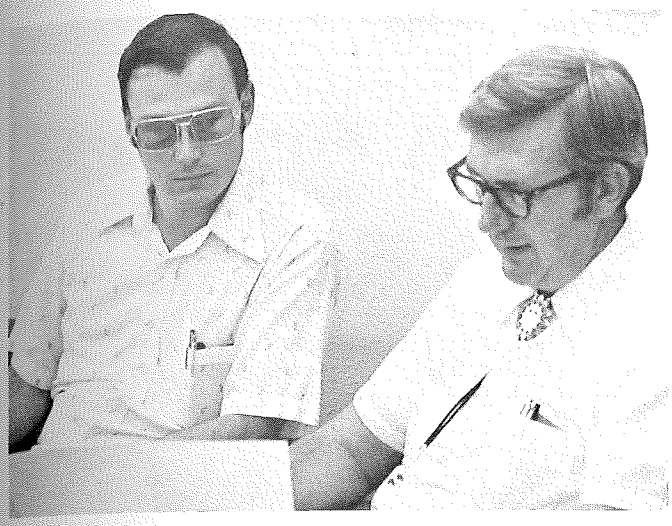
The Bureau sponsored graduate research on the alkaline, cyanide leaching of copper minerals. The purpose of this study was to obtain fundamental data on cyanide leaching of chalcocite, an important copper sulfide mineral, that could be used as the basis for a leaching process that could replace smelting as the copper recovery and refining technique for chalcocite ores. This work resulted in a Ph.D. dissertation in the Dept. of Metallurgical Engineering at the University of Arizona.

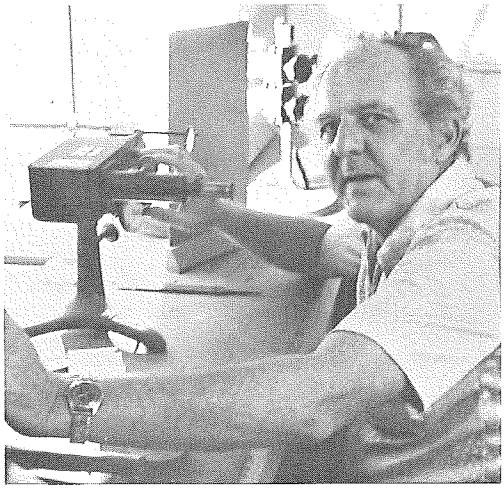
Services performed during fiscal 1975-76 were as follows: Analyses were performed by Associate Mineralogist Robert O'Haire on 1,262 samples of rocks and minerals which were submitted by members of the public for identification. Simple sample identifications, including spectroscopic analyses, were done at no charge for samples originating in Arizona. Small charges were made for samples originating out of state, or when x-ray diffraction analyses were required.





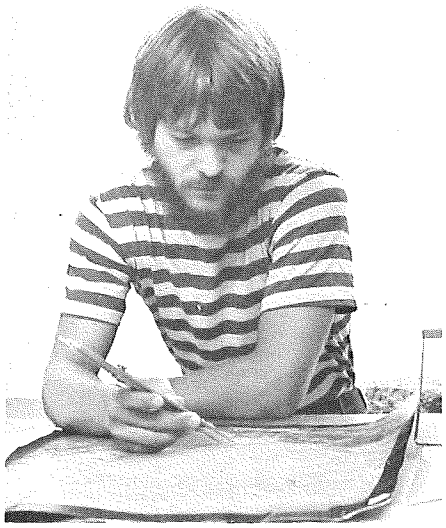






*Clockwise, from above:* **Dr. Walter Fisher,** *Assistant Metallurgist (left) discusses project with* **Dr. William Dresher,** *Director. Assistant Geologist* **John Vuich** *drafts maps to accompany his bulletin on geology and land-use planning. Associate Mineralogist* **Robert O'Haire** *adjusts his spectroscope.* **Bruce Murphy,** *Assistant Field Geologist, works on his geologic hazards project. Assistant Metallurgist* **Sam Rudy** *collects concentrates after completing flotation tests.*

*Opposite page, clockwise from bottom:* **Stanton Keith,** *Geologist, compiles data for his series of bulletins on mining properties. Geologist* **Dr. H. Wesley Peirce** *measures radioactivity of sample from Mogollon Rim area for uranium feasibility study.* **David Rabb,** *Mining Engineer, weighs ore sample.* **Dr. Richard Moore,** *Principal Geologist.*



Amenability tests on 39 lots of ore submitted to the Bureau by members of the public were performed by Mining Engineer David Rabb and Assistant Metallurgist Sam Rudy. Rabb also spent a large part of his time helping interested prospectors, mining property owners, and others in the evaluation of their prospects and in the formulation of workable mining plans for the development of their ore deposits.

Rabb also served in an advisory capacity to several state agencies in the conduct of their responsibilities which interface with mining in the State, and presented talks at numerous colleges, schools, and professional and civic organizations on mining in Arizona. He also taught a course at the University on the practical aspects of mining.

**Other services**

The Arizona Bureau of Mines distributed 5,562 technical bulletins, 4,970 maps, and 24,100 copies of FIELDNOTES. Almost 3,000 individuals visited the Bureau's offices, requesting information pertaining to geology, minerals, metallurgy, and mining. 56 mineral and rock kits were distributed free to public schools for educational purposes. Several out-of-print bulletins and maps were reprinted because of continued public demand. Several staff members gave talks to schools on earth-science-related subjects.

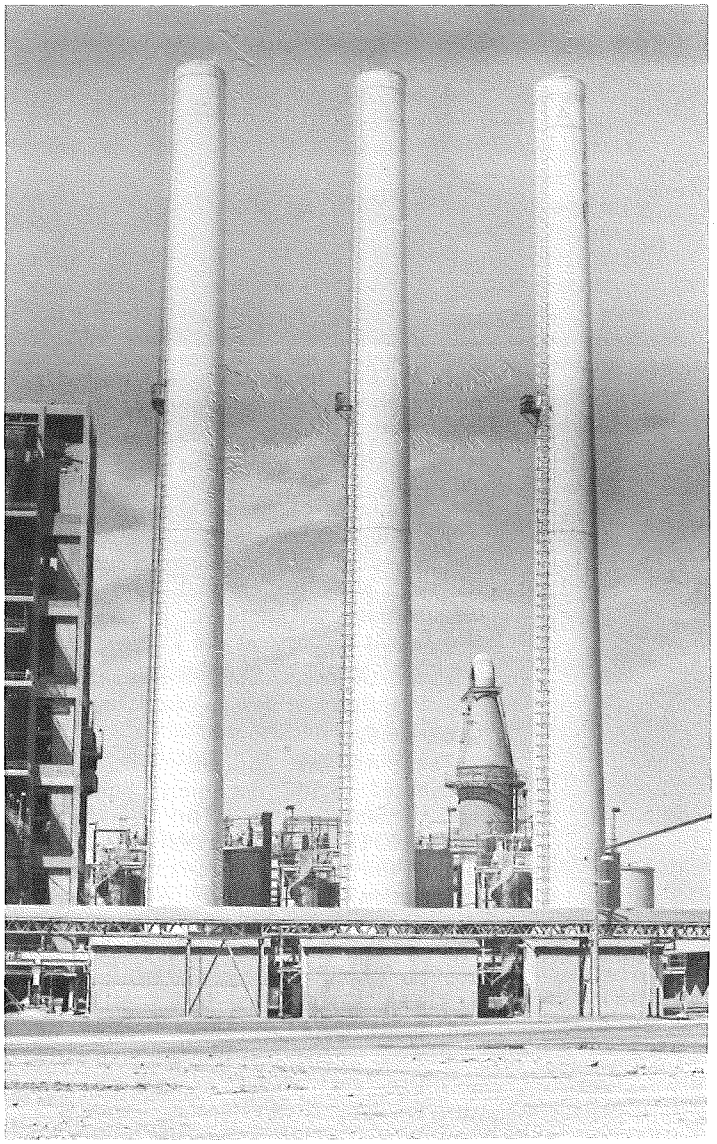
*Continued on page 16*

# Coal Comes to Southern Arizona

In September-October 1976, one hundred and twenty 98-ton-capacity railroad cars loaded with coal were delivered to the Arizona Portland Cement Division (Rillito plant) of the California Portland Cement Co. The production of cement, being highly energy-dependent, is stabilized by having fuel alternatives.

Natural gas, which first came to Tucson in 1933, has been the principal fuel since the plant's first kiln was built in 1949. However, in the last few years in Southern Arizona, peak winter demand for natural gas has exceeded available supplies. At such times the supply to large industry is curtailed, and unless supplementary fuels are both usable and available, production must be limited. Independence is an ideal condition, and energy independence, whether national or local, is no exception.

Rillito cement plant stacks serve three furnaces or kilns.



The Rillito plant northwest of Tucson utilizes furnaces that can be adapted to natural gas, liquid petroleum fuels, or coal. This large-scale coal shipment is the first ever made to this plant. Changeover can be made within a period of 24 hours.

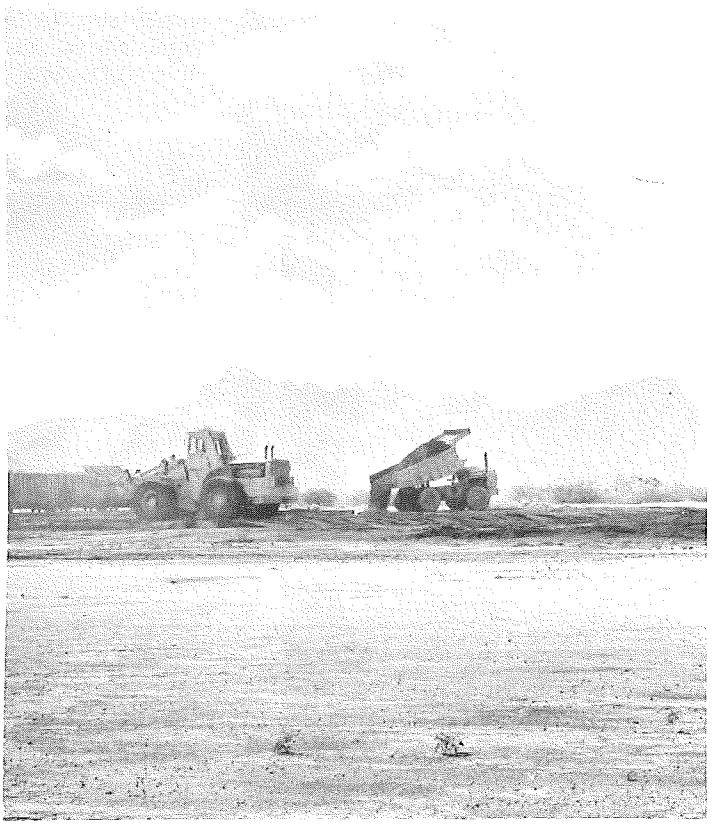
The coal comes from a company-owned mine near Price, Utah, a long-time coal-producing region. It takes about 10 days, utilizing three different railroads, to transport coal from mine to plant.

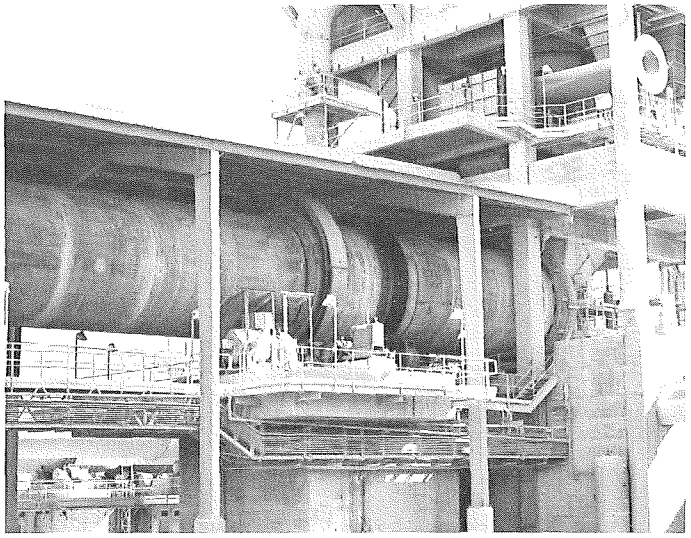
Although the changeover to different fuels is done relatively quickly, there are technological consequences that require sophisticated adjustments. Coal contains substances that become mixed with the cement product, substances not present in the other fuel alternatives. In order to amintain a standard chemical composition, careful adjustments must be made in raw material feed proportions.

The ability of this plant to change over serves not only to even out its production schedule but to release limited natural gas supplies to users that cannot develop viable fuel alternatives.

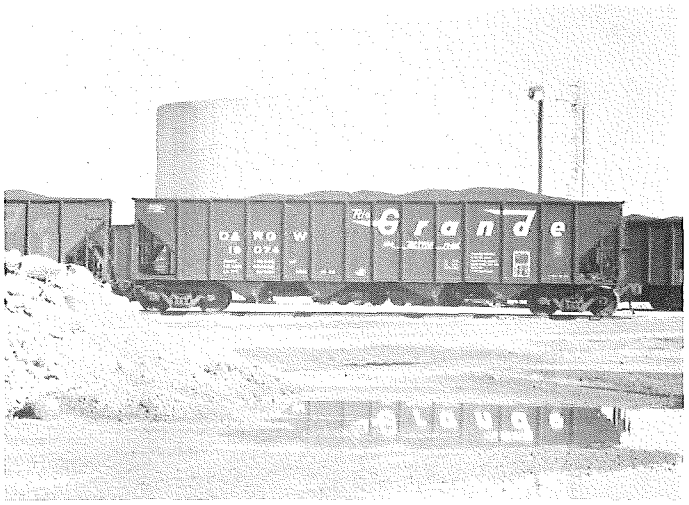
Our thanks to geologist Ken Santini and other plant officials for keeping us posted and allowing us to report on new developments.

Beginning of a coal storage pile. Coal is well packed to decrease oxygen supply and lessen chances of spontaneous combustion.



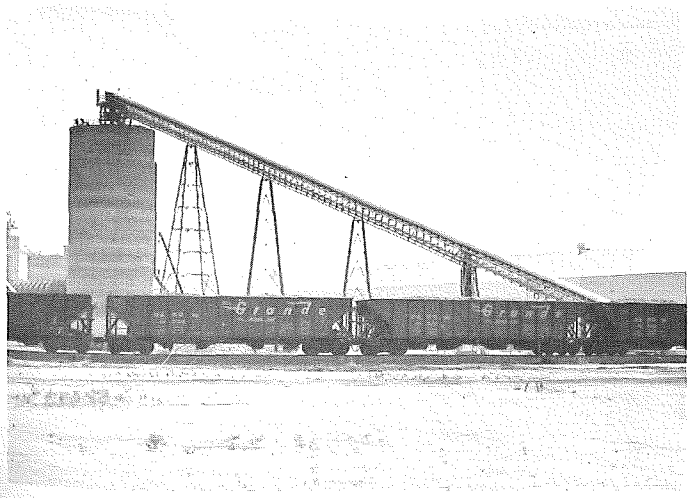


Large rotating furnace where coal is burned in the process of producing cement.



Coal-filled railroad cars with liquid petroleum fuel storage tank in background.

Railroad cars filled with coal. When system is completed, coal will be dumped, crushed, and conveyed to the storage silo in background.



*commentary*

# Geologic Content of Environmental Statements

Recently, the Geological Survey Branch of the Arizona Bureau of Mines submitted an official response to the U.S. Bureau of Reclamation's Draft Environmental Statement on Orme Dam and Reservoir. We, with other agencies and interests, review Arizona environmental matters through a State Clearinghouse that is administered by the Office of Economic Planning and Development in Phoenix. Our obligation is to comment on items coming within our range of professional sensitivity and to return our comments to the Clearinghouse for eventual transmittal to those who initially propose an action in Arizona involving Federal funds.

Subsequent to submittal of our Orme Dam comments, an outside interest obtained a copy of our document from the Clearinghouse and made it public. The ensuing publicity, while a misinterpretation of our comments regarding Orme Dam, served to focus attention on the extent and nature of basic geologic data appropriate to an environmental statement. In the present case, those questioning the need and desirability of presenting a modicum of geologic explicitness cite as their objections: (1) the public's inability to digest technical detail, and (2) the opinion that geology is an existing earth condition and therefore not an impact consequential to the proposed action; that is, geology affects engineering practice and it is the final engineering result that affects environmental conditions, not the geology.

Regarding the "public's" inability to comprehend so-called technical detail, we ask who this public is and to what extent it is represented by agencies that employ professional staffs? We think that the public in general seldom reads and evaluates environmental statements and that this "public" largely is represented by various agencies and organized interests. If there is validity here, then it would seem wise to assemble environmental statements with at least one eye on the diversity of professional agencies whose duty it is to represent the public.

As the state agency responsible for basic geologic understanding and application, do we have a valid interest in something like a large Federal dam project? More specifically, what do we have a right to expect from an environmental statement assembled for such a project?

We agree, in the case of a dam, that geology is not an obvious environmental impact factor. However, it must be of direct concern when considering the general integrity of a feature such as a large dam and reservoir that is proposed to be erected upstream from an already developed region. We think that such a project substantially alters the potential downstream environment – both physically and psychologically. As a consequence, we are not disposed to accept on faith a brief statement to the effect that engineering design and construction, in this case of a dam, will surmount the geologic condition, whatever it may be. The question, then, seems to boil down to the extent to which an investigating agency should share its understanding of the geologic condition with other interested parties through the medium of the environmental statement.

According to the Federal Register, Vol. 38, No. 147, August 1973, p. 20553, the content of environmental statements should include:

*Continued on page 16*

**Commentary** *continued*

"A description of the proposed action, a statement of its purposes, and a description of the environment affected, including information, summary technical data, and maps and diagrams where relevant, adequate to permit an assessment of potential environmental impact by commenting agencies and the public. . ."

Concerning the Orme Dam, from our position we read this to encompass " potential environmental impact" downstream from a dam that will be 195 feet high, over one mile long, and that will back up water for at least 10 miles. We think, therefore, that the environmental statement should contain information, summary technical data, and maps and diagrams adequate to permit an overview and assessment of the downstream environment by this commenting agency.

There seems to be a tendency to avoid inclusion of geologic data that might be misconstrued and/or misused by nongeologists. We are sensitive to this because in our opinion our own Clearinghouse document was misused and misrepresented, though perhaps unintentionally. However, this problem should be lessened by knowing ahead of time that a document will be scrutinized by non-geologically trained persons, and this should be viewed as an opportunity to educate. Perhaps it is better in the long run to err on the side of profuseness rather than brevity when dealing with potentially hazardous matters.

The argument easily is made that none can know more than the investigating agency. Yet there is always the question of whether, in a given circumstance, simply knowing more is enough.

In our opinion, it does not require an excessively lengthy or technical statement to communicate geologic sensitivity, basic investigatory techniques utilized, drill hole patterns and depths, and conclusions regarding those recognized geologic circumstances that require mitigation.

Of course, the extent and nature of geologic coverage varies with each project. However, where appropriate, it is our intent and purpose to encourage both geologic awareness in the unaware and more complete geologic revelation by the aware.

# New ABM Circular

Circular 17, "Utilization of Municipal Waste Water for Froth Flotation of Copper and Molybdenum Sulfides," is now available from the Arizona Bureau of Mines.

This report, written by Bureau metallurgists Walter W. Fisher and Samuel Rudy, describes a laboratory investigation to determine the feasibility of utilizing sewage effluent in place of fresh water in a copper flotation mill.

The detrimental effects of sewage effluent on the flotation process are described along with techniques to modify both the sewage effluent and the flotation process so that waste water is an acceptable replacement for fresh water.

Utilization of municipal waste water in this manner is an important water conservation method that can result in a significant reduction in the consumption of high-quality water.

Circular 17 costs 75¢ per copy. For mail orders, please add 10% of the total order (25¢ minimum) for postage and handling.

**Some views on water** *continued*

ditch, and pumps to keep the water levels down in the valley. Since the valley was once an inland sea, with a lot of salt deposits, the water they're pumping is brackish. The government then delivers this brackish water to Mexico. Mexico starts screaming. The solution? A desalting plant, using reverse osmosis. So, we pay $400 per acre foot to deliver this water to cotton fields in Mexico, which use 2 acre feet per acre (inefficiently) to grow cotton. The 2 acre feet costs *us* $800 — to grow maybe $300 worth of cotton in Mexico. What other country in the world could afford to do this?

*State water plan.* Fortunately, we do have a state Water Commission, they do have good people, and they've come up with a State Water Plan. It's a three-phase plan. The first phase has been completed *(ed. note: see FIELD NOTES, June, 1976).* It's a look at all the water basins in the state. The second phase is due January 1 next year; the third is due January 1 the following year. When the project is completed, the Water Commission will be able to begin to lobby for water legislation.

**ABM annual report** *continued*

**1975-76 Expenditures by Category**

| | |
|---|---|
| Technical and advisory services to members of the public | $ 84,597 |
| Mineral resource and geologic studies (including printing costs) | 172,773 |
| Administration and clerical expenses | 45,555 |
| Total expenditures | $302,925 |

**Sources of Income, 1975-76**

| | |
|---|---|
| Operating budget from State | $251,743 |
| Service charges to members of the public | 6,605 |
| Publication sales | 3,423 |
| Grants from federal agencies | 41,154 |
| Total income | $302,925 |

**FIELDNOTES**

*Volume 6, Nos. 3-4* *Dec. 1976*

State of Arizona
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University of Arizona
President ..... John P. Schaefer
Arizona Bureau of Mines
Director ..... William H. Dresher
Editor ..... Judi Goodpaster

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