# FIELD NOTES FROM THE ARIZONA BUREAU OF MINES

*Vol. 2, No. 1* Earth Science and Mineral Resources in Arizona *March, 1972*

## A NOTE FROM THE DIRECTOR:

### *THE "CONSUMING" CONSUMER*

As regular readers know, I recently became Director of the Arizona Bureau of Mines, the State-supported institution responsible for the geology and mineral technology of one of the major mineral resource-endowed states of the Nation. This move came after 15 years with one of the world's largest resource-based companies: Union Carbide Corporation. The diversity of the products produced by this giant corporation is mute testimony to the U. S. public's reliance on mineral resources.

In Arizona we tend to emphasize copper, the largest single product of the State. To be sure, copper enters into an unusually large number of the manufactured products which make our life what it is today, such as the wires which bring us heat, light, communications, air conditioning, and entertainment, and the pipes which bring water into our homes. But let's go back to my original statement concerning our reliance on mineral resources in general.

Modern lipstick and handlotion rely on silicone compounds derived from *beach sand.* Polyethylene and polypropylene, as used in containers, toys, and notions, require *vanadium oxide* and *titanium oxide* as catalysts in their manufacture, as well as petroleum-derived gases from which the plastic itself is prepared. Flashlight batteries utilize *manganese oxide;* rayon fabrics require *platinum metal* and zinc derivatives in their production. Paint, medicines, foods, fuels, jewelry, photographic film, light bulbs, eyeglasses, automobiles, home appliances, tires, bricks, and the endless numbers of manufactured goods which separate us from the Stone Age have been derived from the ground we walk on. In 1970, Americans consumed 30% of the World's production of minerals but comprised only 5% of the World's population and utilized only 7% of the land area.

We have a responsibility to this generation and future generations to conserve the mineral resources that remain and, more important, to preserve the other less tangible resources, human and environmental, which allow us to enjoy all these consumer goods.

Yet we seem to have entered an era of hysteria. Suddenly we are biting the hand that feeds us – technology and the free enterprise system. As in overeating, excesses usually result in discomfort. But instead of resorting to surgery to cure us, we should analyze what is wrong and correct the cause of the illness.

We recently passed through a decade of intensive technological development: man has walked on the moon; people are walking around with the hearts of other people beating in their chests; a European vacation is but hours away; our farmers are feeding not only our people, but also half again as many more across the world. Suddenly, however, our scientists and our engineers are in public disfavor, and the large corporations which have brought the "good things of life" within economic reach of all of us are blamed for the discomforts we experience – all because of the increasing material demands of the *average American consumer.*

Perhaps in our haste, we haven't taken the time to develop methods of producing goods without waste and contamination. Perhaps we haven't taken the time to either be concerned enough to learn to conserve and reuse the goods we consume, or to care where our waste products are discarded. It becomes evident that these considerations must enter into our manufacturing operations in the future and it is also evident that we, the "consuming" consumer, must be prepared to bear the expense of providing a quality environment as part of the price of having the goods which we require to maintain our standard of living.

### *ORE IS WHERE YOU FIND IT*

At a recent meeting of the Governor's Advisory Commission on Arizona's Environment, Mr. Clarence Hamilton, Chairman of the Tribal Council of the Hopi Tribe, told of his people's philosophy concerning mineral resources. He said: "Our Creator has placed valuable resources in the ground. It is our obligation to discover these resources and use them for the benefit of man." He further pointed out that the income paid to the Tribal Council derived from the coal being removed from Black Mesa, and wages paid to the Hopi people employed in the mine and power plant, would enable his people to raise themselves to a modern standard of living. Their children would be better clothed and fed; their young people could go to college, more industry would be attracted, and the people could become self-supporting.

In contrast, environmentalists cry that "King Coal" is despoiling Black Mesa. "Taking anything out of Black Mesa is, to the Indians, like telling the Pope you're going to tear down St. Peter's to sell the marble," they say. And yet, when the air is cleared of charges and counter-charges, a calm little red-skinned man in broken English says "...we will be able to send more of our young people to the colleges and universities." This is what a natural resource means to one group of people!

We are hearing more and more about trade-offs, of analyses of alternatives, of cost impacts on the utilization of our mineral resources. Although there are many unknowns and uncertainties in such studies, there is one thing that is absolutely certain: ore is where you find it, and we must be prepared to make use of it regardless of its location. A mineral deposit cannot be moved (unless it is mined); it cannot be conveniently located away from a town, and it can't be relocated to someone else's backyard: ore is where you find it!

Its presence is a constant reminder of a supply of needed material to maintain our modern society, and a reminder that provisions must be made to enable the development of mineral resources without conflict with other uses of the land. Priorities must be established by proper and farsighted legal actions which are taken only after careful consideration of alternatives.

There are those who advocate closing public lands in the name of wilderness preservation, before geologists are permitted to determine the mineral potential of the area. To do so would be to overlook a very important fact: basically, the United States is not overly endowed with mineral resources. We are increasingly dependent upon foreign sources of supply. Mined imports now providing 15% of our needs are projected to 30 to 50% by the year 2000. This is good for neither our balance of trade with foreign governments nor for our national security.

During the recent embargo on the Rhodesian regime of Ian Smith, our country was forced to become almost wholly dependent upon the purchase of metallurgical-grade chrome ore from the Soviet Union. Chromite is a strategic material, vital to the defense of our country. It is also required for the many stain-resistant alloys required in our shiney modern consumer goods. During

*Continued on page 2*

*Director (continued)*

this time, the price of ore continually increased, the grade decreased, and we were completely dependent upon the whims of an unfriendly nation for a vital mineral commodity! In fact, we were further embarrassed by the suspicion that much of the ore we were purchasing was Rhodesian ore, resold through Iron Curtain channels. Regardless, the fact remains we do not have an economic source of chrome ore in this country! Is this to happen to copper, lead, zinc, iron and other vital materials for use in our society? It could in the forseeable future!

A storekeeper must continually monitor his inventory to assure himself that he can supply his customers with the goods they require. In the same way, agencies responsible for mineral resource development must survey the extent of mineral reserves in order to assure an adequate supply for the future. Ore deposits are similar to the other goods we consume with but one exception: a deposit can be mined out but that deposit can never be reinstated; thereafter we must go elsewhere for our needs. Minerals are a depletable commodity! Is it unreasonable, therefore, that the U.S. should have a continuing inventory of domestic mineral commodities? Is it unreasonable that, before we place a tract of land in the time-capsule of "wilderness area," we attempt to gain intimate knowledge of its mineral-producing value? Should we sterilize an area by land development without first evaluating its full potential; especially since modern exploration techniques permit the required information to be gathered with little disturbance of the land being explored? Remote sensing methods and careful housekeeping during drilling can cause little evidence that man has intruded on the wilderness. If mineralization is evident, plans can be made to ultimately develop the area for the production of these mineral resources. If no mineralization is evident, alternate uses for the land can be established with a clear conscience.

The Federal Government has developed the procedure of preparing an "Evnironmental Impact Statement" for every project potentially involving the quality of the human environment. By law, state and local governments must do likewise if Federal funds are to be involved in the project. "Econometric models" are being established to evaluate the extent of the *cost to society* of actions affecting the quality of the environment. These procedures are certainly in keeping with the philosophy of gathering all relevant facts before decisions are made!

These are sensible steps to be taken, providing the fact-finding and decision-making procedures can be managed properly and objectively. Thus far the trans-Alaska pipeline and the cross-Florida barge canal have experienced inordinant delay because of the political ramifications of the "Environmental Impact Statement." In spite of the enlightened intent of the "Environmental Impact Statement," there are questions as to the implementation and enforcement. Who will decide yes or no once the facts have been accumulated? How can political overtones be removed from such decisions?

## *THE TECHNOLOGY DILEMMA*

The United States has always prided itself on being competent in the technology required to manufacture the goods its population needs. This technology has kept us competitive in a world which not only offers more mineral resources than those which we possess, but pays its labor much less than we pay ours. World conditions have changed, however. As the war-devastated industries of Europe and Japan were rebuilt, new, very advanced technology was developed and injected into these industries. Nearly every major technological development in the minerals industry in the past two decades originated overseas! The new smelter at Inspiration, Arizona is based predominantly on European technology, and a portion of its engineering and equipment is being purchased overseas. There are other examples: the flash smelting process for San Manuel was first developed and put into practice in Finland and Canada; the basic-oxygen steel-making process was developed and first placed in operation in Austria, Sweden and Germany; the new lead-zinc blast furnace was developed by the Imperial Smelting Company of England; the continuous refining of crude lead was perfected in Australia; the autogenous method of grinding (used extensively by Arizona mills), began in Canada; and the hydro-cyclone, a device widely used in Arizona for the continuous separation of fine mineral particles from fluids, is a Dutch contribution. The point is: we do have the *latent* capability for technological achievement in these areas; e.g., spurred by the needs of national defense in the late 40's and early 50's, we developed a pre-eminent position in the production of columbium, titanium, zirconium, hafnium, uranium, rare earth and rhenium – metals which had limited use before these years. These are some of the brightest accomplishments of U.S. extractive metallurgy. Novel chemistry and engineering were combined to make these innovations.

The unit operation of solvent extraction in which an organic liquid is used to extract and purify constituents from aqueous solutions was developed in this country for the relatively difficult purification of metallic elements. Since then the method has been applied here in Arizona and elsewhere in the world to the large scale commercial extraction of copper.

The U.S. development of metal chloride separation and purification processes has led to the large tonnage, commercial process for producing titanium dioxide, a widely used non-toxic substitute for lead compounds formerly used in paint.

There is growing anxiety on the part of our government, (BUSINESS WEEK, January 15, 1972, page 44), that the widening gap between foreign technology and domestic technology is going to place the United States in an increasingly poorer position in foreign trade. We could become dependent on foreign governments to supply us with many vital materials required by our consumers. Economists emphasize that no factor is more fundamental to a nation's security and its standard of living than its technology. This includes the inventiveness of its people, the cost effectiveness of its products, and the productivity of the means by which it makes them. To compete, we must restore the pre-eminent position we once had in many technological fields but most important, we must learn to competitively develop our natural resources and still accomodate our need to conserve these resources and to preserve our environment.

## *THE CLIMATE FOR INVESTMENT*

Here in Arizona we boast a perfect climate for the enjoyment of man. Our population has shown a steady increase, and our construction industry is thriving. It is plain to see what a favorable climate can do; Arizona is a perfect example. However, it is not this type of climate I wish to discuss but rather the climate for progress in the quality of living, in economic growth, and in technological innovation with the end result, the betterment of man.

The minerals industry, like agriculture, is a prerequisite for human development because, as we pointed out in the introductory paragraphs, we are totally dependent upon mineral resources for the goods we rely upon for survival. We tend to lose sight of this point because, unlike agriculture, the products manufactured by the industry are not available as such on the shelves of the supermarket. Rather, these products are intermediates to the products we ultimately buy. It has been estimated that approximately 300,000 individual companies are directly dependent upon the 50 companies which comprise the bulk of the minerals industry in the United States! For every mineral product produced, there are literally hundreds of products derived for our purchase, enjoyment and consumption.

A mineral-producing company is, in the terms of the economist, *capital intensive.* That is, the industry requires great sums of money to invest into its operations in order to conduct its business in a cost-effective manner. In contrast, for example, an electronics instrument-manufacturing company is *labor intensive.* Today the copper industry requires nearly $3000 of capital investment per ton of refined copper per year. This figure has been steadily increasing because of the continually decreasing quality of ore available. Ten years ago, only half of this amount was required per ton of plant capacity. Thus, a large copper-producer in Arizona may have as much as $250,000,000 invested in its mining and processing operations. The question is, where is money to come from to provide for modernization and expansion? The answer is obvious; under the free enterprize system, the investment comes from the public. We, the consumers, have supplied the money required for the manufacturing facilities of all the goods we buy. The real question is, who makes the decisions as to what company to invest in? Here most of us have lost control, for our money is in the hands of custodians: the banks, the insurance companies, etc. How that choice is made is fundamental. We invest in the company that can either give us the best long-term stability of an income from our investment, or in the company that can give us the maximum return on our investment, i.e., the interest rate. In order to restore the public's confidence in banks after the crash of 1929, the Federal Government insured the investor's savings, thus assuring the investor that his money would be safe. No such system exists for investment in the minerals industry. This is a risk market. To attract risk money to the minerals industry, the climate must be such that investors are willing to put their money here. They must be willing to place their bets on the health and welfare of the minerals industry.

At the present time there are uncertainties developing from all quarters which promise to deter investment in the minerals industry – the threatened closing of federal lands to mineral exploration, the proposed auction system for assigning mineral rights to the highest bidder once a new deposit is located, repatriation of U.S.-owned foreign mineral operations, the "pollution over-kill" movement, temporary over-capacity conditions, price stabilization, and unstable labor conditions. Such uncertainties foster curtailment of industrial activities aimed at long-term development – exploration for new mineral deposits stops, research and development into new processes and products ceases, and investment into new and expanded facilities is curtailed. To preserve our standard of living and national security, we must take measures to create a more favorable climate for investment in the industries which are so close to our basic needs. One approach to a better realization of this goal is the full utilization of our technological resources, starting with our research and development capabilities in thinking, testing, exploring, discovering, and working out new ways to make the best and most efficient use of our mineral resources.

## *THE ARIZONA BUREAU OF MINES*

The Arizona Bureau of Mines was specifically chartered to aid and assist in the development of the mineral resources of Arizona. Under this charter, it has concentrated its efforts on delineating the natural resource base of the State through geological survey activities and in the assistance of mine and mill operators in the solution of their technological problems.

In surveying the scene from THE "CONSUMING" CONSUMER to THE CLIMATE FOR INVESTMENT, I see a sobering picture before me – a picture which could affect our lives as well as the lives of our children. Insofar as Arizona is concerned, the Bureau must shoulder the responsibility of providing an objective, professional interpretation of the issues before the State in the development of its mineral resources and to provide technological input to the solution of the problems before us. In this work, it is important that guidance and direction be provided in an environment which promises benefit to all peoples of the State, rather than an approach which will benefit one group at the expense of others.

Historically, the development of mineral resources has been a major segment of the economy of the State. At a time when America depends more on foreign sources of mineral commodities and controls less and less of these commodities, the State of Arizona has the opportunity to boost its economy to an even greater extent by supplying the nation with much of its needs. How to do this while preserving the quality of Arizona's environment and respecting the rights and desires of its citizens is the challenge which we face in the Arizona Bureau of Mines.

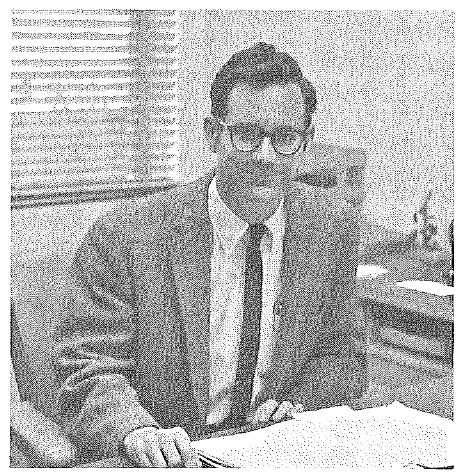
## SPECIAL GEOLOGY COURSE

This spring from January 31 to April 17, a special course in geology is being presented by Professor Spencer Titley at the University of Arizona. In order to acquaint exploration geologists with this part of the southwest and to specifically consider geological problems in the exploration of this region, Dr. Titley is reviewing the major characteristics of Basin and Range geology in Arizona, with special emphasis on the geology pertinent to the porphyry copper deposits. The course fee was $35.00 for the 10 sessions and further information on this or subsequent courses can be obtained from:

General Extension Specialist
Division of Continuing Education
Room 103, Administration Building
University of Arizona
Tucson, Arizona 85721

## NEW ASSISTANT TO THE DEAN, COLLEGE OF MINES

Effective January 1, 1972, Professor William P. Cosart was appointed the Assistant to the Dean of the University of Arizona College of Mines. Dr. William H. Dresher, Dean, announced that Professor Cosart will be responsible for assisting him in the administrative affairs and, when required, will substitute for the Dean in all matters pertaining to the College. In addition to this responsibility Professor Cosart will retain his Professorship in the Department of Chemical Engineering and conduct those classes and fulfill those duties assigned to him by the Chemical Engineering Department Head.



Dr. William P. Cosart, new assistant to the dean, College of Mines.

Bill Cosart did his undergraduate work at Stanford University and received his M.S. in Chemical Engineering from Stanford in 1960. After a tour in the U.S. Army Chemical Corps, he was associated with the Bio-Engineering Department of the Oregon Private Research Center at Beaverton and later worked toward a Ph.D. degree in Chemical Engineering at Oregon State University, Corvallis, this degree to be awarded in June 1972. Professor Cosart has been a member of the faculty of the Chemical Engineering Department since February 1968.

# RED LAKE SALT MASS

by
H. Wesley Peirce

## INTRODUCTION

Surface to near surface halite occurrences in the Nevada portion of the Lake Mead region have been known for many years. In 1958, thirty miles south of Lake Mead near a playa known as Red Lake, the Kerr-McGee Red Lake No. 1 evaporite test cored 1190 feet of relatively pure, coarsely crystalline halite. The site of this encounter is in Hualapai Valley north of Kingman, in Mohave County, Arizona (Fig. 1). A short time later the Kerr-McGee Red Lake No. 2 was drilled about two miles NE of the No. 1. The No. 2 test cut 635 feet of similar halite, the top in both cases being on the order of 1500 feet below the relatively flat valley surface. Both tests terminated in salt. Then, in July 1970, the El Paso Natural Gas Company Red Lake No. 1, drilling within one-half mile NE of the No. 2 Kerr-McGee test, cut slightly in excess of 4,000 feet of apparently similar halite. This test also bottomed in salt.

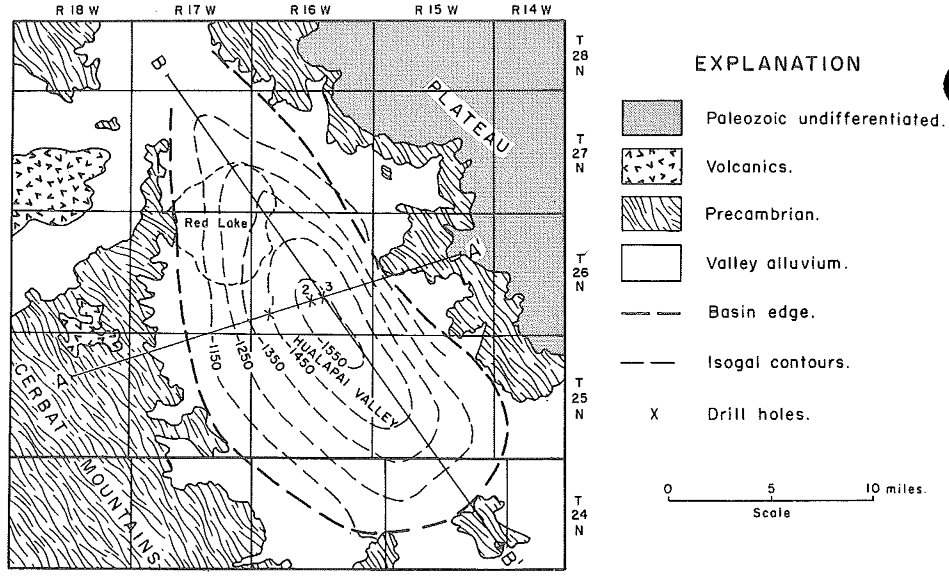



Figure 1. General geologic map, Red Lake-Hualapai Valley area, Mohave County, Arizona.

## SHAPE AND SIZE

The approximate elevations of the salt tops in the three holes are: KM-1 – 1382, KM-2 – 1310, and EP-1 – 1004 feet above sea level. All were drilled from a surface elevation near 2800 feet. The inferred relief on the top of the salt approximates 380 feet over a lateral distance of about 12,000 feet.

Geophysical work, principally gravity data, suggest that the salt mass might be on the order of 12 miles long paralleling the length of Hualapai Valley, 5 miles wide perpendicular to the sides of the valley, and as much as 2 miles (10,000 feet) thick (Davis, 1972). If these data represent good approximations, the salt mass in gross aspect is tabular in shape. The long and intermediate axes occupy a horizontal plane oriented along and across the valley, respectively. The shortest dimension is the vertical axis or thickness factor.

## BASIN FORM

A plan view of the valley suggests the possibility that a closed basin existed in the geologic past (Fig. 1). Outcrops of Precambrian crystalline rocks appear to restrict the basin to the south. North of Red Lake there is a constriction that narrows the valley width from about eleven to five miles. A seismic profile included in Gillespie and Bentley (1971) crosses the valley near this neck. The elevation of "bedrock" in the center of the valley is shown by them to be just slightly below sea level whereas the elevation of the bottom of the El Paso test (still in salt) is near 3,000 feet below sea level (Fig. 2). The inferred depth to "bedrock" in the El Paso test area is no less than 9,000 feet below sea level. The gravity pattern itself suggests a closed basin (Fig. 1) and the amount of closure in the basin seems to be at least 9,000 feet.

## STRUCTURAL POSITION

Hualapai Valley occupies a unique position in that it lies between the relatively stable Colorado Plateau to the northeast and the first range in the Basin and Range country to the southwest, the Cerbat Mountains. Also, the valley, which is elongated northwesterly, is immediately south of the point where the edge of the Plateau swings from east of north to a northwesterly trend. The Hualapai basin-plateau boundary is usually considered to be a buried normal fault. The Grand Wash fault, which bounds the Plateau further north, has a postulated stratigraphic throw of 16,000 feet (Longwell, 1936). Whether or not the suspected fault that forms the northeastern limit of Hualapai basin is an actual continuation of the Grand Wash fault is not known. The basin margin on the Cerbat side may or may not be significantly faulted. Remnants of probable Tertiary volcanics that rest unconformably on the Precambrian terrane of the Cerbats dip toward the Hualapai Valley as much as twenty degrees (Wilson and Moore, 1959). If this attitude is tectonically derived then it is reasonable to suspect that the Cerbat block has been rotated to the northeast. The asymmetry of the gravity contours is suggestive of a one-major-fault valley. The longitudinal basining suggests differential movements amounting to several thousands of feet over a lateral distance of about twenty miles (Fig. 2).

## AGE

The age of the salt in the Hualapai Valley is subject to interpretation. The exposed regional geologic habit strongly indicates that Mesozoic and Paleozoic strata were removed from the Cerbat-Hualapai Valley region before detachment from the Plateau, by subsidence, took place in Tertiary time. South of Lake Mead probable pre-salt Tertiary volcanics characteristically overlie a stripped surface cut on Precambrian crystallines. Longwell (1963) observes that an estimated 17,000 feet of Mesozoic-Paleozoic strata present in the Frenchman Mountains near Las Vegas are not represented in northern Mohave County south of Lake Mead. This regional stratigraphic setting places constraints on the age possibilities of the salt. The basining event clearly appears to be a Tertiary feature and the salt in the basin, regardless of origin, is likely to be Tertiary in age. The El Paso Natural Gas Company has attempted to obtain an idea as to the age of the salt. Pollen work was done on a piece of core (supplied by the Arizona Bureau of Mines) that was taken from above the evaporite sequence and potassium-argon techniques were applied to water insolubles contained in the salt (Spitler, 1971). Data obtained from these two studies suggest a Triassic-Jurassic age for the materials dated, namely pollen above and mineralogic contaminants in salt. It seems possible, however, that these determinations are dating transported materials derived from Triassic-Jurassic source rocks, and not the salt.

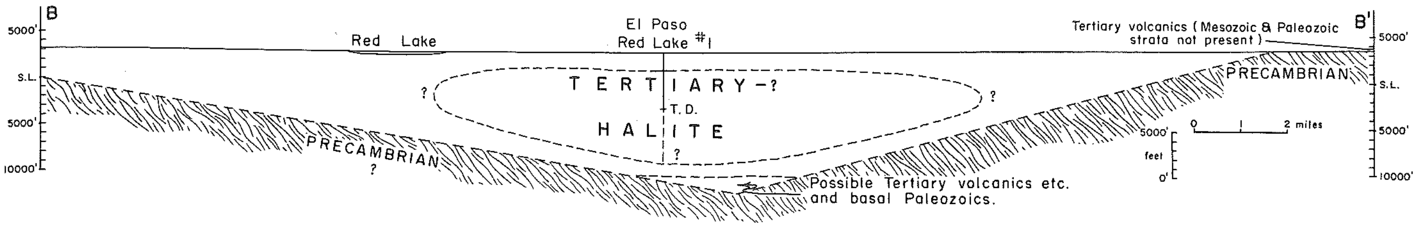



Figure 2. Longitudinal generalized geologic section B-B' along Hualapai Valley.

Evaporites including halite, gypsum, and carbonate (Hualapai Limestone) are associated with the largely Pliocene Muddy Creek Formation in the Lake Mead region to the north. It appears reasonable to consider that the salt in Hualapai Valley may be Pliocene in age but not necessarily the precise time equivalent of halite previously recognized in the Muddy Creek Formation.

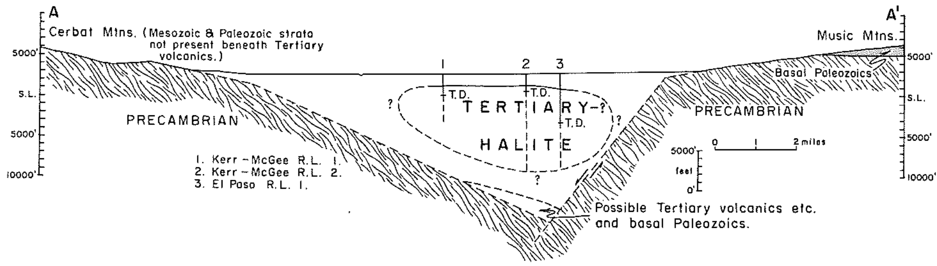



Figure 3. Generalized geologic cross section A-A' across Hualapai Valley.

## MODELS

The model presented here is that of rapidly accumulating non-marine halite in a likewise rapidly subsiding closed basin in late Tertiary time. It is believed that this interpretation is a logical extension of the basic geologic data presently in hand. The geologic framework envisioned is perhaps quite different from that involving marine waters and unstable continental margins. It might well be that subsidence rates of some basins during Basin and Range tectonism were sufficient to accommodate the relatively rapid depositional rates normally credited to halite.

Koester (1971 and in McCaslin, 1972) has presented a different model in that he considers the Red Lake salt mass to be a salt dome. His "reasons for considering the Red Lake salt as a salt dome are the great thickness of relatively pure salt, the presence of caprock-like material above the salt, the dip between the Kerr-McGee No. 2 well and the El Paso well, the proximity to the salt dome in the Overton Beach area of Clark County, Nevada, and the geophysical and palynological data."

## COMMENT AND CONCLUSIONS

The present salt mass might contain as much as 100 cubic miles of halite. If this mass is to be considered intrusive then there is an additional room requirement for the source material. If the basin walls are converging with depth, a constraint is placed upon the amount of available room. The fact that the inferred vertical dimension of the salt mass is less than width and length is not suggestive of large magnitude extension in a vertical dimension as is commonly associated with salt dome intrusion. The so-called "caprock" might well represent a normal accumulation of sulfate associated with salinity decrease as is implied by encroaching fine-grained clastics that eventually covered the evaporite materials. The Overton Beach area in Nevada appears to be within a complex tectonic region. On the other hand, the Hualapai salt mass, though probably internally rearranged to some extent, might be in a more stable tectonic setting against the Plateau.

The geologic history of thick halite deposits being discovered in Arizona valleys is of much interest. Although the final story of their genesis is not yet available, it is suggested that "thickness" be placed in the perspective of Basin and Range history and possibilities. When this is done perhaps we will be able to encourage a multiple hypothesis approach to this relatively new problem in Arizona geology.

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Gillespie, J.B., and Bentley, C.B., 1971, Geohydrology of Hualapai and Sacramento Valleys, Mohave County, Arizona: U.S. Geological Survey Water-supply paper 1899-H.

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Longwell, C.R., 1936, Geology of the Boulder Reservoir Floor: Geological Society of America Bulletin, Vol. 47, p.p. 1393-1476, maps.

McCaslin, J.C., 1972, Arizona Salt Domes Command Oil, Gas Study: Oil and Gas Journal, Jan. 17, p. 125.

Randolph, P.L., 1971, Natural Gas Storage: Paper presented at the ANS/AIF Annual Conference, Miami Beach, Oct. 1971.

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Wilson, E.D. and Moore, R.T., 1959, Geologic Map of Mohave County, Arizona (scale, 1:375,000): University of Arizona, Arizona Bureau of Mines.

__________, 1963, Reconnaissance Geology Between Lake Mead and Davis Dam Arizona-Nevada: U.S. Geological Survey Professional Paper 374-E, 51 p.

## GRADUATE MINING CONSERVATION SEMINAR

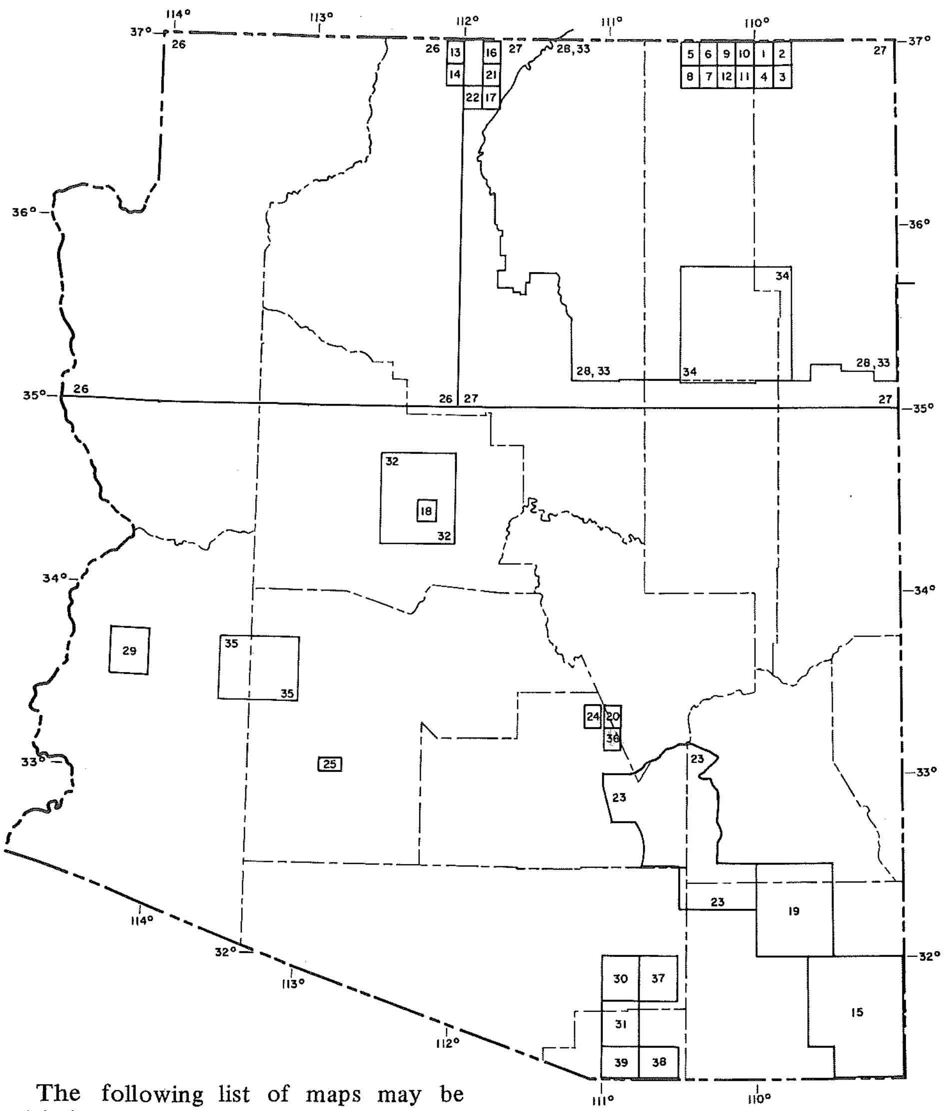
A graduate-level seminar on "Conservation of Mineral Resources" was offered during the spring semester by the University of Arizona College of Mines.

Co-sponsored by the UA Division of Continuing Education and the Summer Session, the seminar presented an overview of conservation objectives and practices in the fields of exploration, mining and resource management.

Meeting 13 times during the semester beginning Jan. 31, the series offered two units of graduate credit upon successful completion.

Topics included in the schedule were: estimation of resources; trends in mineral demand; innovations in mining; the energy crunch; minerals and the physical environment; waste management and surface restoration; multiple use and economic analysis; international aspects of conservation, and guidelines for mineral planning.

# GEOLOGIC MAP INDEX OF ARIZONA




The following list of maps may be added to the geologic map index listed in Field Notes, Volume 1 No. 1, March, 1971. Back issues of Field Notes Nos. 1 and 2 may be acquired from the Arizona Bureau of Mines, University of Arizona, Tucson, Arizona 85721, to enable those who are interested to keep their map index up to date.

KEY TO MAP

1. 1956. Witkind, I.J. and others, Preliminary Geologic Map of the Dinnehotso NW Quadrangle, Arizona – Utah: U.S.G.S. map series MF-92, scale 1:24,000.
2. 1956. Witkind, I.J. and others, Preliminary Geologic Map of the Dinnehotso NE Quadrangle, Arizona – Utah: U.S.G.S. map series MF-93, scale 1:24,000.
3. 1956. Witkind, I.J. and others, Preliminary Geologic Map of the Dinnehotso SE Quadrangle, Arizona: U.S.G.S. map series MF-94, scale 1:24,000.
4. 1956. Witkind, I.J. and others, Preliminary Geologic Map of the Dinnehotso SW Quadrangle, Arizona: U.S.G.S. map series MF-95, scale 1:24,000.
5. 1957. Witkind, I.J. and others, Preliminary Geologic Map of the Boots Mesa NW Quadrangle, Arizona – Utah: U.S.G.S. map series MF-84, scale 1:24,000.
6. 1957. Witkind, I.J. and others, Preliminary Geologic Map of the Boots Mesa NE Quadrangle, Arizona – Utah: U.S.G.S. map series MF-85, scale 1:24,000.
7. 1957. Witkind, I.J. and others, Preliminary Geologic Map of the Boots Mesa SE Quadrangle, Arizona: U.S.G.S. map series MF-86, scale 1:24,000.
8. 1957. Witkind, I.J. and others, Preliminary Geologic Map of the Boots Mesa SW Quadrangle, Arizona – Utah: U.S.G.S. map series MF-87, scale 1:24,000.
9. 1957. Witkind, I.J. and others, Preliminary Geologic Map of the Agathla Peak NW Quadrangle, Arizona – Utah: U.S.G.S. map series MF-88, scale 1:24,000.
10. 1957. Witkind, I.J. and others, Preliminary Geologic Map of the Agathla Peak NE Quadrangle, Arizona – Utah: U.S.G.S. map series MF-89, scale 1:24,000.
11. 1957. Witkind, I.J. and others, Preliminary Geologic Map of the Agathla Peak SE Quadrangle, Arizona: U.S.G.S. map series MF-90, scale 1:24,000.
12. 1957. Witkind, I.J. and others, Preliminary Geologic Map of the Agathla Peak SW Quadrangle, Arizona: U.S.G.S. map series MF-91, scale 1:24,000.
13. 1958. Wells, J.D., Preliminary Geologic Map of the House Rock Spring NE Quadrangle, Coconino County, Arizona: U.S.G.S. map series MF-188, scale 1:24,000.
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Cameron, S.P. (1971 MS) Ostracodes of Pluvial Lake Cochise, Cochise County, Southeastern Arizona: 65 p.

Deal, E.G. (1969 MS) Volcanic Geology of the Interior Valley, San Francisco Mountain, Arizona: 82 p.

Fodor, R.V. (1968 MS) Petrography and Petrology of the Volcanic Rocks in the Goldfield Mountains, Arizona: 66 p.

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Norby, R.D. (1971 MS) Conodont Biostratigraphy of the Mississippian Rocks.

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NOTE

Publications and maps issued by agencies other than the Arizona Bureau of Mines must be ordered directly from the issuing agency. Arizona Bureau of Mines publications and maps may be purchased at, or ordered from, the Arizona Bureau of Mines, University of Arizona, Tucson, Arizona 85721.

### GAS STORAGE

The El Paso Natural Gas Company is considering a proposal to blast a huge cavity for storage of natural gas in a massive deep salt deposit beneath Red Lake, 20 miles northwest of Kingman. If five 200-kt detonations were employed at a depth of about 5600 feet underground, the cost could be about $20 million, versus $60 million for conventional surface storage. The blasts are not expected to cause unacceptable seismic damage to the few local water wells, nor will they disturb residences in Kingman.

*Continued on page 8*

*Gas Storage (continued)*

Dr. Philip L. Randolph said the storage would be used for natural gas to be piped to California customers during peak-demand periods. The Mohave county site is favored over two other possible Arizona sites in salt because of its relatively low level of culture. It is obvious that some type of natural gas storage will be required before 1975 if gas consumption increases as predicted.

In the event the present tentative proposal goes ahead, the U.S. Atomic Energy Commission would supply and handle the nuclear explosive devices. El Paso will be responsible for conducting the environmental studies and determining the feasibility of the project. The AEC would then monitor these studies to insure that all possible precautions were taken and that the project was completely safe. If any potential danger or hazard was present, the project would be scratched. None of these studies are started and the El Paso Natural Gas Co. or other parties involved are not, at this time, committed to even the preliminary feasibility study.

Recently, however, public concern for the groundwater supply in the Hulapai Valley has caused suspension of the studies by the Atomic Energy Commission and El Paso Natural Gas.

## UA PROFESSOR ELECTED

The Tucson Regional Committee of the Arizona Council of Engineering and Scientific Assns. (ACESA) has elected as its chairman Dr. Neil D. Cox, University of Arizona chemical engineering professor in the College of Mines.

Cox, American Institute of Chemical Engineers representative to ACESA, succeeds Dr. George W. Howard, director of the UA Engineering Experiment Station.

Cox said goals for the coming year would include a more direct participation of ACESA in trying to find solutions to community problems, such as unemployment of technical personnel and pollution control.

# ENVIRONMENTAL CORNER

## ENVIRONMENTAL AWARENESS IN MINERAL EXPLORATION

Mining companies have long been aware of their responsibilities for the preservation of the natural environment. The published instructions of several companies order employees to make all reasonable effort to insure exploration and development work cause as little disruption as possible. The following practices have been considered as standard for most of the exploration and mining personnel.

I. FIELD RECONNAISSANCE

1. Investigate land status and ownership of an area before entering. Know and observe local Forest Service rules and regulations. Understand the activities that require Special Use Permits, and do not engage in such activities until permits are obtained. Know the special stipulations in each Special Use Permit and see that they are observed. Obtain permission before entering an area.
2. Study and follow regulations governing access to state or federally controlled land.
3. Respect fences and gates to minimize disturbance of livestock and observe signs posted by land owners.
4. Get acquainted with and maintain contact with local Forest Service representatives, supplying information as necessary to aid them in their administrative duties, including matters related for forest uses by others and to future forest plans as they may be affected by mining activities.

5a. Carry fire fighting equipment as required by local regulations. Be aware of fire hazard levels and take positive steps to prevent the starting of fires. Report fires and suspected fires immediately. Make men and equipment available to the Forest Service in case of fire emergency.

5b. Avoid unnecessary disturbance of vegetation and wildlife.

5c. Keep vehicles on established roads wherever possible.

5d. Attempt to leave an area cleaner than when you arrived. Bring back deposit in receptacles provided; as a last resort, bury all trash, garbage or abandoned materials – from lunch bags and can to tools and pipes, both employees' and contractors', as well as that left by others.

6. Avoid blazing or unnecessarily damaging timber. Minimize the use of plastic flagging or other markers, and retrieve these materials whenever possible. A blazed tree or discarded flagging is a lasting reminder of our passage through an area.
7. Keep excavations to a minimum (test pits, roads, drill sites). When no longer needed, level and revegetate to the extent that it is practicable. In many states, however, location pits on new, unpatented claims are legal requirements.
8. Avoid stream pollution, particularly from drilling fluids and oils but also from soaps, detergents, garbage, etc.
9. Camp areas should be regularly policed of refuse. When a camp area is abandoned, tent frames should be torn down and removed, safely burned or stacked on the ground to encourage rotting.
10. All camp activities should be conducted with proper regard for good standards of safety. First aid equipment should always be available.
11. Contractors and their employees should be briefed thoroughly on their activities, conduct and responsibilities in wilderness areas.

II. PROPERTY ACQUISITION

1. Investigate the status of both surface and mineral rights before taking action to acquire an area. Know the regulations and mining laws relating to property acquisition and explorations procedures for the particular region in which you are working.
2. After mineral rights have been acquired, discuss presence in the area with surface right owners to avoid misunderstandings.
3. Whenever possible utilize drill holes to satisfy location work requirements rather than pits or cuts. If pits and cuts are necessary, limit excavations to a minimum size.

III. DRILLING PROGRAMS

1. Be familiar with regulations regarding road and drill site construction before beginning such work. Consult with the appropriate governmental agency, such as the U.S. Forest Service or U.S. Bureau of Land Management, regarding permission and procedure in the required construction. Encourage government representatives-in-charge to review the planned work in the field prior to commencement and maintain communications during the program. Attempt to resolve differences before initiating program.
2. Emphasize to all contractors involved in the explorations program that they must abide by all environmental control regulations.
3. Keep noise pollution produced in road construction and drilling to a minimum by

requiring appropriate mufflers on contractor's equipment.

4. Choose the location of drill sites whenever possible that access and site will result in a minimum disturbance of the surface and be generally inconspicuous. Minimize approved road penetration to support shed management programs supervised by federal and state agencies.
5. Attempt to use minimum size drilling equipment to drill holes whenever feasible to reduce the need of elaborate access roads.
6. Obtain permission of the owner before using wood from or cutting vegetation on private land.

IV. COMPLETION OR ABANDONMENT OF DRILLING PROGRAMS

1. Cap drill holes and seed drill-site areas with vegetation indigenous to the area.
2. Remove all trash and other foreign material from drill site premises. Do not burn or bury trash.
3. When feasible, fill in location pits, cuts, and sumps and seed the disturbed surface with appropriate vegetation.
4. Inspect gates and fences used for access to ascertain that no significant damage exists.
5. If an area acquired by the location of claims is abandoned, remove physical evidence of location.

These procedures should be followed in all exploration projects. Each project is unique and consequently some adaptations must be made accordingly.

## CURRENT STATUS OF POLLUTION CONTROL EQUIPMENT

Phelps Dodge at Ajo; acid plant under construction. Phelps Dodge at Morenci; relocation of acid plant and possible elimination of sulphur process plant. Phelps Dodge at Douglas; no firm commitment. Magma at San Manuel; flash smelter, with acid plant planned. ASARCO at Hayden; acid plant just completed, approximately 60 percent removal. No further commitment. Kennecott at Hayden; tail gas scrubbing and other minor modifications. Compliance planned. Inspiration at Inspiration; electric smelting and acid plant planned for compliance.

## KENNECOTT GRANTED PERMIT

Kennecott Copper Co. has been granted a conditional permit for a second year by the State Air Pollution Control Board. Ivor G. Pickering, general manager of the Ray Mines Division, said the major change undertaken by Kennecott was to switch to a water-spray system for cooling smelter gases before the gases are sent to an acid plant.

The change from an elaborate heat exchange device was expected to save the firm \$3 to \$4 million, said Pickering, but would not decrease the effectiveness of the proposed pollution control measures.

## ELEMENTAL SULPHUR PLANT OPENS

A \$17 million pilot plant to make dry elemental sulphur from smelter effluent gases was dedicated in El Paso late in 1971. It was a joint venture of Phelps Dodge Corporation and American Smelting and Refining Company, who will share the yearly operating cost of \$800,000, as well as their technical expertise. The process was tested in the ASARCO laboratories prior to construction of the El Paso plant. Dry elemental sulphur is physically easier to handle, store and transport. One ton of dry sulphur is equivalent to over three tons of concentrated acid; more, if the acid is an impure lower-grade commercial product.

## COST FACTORS FOR $SO_2$ ABATEMENT IN COPPER SMELTERS

by Peter J. DeVasto
Fluor-Utah Engineers and Construction Inc.

In the past, control regulations for sulphur compounds emitted from industrial processes merely limited the parts-per-million in effluents and established limits on ground level concentrations. Current emission standards now require, in addition, that the sulphur content of emissions to be less than 10 per cent of weight of the sulphur entering the process. Also, they stipulate a maximum per diem emission limit in tons. Requirements for effective emission control involved major changes in flue design, gas temperature control, and gas cleaning methods. Processes for removing sulphur oxides from gas streams include:

a. sulphuric acid recovery
b. sulphuric dioxide enrichment and production of elemental sulphur.
c. ammonium sulphate recovery
d. limestone scrubbing
e. and caustic scrubbing and sodium sulphate recovery

Caustic scrubbing requires essentially the same equipment as a limestone scrubber to handle the same gas loading, with the added problem that the soluble sodium salts may not be disposed of as easily as the relatively insoluble calcium compounds.

The addition of heated ambient air to the smelter stack is beneficial because concentrations are reduced and plume rise and dispersion are enhanced. The same results might be achieved by increasing the stack height though this alternative would probably be much more expensive. Another idea was to reduce the treatment of sulphur-bearing concentrates during those times when weather conditions were prejudicial to air quality standards: this method is termed "production variation."

## VOLCANOES OF ARIZONA

Mount Baldy, an extinct middle Cenozoic volcano in the heart of the White Mountains of east-central Arizona, is one of two volcanic mountains on which alpine glaciers occurred during the Pleistocene Epoch in Arizona. Mount Baldy (elev. 11400 feet) is the eroded remnant of a composite volcano primarily of quartz-latite composition. It dominates the area, rising from a broad basalt plateau having an elevation of about 8850 feet. Abundant cinder cones and rare domes compose the White Mountain Volcanic Field.

A recent study by the Department of Geology, Arizona State University, under a grant from the National Science Foundation, attempted to relate the volcanics, epiclastic sediments, and glacial sediments. It soon became apparent that the volcanics and epiclastic debris were much older than the Pleistocene and could not be utilized in establishing the glacial chronology of the area. A detailed study of the volcanics was necessary to fully understand the bedrock geology of the volcanic rocks and 2) the surficial geology of the Tertiary epiclastic sediments and the Quaternary glacial and periglacial sediments. Glaciation is recognized to have occurred at least four times during the late Quaternary time. The study of the consolidated and unconsolidated rocks provided the basis for inferences on the late Cenozoic history of the region as well as valuable land-use data for the area, located in the Apache National Forest and on the White Mountain Apache Reservation.

## WATER CLARIFICATION

A university – industry team has developed a magnetic method for treating turbid water. The technique which was developed by Dr. Henry Kolm of Francis Bittner National Magnet Laboratory at the Massachusetts Institute of Technology uses a magnetic separation scheme to remove small, weakly magnetic particles of clay from water. Scientists at the Magnet Laboratory and a Cambridge, Massachusetts engineering firm, Magnet Engineering Associates, found that insoluable suspended impurities in waste water can be made slightly magnetic if small amounts of a soluble iron compound are also present in the water.

In practice, after adding the soluble

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*Water (continued)*

iron, the dirty water is passed through a magnetized filter bed material such as a relatively coarse magnetite sand (say 20 or 65 mesh), a common commercial product from magnetic concentrators. The pollutant solid particles, all slightly magnetized, are trapped in the matrix of the filter bed while the clean water flows through easily. Advantages include relatively low cost and high flow rates.

The trapping of fine colloidal particles at high flow rates has never before been commercially feasible. Since small particles must be stopped by an even smaller hole, conventional mechanical filtration of small particles is inherently slow and subject to clogging. In magnetic separation, however, the filter is quite porous and open so that flow is relatively unimpeded.

This new concept suggests a use for the magnetite black-sands concentrates which can be found in quantity in several areas of Arizona.

## NEW DIRECT REDUCTION METHOD

A new process for the direct reduction of copper concentrates that may some day have commercial application is being tested and evaluated in a joint program between Inspiration Consolidated Copper Company and the Metallurgical Engineering Department in the College of Mines at the University of Arizona.

An ill-timed and poorly written news release from the University of Arizona made it sound as though the process has been completely evaluated, thoroughly tested, and is ready for immediate application, thus bringing to an end air pollution problems for conventional smelters. This is not so.

It will be some time before a regular operating plant can be built. In the meantine, considerable additional testing work remains to be done before a pilot plant can be considered. After design and engineering, the pilot plant would be constructed and operated to test the new process for some time to determine if it is feasible in large-scale application and to evaluate its economics.

The University news release stated that the new process under development uses chemicals, electricity and heat to recover copper from ore. No gas or dust is generated by the process, which also recovers contained sulphur as elemental sulphur in solid form.

Dr. Thomas M. Morris, professor and head of the Department of Metallurgy in the College of Mines, said:

"Copper sulphides such as chalcocite and chalcopyrite are dissolved in an acid solution at atmospheric pressure and at a temperature of 95 degrees centigrade.

"The chemical reaction is very rapid – about 20 minutes – and heat is produced by the reaction. The copper and some iron will exist as sulphates in solution and most of the sulphur will be converted then into elemental sulphur. After the sulphur is separated from the copper and the iron, the solution is treated to separate the dissolved copper from the iron.

"The copper sulphate solution is then electrolyzed, producing Electrolytic grade copper at the cathode, while the solvent used in the leaching step of the process is regenerated at the anode." He also said solutions used in the process are not excessively corrosive to the equipment and that preliminary studies indicate the operating cost will be about the same per pound of copper recovered as that for the conventional smelters.

He said the process will also dissolve sulphides of zinc and nickel and work is in progress relating to extracting zinc and nickel from their concentrates.

Graduate students Robert F. Shantz of Silver City, New Mexico and Edward A. Bilson of Inspiration have been working in the research and will use the study for masters theses.

Inspiration employees instrumental in development of the process are Frank Christmas, research engineer, and Frank Horton, consultant. Application is being made for a patent.

Morris also said the new process will not supplant existing smelters in which mining companies have a heavy investment. "But, we are going to have increased production in this state and this method could handle it so no new smelters will be built."

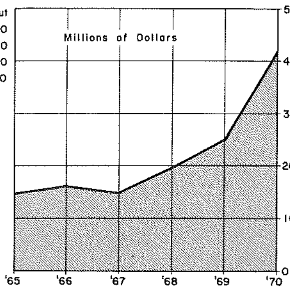
"APPARATUS FOR THE PRECIPITATION OF METALS FROM SOLUTION" is the title of a new patent (No. 3,606,290) issued to Kennecott Copper Corp. The inventor is N. L. Ransom, a former employee of the company's Chino Mines Division. Ransom's invention introduces metal-bearing solution into the treatment vessel through a specially designed nozzle under high pressure. A void is forcibly established and maintained immediately above the nozzle in the body of the solid precipitant that gradually descends toward the apex to replace what is consumed by the precipitation reaction. The apparatus of this invention is especially suitable for use with light scrap iron, such as de-tinned, crushed or shredded cans, as the precipitant for copper in solution.

## MINING

As the accompanying table and graph depict, mining has taken on considerable importance in the Tucson area. Most of this activity involves copper production. Of the fifteen largest copper mines in Arizona, seven are located in Pima County.

Arizona produces over half of the U.S.'s entire copper production. The total value of copper output in Pima County alone last year exceeded the production of the second-ranked state (Utah) by over $110 million.

| Year | Value of Output |
|---|---|
| 1967 | $150,770,000 |
| 1968 | 198,077,000 |
| 1969 | 251,563,000 |
| 1970 | 422,298,000 |




1970 saw the first full year of production at Anaconda's Twin Buttes Mine 25 miles south of Tucson, and the startup in February, 1970 of the Duval Sierrita Mine 35 miles southwest of Tucson. Both events contributed to Pima County's whopping 67% year-to-year gain in mineral production in the period 1969 to 1970.

In 1971, this figure of 422-plus dollars is expected to drop by more than 10 per cent due to strikes, lowering metal prices and declining production.

# NEWS FROM AND ABOUT OTHERS

## MOVES TO AUSTRALIA

In January 1972, Dr. Willard C. Lacy, former Head, Mining and Engineering Geology Deaprtment, College of Mines, University of Arizona took up his appointment to the Foundation Chair in Geology at James Cook University, North Queensland, Australia.

Bill Lacy did his undergraduate work in Chemistry at De Pauw University and his M.S. in Geology at the University of Illinois in 1940. He was awarded a Ph.D. in Economic Geology from Harvard in 1950. He later was visiting lecturer at Harvard and was in Queensland in 1967 as Fulbright lecturer in Applied Geology at the University of Queensland.

From 1955 to 1964, he was Professor of Geology at the University of Arizona and prior to that, Petrologist and then Chief Geologist for the Cerro de Pasco Corporation in Peru. In 1964 he became Head of the newly-formed Department of Mining and Engineering Geology. During Dr. Lacy's tour of service at the University, there were many significant accomplishments and innovations in the Mining and Engineering Geology Department.

In 1960 the mining engineering group initiated the International Symposium and Short Course on The Application of Computers in the Minerals Industry. This was the introduction of the computer approach to mining problems and most of the present-day leaders in these applications obtained their indoctrination at that session. In addition to the University of Arizona, the participants in this program now include the Colorado School of Mines, Penn State University and the Society of Mining Engineers AIME. In past years the meetings have been held in Tucson, and in Canada and this year will be held in South Africa on April 9th.

In March of 1966 the Department of Mining and Geological Engineering in conjunction with the College of Law sponsored a Symposium on American Mineral Law as Relating to Public Land Use. The 320 attendees (mining executives, legislators, lawyers, and engineers) "kicked off" the study by the Federal Public Land Law Review Commission. Furthermore, it was a principal factor in the award of a government contract to Dr. Lacy's Department for the study of tne Non-fuel Mineral Resources on Public Lands.

In 1965 the Department presented a two-week short course in exploration philosophies and techniques in the search for porphyry copper deposits for the United Nations Mineral Mission to Mexico.

Eight of Mexico's leading exploration geologists participated, and their activities resulted in the discovery of one of the world's great ore deposits at La Caridad.

In March 1969 the Department sponsored a symposium on Mine Taxation involving 127 participants from 15 states, Mexico and Canada. This served as the basis for a subsequent evaluation and proposed revision of the mining tax structure.

In conjunction with the University of Missouri at Rolla, the Arizona Mining Association, Thorne Ecological Foundation and the Arizona Department of Watershed Management, the Department sponsored a 1969 Symposium on Mining and Ecology in the Arid Environment.

For the first time representatives from conservation, and preservation groups met with federal and civil government officials and engineers from the mining industry; 161 persons from 16 states, Mexico and Canada, in face-to-face discussions.

The Department-sponsored symposium programs will continue with a scheduled Minerals Industry Financial Analysis Workshop in the spring of 1972 and a Computer Application Symposium in the spring of 1973.

When the Department was formed in 1964 on the basis of common interests between Mining and Geological Engineering, it had an enrollment of 62 undergraduates in mining engineering and 15 in geological engineering, plus 15 graduate students.

By 1971 enrollment was 98 undergraduates in mining engineering and 54 in geological engineering with 30 graduate students. A doctoral program was introduced in Geological Engineering in 1964 and in Mining Engineering in 1968.

To encourage continuing education programs on the part of locally-based mining and geological engineers, in 1964 the Department introduced a series of non-credit evening courses which evolved into a regular scheduling of upper division and graduate evening courses which could be applied to a graduate degree program.

It is with sincere best wishes that Bill Lacy's friends say, "Hasta la vista, not goodbye." As of press time Dr. William C. Peters is acting Head of the Department and no replacement has yet been chosen.

## NEWS ITEM

Thomas W. Mitcham, former District Geologist for the Cerro Corporation, has accepted a one-semester appointment as Visiting Professor at The University of Arizona where he will lecture in mining geology and remote sensing. Also, he has been recently appointed as Deputy Director of the Geologic Applications Subcommittee of the Remote Sensing Committee of the American Society of Photogrammetry.

Most of Dr. Mitcham's career has been in Arizona and New Mexico as geologist for the American Smelting & Refining Company, the Guggenheim Exploration Company, and the U.S. Atomic Energy Commission. Immediately before joining the Cerro Corporation he was Chief of the Geologic Research Division for the Kennecott Copper Corporation.

Dr. Mitcham was formerly President of the Arizona Geological Society, Counselor for the Utah Geological Society, Chairman of the Tucson Subsection of the American Institute of Mining, Metallurgical, and Petroleum Engineers, and is a member of the Editorial Board of Economic Geology.

## UA CHEMICAL ENGINEER'S BOOK PUBLISHED

The processes utilized to create particulate solids are detailed in a new book by a University of Arizona chemical engineering professor.

In *Theory of Particulate Processes,* released by Academic Press of New York, N.Y., Dr. Alan D. Randolph describes a decade of research he and associates have conducted on the chemical and physical methods of producing solids of varied sizes, shapes and purities.

Table salt, sugar and ammonium sulfate fertilizer are examples. Theories outlined in the book are currently being applied by Randolph and his associates to the development of a computerized model of a typical copper ore grind-flotation mill because a crucial factor is the size-distribution of the rock particles.

With National Science Foundation support and grants from several other agencies, Randolph is continuing basic research in the field of particulate systems.

A consultant to numerous industrial firms, Randolph came to the UA in 1968 from the University of Florida Chemical Engineering Dept.

## FORMATION OF SOUTHWESTERN MINERALS EXPLORATION ASSOCIATION

In December 1971, forty two professionals associated with exploration for mineral deposits in the southwestern United States formed the Southwestern Minerals Exploration Association. The organization will provide the members a means by which they can take an active role in public affairs concerning the mining industry. The group intends to provide qualified speakers for governmental, civic or other groups to explain the importance of mining and exploration in our society; to promote exploration practices and conduct in keeping with good conservation and environmental principles; to coordinate with environmental and conservation groups in all areas of exploration activity; to provide testimony at public hearings and to governmental officials promulgating the viewpoint of the exploration group; to actively seek legislation in the best interests of exploration and mining; to write letters to Congressmen and Senators, State Legislators and other elective or appointive officials, stating the views of the exploration group, and to do other things which in the opinion of the Membership would enhance the status of the mining industry and the exploration fraternity.

The group began in 1966 as an advisory committee of 12 to the Department of Mining and Geological Engineering at the University of Arizona. Their original function was to advise on professionalism and environmental-political factors in the education of mining and geological engineers. In the years 1967-1970, the body became a discussion group concerned with factors at the interface between legislation and exploration, land withdrawals, heavy metals programs and the future of mining. In 1971 in response to increased interest, it was decided to enlarge the membership and form a more formal organization.

Meetings of the Southwestern Minerals Exploration Association are held in the Mining Club of the Southwest, at the Aztec Inn. Current officers are:

President: William C. Peters, Department of Mining & Geological Engineering, University of Arizona

First Vice President: A. J. Perry, Perry, Knox, Kaufman, Inc.

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Second Vice President: William A. Saegart, Quintana Minerals Corporation

Secretary: Charles Miller, Amax Exploration, Inc.

Treasurer: Thomas Nye, Cerro Mineral Exploration Co.

COMMITTEE CHAIRMEN

Legislative Committee: Ben Dickerson, Superior Oil Company

Speakers Committee: Dean Lynch, Duval Corporation

Correspondence Committee: Robert E. Radabaugh, New Jersey Zinc Co.

Public Hearings Committee: W. W. Simmons, Cities Service Minerals Corp.

Publicity Committee: Edgar J. McCullough, Jr., Department of Geosciences, University of Arizona

Membership Committee: John Roscoe, Continental Copper.

## REPORT FROM THE DEPARTMENT OF MINING AND GEOLOGICAL ENGINEERING

A three-day financial analysis workshop was held in March, 1972 on investment decision-making in the minerals industry. Twenty-five participants from industry met with staff members of the Department of Mining and Geological Engineering plus speakers from N.L. Industries, Kennecott, and the University Department of Finance. Topics included evaluation criteria, equipment replacement alternatives, capital budgeting, and methods of accounting for uncertainty in the key variables that affect investment projects.

Dr. Thomas W. Mitcham, recently with Cerro Corporation and Kennecott, is affiliated with the Department this semester as visiting professor. Based on his widely-recognized experience in managing and conducting mineral exploration programs, Dr. Mitcham is teaching courses in Engineering Ethics, Applied Multispectral Imagery, and Exploration for Ore Deposits.

As part of the established educational service to mining industry personnel, an evening course in Conservation of Mineral Resources is being given. Lecturers are from the Department, from the Arizona Bureau of Mines, from the University Division of Economic and Business Research, and from other campus departments including Geosciences and Agriculture Economics. Topics under discussion include International Aspects of Conservation, Geophysics in Resource Planning, Multiple Use of Mineral Resources, Geothermal Energy, Fluid Fuels, and Surface Restoration.

The evening educational program was highlighted during the Fall Semester by a course in Mine Environments arranged by Professor Dotson to treat aspects of health conditions in the minerals industry. Speakers comprised industrial hygiene engineers, physicians, plant design engineers, governmental administrators, and the superintendents of several mining and processing enterprises. Twenty students, from on-campus and from industry, participated, with some coming regularly from locations as distant as Bisbee.

A new course in Rock Slope Design is being given in recognition of the increasing emphasis on lower grade material and new dimensions in open pit mines. The course takes into account current methods of mathematical analysis and field investigation for the solution of problems in determining pit-slope angle and configuration. Two teachers are directing this course; Dr. J. F. Abel is lecturing in the field of stress and strength analysis while Dr. R. D. Call considers the geologic parameters. Dr. Abel recently contributed to similar projects in this area for the U.S. Geological Survey, for the Corps of Engineers, and for several industrial companies. Dr. Call draws upon his experience in designing a large iron ore pit in Africa and in participating in the U.S. Bureau of Mines-Kennecott research study of the Kimbley Pit, Ruth, Nevada; he recently gave a paper, "Slope Stability Study of the Tazadit Pit, Mauritania, West Africa," at a seminar on related topics sponsored by the Canadian Institution of Mining and Metallurgy with the University of British Columbia.

Recent work by graduate students from the Department has resulted in three doctoral dissertations concerning geomechanics and pit design aspects of mining in the Cananea mining district, Mexico. Donald Gentry, David Hammel, and Zavis Zavodni were involved in this research.

A one-week field trip, taken by 25 students and faculty under the auspices of a grant from Union Pacific, included study sessions at uranium, coal, base metal, manganese, potash, and sulfur mines near Grants, Farmington, Socorro, and Carlsbad, New Mexico.

Enrollment in the Department currently numbers 152 undergraduates and 30 graduates.

FIELD NOTES

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State of Arizona
Governor . . . . . . . . . . Hon. Jack Williams
University of Arizona
President . . . . . . . . . . . John P. Schaefer
Arizona Bureau of Mines
Director . . . . . . . . . . . William H. Dresher

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