FIELD NOTES FROM THE ARIZONA BUREAU OF MINES

Vol. 1, No. 4 Earth Science and Mineral Resources in Arizona *Dec. 1971*

LEACHING OXIDE COPPER

by
G. H. Roseveare

The leaching of copper oxide ore was first started in Arizona at Ajo in 1918. It is now practiced in many areas of the state and accounts for approximately 10 percent of the present copper production in Arizona.

Four types of leaching operations are used in Arizona–vat, agitation, heap and underground.

In vat leaching, the ore is ground to about one-quarter inch, put in tanks or vats and flooded with weak sulphuric acid. In about seven days the acid leaches out about 80 percent of the copper contained in the ore. The solution is removed from the vat, the copper is recovered by electrolisis and goes to market as 99.95 percent copper.

Fine ground ore treated in an agitator tank requires a short time of contact to obtain good recovery. The copper is removed from the pulp by counter current decantation in thickeners. The solution goes to iron precipitation and the copper mud is processed in smelters the same as copper concentrates.

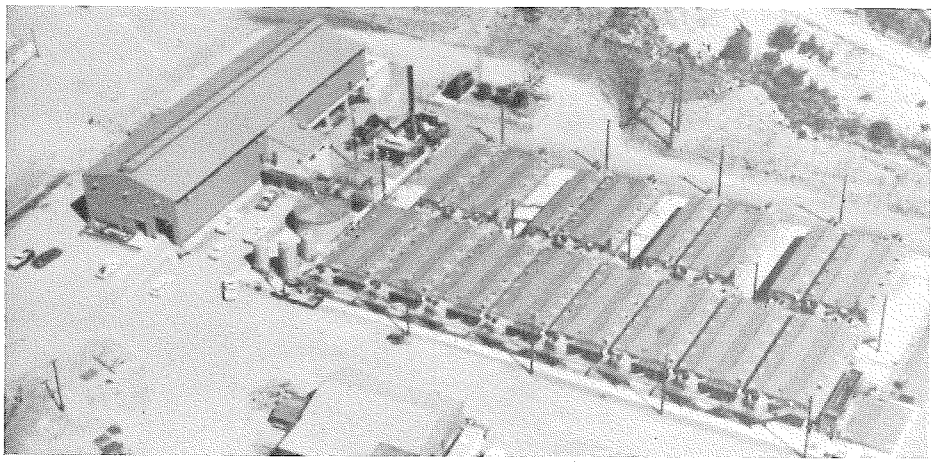
In heap leaching, the ore, with or without crushing, is piled in large heaps preferably on bedrock and acid is spread over the top by irrigation or sprays. The solution percolates through the heap and is collected at the bottom in ponds ready for precipitation. Recoveries vary from 35 percent to as high as 60 percent, but the method is slow–usually taking years. One metallurgist estimated that ten years is required to make a 51 percent recovery.

Several mines in the state are leaching cappings of old mines. Acid solutions are sprayed on the surface and trickle down through the oxide cappings and old filled stopes into old drifts where it is collected and pumped to the surface for precipitation.

Although most of the copper is precipitated by scrap iron or shredded tin cans and sent to a smelter for processing, the liquid ion exchange (LIX) method is being used at some mines and is producing metallic copper of 99.95 percent purity. The Blue Bird and Bagdad leaching plants are using this method and

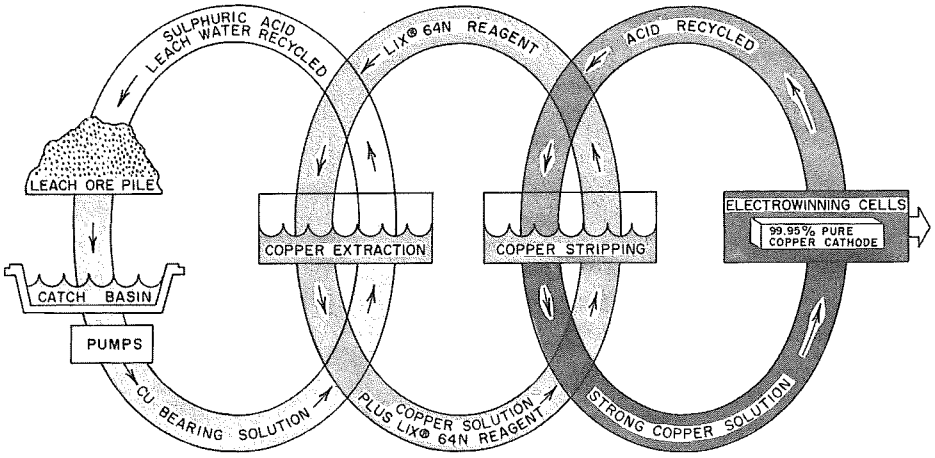
continued on page 2

LIQUID ION EXCHANGE



Courtesy of Bagdad Copper Corporation

Liquid Ion Exchange and Electrowinning Plant, Bagdad Copper Corporation.



Courtesy of General Mills

Copper recovery at Bagdad and Blue Bird begins with sprinkling of weak acid solutions on the copper oxide ore dumps. Acid dissolves copper as it trickles through the ore pile and the resulting copper bearing solutions are pumped to a catch basin. Next, the weak copper solution from the catch basin is mixed with the General Mills' LIX 64N reagent which has a high degree of affinity for copper ions and a low affinity for other contaminating ions, including iron. The reagent operates on a hydrogen ion cycle, which in general proceeds as follows:

The reagent carried in an organic medium, is intimately contacted with the aqueous leach solution in the extraction stages where hydrogen ions are exchanged for copper ions. Thus the sulfuric acid content of the leach solution is regenerated while the copper is extracted. The organic solution containing the copper passes to the stripping stages where it is contacted with sulfuric acid. The LIX 64N is thus regenerated and recycled to the extraction system. The enriched copper sulfate solution is an essentially impurity-free concentrated electrolyte from which high quality cathode copper is produced by electrowinning.

An electric current is passed through the solution and this deposites the copper on thin copper sheets called "starter sheets." The electrowinning circuit produces the sulfuric acid required in the stripping of copper from the organic medium. In about a week the starter sheets grow to approximately 130 pounds of copper. Bagdad and Blue Bird produce about 35 tons of electrolytic copper per day.

Leaching (continued)

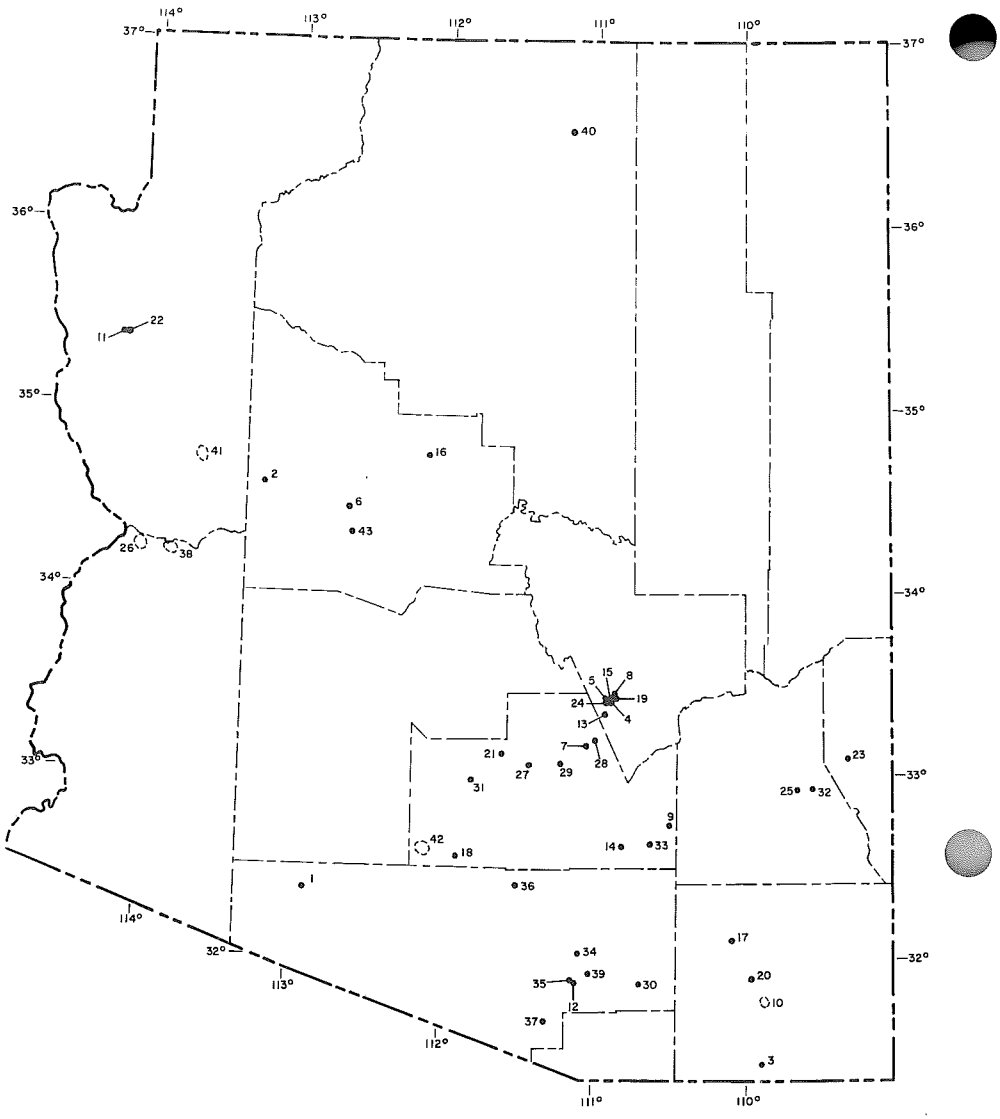
producing about 35 tons of copper per day. Although the future of this process looks promising for large operations, it is too expensive for the small producer whose property has only a short life expectancy.

Oxide copper ores in limestone or containing calcite have not been treated by leaching in the past because they require large quantities of acid to neutralize the lime before any leaching of the copper takes place. This type of ore may require from 150 to 300 pounds of acid per ton of ore to obtain a good copper recovery. However, since there will be considerable cheap sulphuric acid available in the near future resulting from the large production due to smelters converting sulphur dioxide to acid, high lime ores will become attractive as a source of copper.

The high lime ore consumes an enormous amount of acid and cannot be leached in heaps because in neutralizing the calcite, gypsum is formed and this soon blocks off the solution circulation. The Arizona Bureau of Mines has made several tests on ore ground to minus 20-mesh that required 160 pounds of acid per ton and was leached successfully in a pachuca tank. Approximately 85 percent of the copper was dissolved in 3 to 5 hours.

The high lime ores will require up to 8 times as much sulphuric acid as the non-lime bearing ores and will use much of the cheap acid which will be available at the smelters putting in sulphuric acid plants to reduce the sulphur dixide polution problem.

LEACHING IN ARIZONA



FLOTATION OF CONVERTER SLAG

Metallurgists are interested in a new use of flotation. Smelters produce considerable slag from their converters containing from 1 to 6 percent copper which is poured into the reverberatory furnace. This slag contains considerable magnetite that forms a mushy layer between the slag and the matte which hinders the copper-iron sulphide, or matte, from settling from the slag.

The U.S. Bureau of Mines recently published Report of Investigation 7562 on the flotation of copper-bearing material from converter slag, and currently an Arizona company is experimenting with the separation of the copper-bearing material from convertor slag in the mill by means of fine grinding and flotation. Additionally, Cia Minera de Cananea, S.A. de C.V., has made several runs using converter slag. It has been found that treating the slag separately from the ore gives the best results. The slag is crushed and ground at about half the feed rate of the ore. The amount of collector used is abnormally high, approximately 0.6 pounds per ton of slag. The concentrate thus far produced from slag assays approximately the same as concentrate produced from ore and the tailing assays about half that of the smelter slag. Smelters which may employ flash smelting will be able to use converter slag concentrate along with regular concentrate from ore as feed to the new type of furnace.

CHEMICAL ENGINEERS AND MINING INDUSTRY

The University of Arizona is fortunate to have its Department of Chemical Engineering within its College of Mines. Here the Chemical Engineers can work closely with the Department of Metallurgical Engineering in research of particular benefit to the mining industry. Techniques developed originally for the chemical or petroleum industries are being applied to mining and milling processes.

For example, beginning in 1967, cooperative Chemical-Metallurgical studies directed by the Chemical Engineering staff resulted in two unique advances in the state-of-the-art of large tonnage grinding circuits.

In 1967, Dr. Edward J. Freeh, (Chemical Engineering faculty) realizing the importance of grinding in efficient concentrator operation, recognized the existence of a lack of understanding of the mechanics of comminution. As advisor to Dr. W. E. Horst (then a graduate student in Metallurgical Engineering), Ed Freeh initiated a research program to evaluate the mechanisms and effectiveness of alternative grinding processes. Computer modeling and subsequent experimental verifications of a model by Horst and Freeh resulted in a "best paper award" when published in a technical journal. Upon graduation Dr.

LEACHING IN ARIZONA

Name of Property or Location Number Keyed to Map	Tank	Heap	Liquid extraction	Proposed	Potential
1. Ajo	○				+
2. Bagdad		●	●		
3. Bisbee		●			
4. Blue Bird		●	●		
5. Castle Dome		○			
6. Copper Basin		○			+
7. Copper Butte					+
8. Copper Cities		●			
9. Copper Creek area					+
10. Courtland-Gleason area	○				
11. Emerald Isle **	●				
12. Esperanza		●	○		
13. Gibson Mine		●			
14. Gold Hill					+
15. Inspiration *	●	●			
16. Jerome					+
17. Johnson Camp					+
18. Lake Shore				+	
19. Miami *		○			
20. Middle March		○			
21. Mineral Butte					+
22. Mineral Park		●			
23. Morenci		●			
24. Ox-Hide		●			
25. Peacock		●			
26. Planet area	○	○			
27. Poston Butte					+
28. Ray	●	●			
29. Red Hill		●			
30. Rosemont					+
31. Sacatone					+
32. Sanchez					+
33. San Manuel				+	
34. San Xavier		●			
35. Sierrita		●			
36. Silver Bell		●			
37. Silver Ray		○			
38. Swansea area		○			+
39. Twin Buttes				+	
40. White Mesa	○				
41. Wickieup area					+
42. Vekol area					+
43. Zonia		●			

● operating
○ not operating
* underground
** floating precipitated copper

Horst continued his studies of grinding and comminution mechanics, and now lectures regularly at the College of Mines as well as consults in the fields of concentrator design and computer modeling.

Second, and concurrent with the work of Dr. Freeh, Dr. R. M. Edwards (Chemical Engineering) initiated an experimental and computer simulation of hydrocyclone operation. This study coupled computer models of the open-loop comminution process with those of the hydrocyclone for closed-circuit grinding. Dr. Edwards had previously interacted with Dr. T. M. Morris (Metallurgical Engineering) in the study of applications of special purpose analog computers and modeling to froth flotation. These studies outlined techniques which could provide mill operators with low cost on-site guidance, not available in current conventional operations.

Later, Dr. Alan D. Randolph (Chemical Engineering) used a new approach to the study of comminution; i.e., formulation of fundamental functional relationships (adapted from population birth and death statistical functions) as applied to particle-size distribution in crystallization. The predictive capability of this theoretical approach has been validated by an M.S. graduate student in Chemical Engineering, Mr. Tony Durando, by comparing open-circuit grinding data with the computer simulation results. This work in the College of Mines Metallurgy Department is being expanded by two of Alan Randolph's students, Jose Larios and Ricardo Cornejo. Computer modeling is being employed to validate theoretical projections and to expand the spread of basic data on ball mill parameters and variations in the characteristics of concentrator feed or mill heads.

In addition to his pioneering work of theories of comminution, Alan Randolph this year initiated studies of alternate processes for the removal of iron oxides from recycled acidic copper leach liquors; e.g., iron launder OFF-solutions. One process uses a high-slurry-density reactor–crystallizer to eliminate the need for acid neutralization. Since the liquor remains acid, the copper is not lost by entrainment in the flocculated basic-iron precipitates which ensue if the solution is neutralized. A Chemical Engineering doctoral candidate, David Milligan, will study the parameters of this process using experimental apparatus now under construction.

The simulation of single process units for specific operating conditions and changing ore characteristics is but the first step toward a practical application of this research. In the design of a new concentrator or in the operation of any given concentrator, the interaction of grinding and flotation circuits with variations in mill feed compositions and flow are of primary concern to the mining industry. Low cost techniques to evaluate proposed control philosophies are important and this is where a system approach is useful. A newly-appointed member of the College of Mines faculty, Dr. James W. White (Chemical Engineering), is working with both chemical and metallurgical engineers to define the requirements for useful systems for data analysis. The goal is model building and computer simulation of the various steps in ore processing flowsheets plus the regulatory philosophies involved. Dr. White currently has a Chemical Engineering graduate student, Bill Root, studying grinding circuit performance and cost/performance factors. Another Chemical Engineering graduate student, Mark Richardson, and Bill Root, are looking at the flotation/grinding circuit operations which are of interest to Alan Randolph. Dr. White and the College of Mines Computer Committee are planning the expansion of the Mines Computing Laboratory to cover metallurgical instrument analysis and, especially, the analysis of data from measuring devices in operating mines, mills and smelters in the field.

The results of these computer modeling studies of metallurgical processes appear very encouraging. The useful data developed thus far justifies the effort. Consequently, the interdisciplinary aspects of the research program and the communication with industry are being stepped up. The College of Mines at the University of Arizona hopes the result will be a maximum utilization of the new knowledge being generated by these studies.

ENGINEERS BREAKFAST

At the annual Engineers' Breakfast on October 28, 1971, George E. Atwood, Executive Vice-President of Duval Corporation, and Lawrence K. Cecil, retired chemist and consultant on water, environmental, and pollution problems, received the University of Arizona Alumni Associ-

Continued on page 4

Engineers continued

ation Distinguished Citizens Award. The guest speaker was Dr. William C. Peters, recently returned from a year's sabbatical. His subject was "Industry in Europe" and, particularly, how the mining industry was accomplishing restoration and preservation of the environment. Introductions were made by Barbara Neff, senior, College of Engineering, and Ashley G. House, College of Mines. Attendees consisted of the faculty and student body of the College of Engineering and College of Mines of the University and representatives from business and industry.

VICE PRESIDENT NAMED FOR UA STUDENT AFFAIRS

Dr. Richard M. Edwards, University of Arizona faculty member since 1959, was appointed vice president for student relations Nov. 1.

His appointment was approved by the Arizona Board of Regents upon the recommendation of UA President John P. Schaefer.

Dr. Edwards, former associate dean of the College of Mines and professor of chemical engineering, served as acting dean of the college and acting director of Arizona Bureau of Mines in 1970-71.

The new vice president's primary responsibility will be to coordinate the offices of the Dean of Students, Placement Health Service, Student Counseling Service, and other areas pertaining to student affairs.

Dr. Edwards served as chairman of the UA Committee on Academic Counseling from 1965-67 and has been a member of the committee on intercollegiate Athletics since 1964 and chairman since 1969.

ENVIRONMENTAL CORNER

SULPHUR IN AIR– WHAT HAPPENS TO IT?

In a study by Dr. Robert Robbins and Elmer Robinson of the Environmental Research Department of Stanford Research Institute, Menlo Park, California, an estimate was made of the amount and distribution of sulphur and sulphur compounds entering the atmosphere. Their findings indicate that only about one third of the sulphur discharged to the atmosphere comes from mankind's activities while the remainder comes from natural sources in the form of sulphur dioxide, hydrogen sulphide, sulphuric acid and various sulphates principally from volcanic activity, fires and plant and animal life or decay.

Dr. William T. Pecora, Director of the U.S. Geological Survey, points out in an article in Industry Week, August 17, 1970, that in the atmosphere, both hydrogen sulphide and sulphur dioxide are oxidized within a few days to sulphates and are removed from the atmosphere by precipitation in rain or snow. A large fraction of the sulphates end up as ammonium sulphate because nitrogen is the most plentiful element in the atmosphere and plays a key role in life processes of all plants and animals.

Dr. R.G. Larson, Shell Development Company, in a speech before a chemical society stated that, in air, the most plentiful contaminant is ammonia. It is formed from decomposition of cells and is universally associated with life. The ecology is upset only when the rate of discharge into a given basin exceeds the neutralization ability of the ammonia reaction. Larsen reports there is no measurable accumulation in the atmosphere of oxides of sulphur in spite of the millions of tons which have been discharged over the years.

As reported in Industrial Research October, '71, Dr. E.K. Bigg of the Commonwealth Scientific and Industrial Research Organization, Sydney, Australia, sampled the atmosphere at levels up to a height of 130,000 feet and found particles collected to be predominantly composed of ammonium sulphates, although some sulphuric acid particles were found in the atmosphere up to 35,000 feet. Bigg's concern was the effect of SST aircraft exhaust gases. Since water is one of the main products, the affinity between water and sulphuric acid will cause the particles to enlarge and result in an increase in light-scattering with a decrease in the amount of sunlight reaching the earth.

In any event, it appears that the sulphur dioxide that goes out into the atmosphere will eventually come back to earth as a heretofore unrecognized but beneficial fertilizer. The ammonia in the atmosphere reacts readily with the sulphates and ultimately falls back to surface.

THE HAZARDS OF HYDROGEN SULPHIDE

Hydrogen sulphide (H_2S) is a colorless gas, heavier than air, possessing the odor of rotten eggs. It is also flammable in concentrations of 4.3 to 46 percent by volume in air and explodes violently upon ignition. Most important, however, it is a rapid and powerful poison. Though it has the characteristic bad ordor, smell is not a dependable way to detect this gas because it can produce a rapid paralysis of the olfactory. One good whiff and then you can't smell it anymore. The odor can be detected at about 0.000015 percent or 0.15 ppm but this sense of smell is lost in 2-15 minutes exposure making it impossible to sense dangerous concentrations. In strong concentrations, it is reported to have a sweet cloying odor.

The maximum allowable concentration for prolonged exposure is 0.002 percent (20 ppm). Vapor concentrations as low as 0.005 percent (50 ppm) in the air may cause toxic symptoms and 0.1 to 0.2 percent (1000-2000 ppm) is usually fatal within a few minutes.

It has been stated that the maximum concentration for one hour without serious consequences is 170-300 ppm but that susceptibility to hydrogen sulphide many vary among individuals. Also, it is believed that sensitivity may be increased by previous exposure and that hydrogen sulphide can penetrate the intact skin to produce signs of systemic intoxication with general action on the nervous system. Hydrogen sulphide causes both a deficiency of oxygen and damage to the central nervous system.

In high concentrations of hydrogen sulphide unconsciousness and collapse can occur within seconds, with or without a warning cry, and for that reason many persons have lost their lives attempting to save a previous victim who has collapsed. Once a victim is removed to pure air, however, and respiration set in motion by any means before heart action has ceased, rapid recovery may be expected. Death is caused by prompt respiratory paralysis, usually with a terminal asphyxial convulsion. Humans exposed to even moderate concentrations of the gas experience headache, nausea, dizziness, confusion, and weakness of the extremities followed by a precipitious lapse into unconsciousness. Survivors of acute toxic episodes sometimes show amnesia, tremors and disturbances of equilibrium. Sub-acute poisoning is evidenced by:

1. Eye and respiratory irritation.
2. Profuse salivation, nausea, diarrhea
3. Giddiness, headache, amnesia, confusion and unconsciousness.
4. Palpitations, sweating, weakness and/or cramps

After sub-leathal exposures, the recovery is usually slow; the patient may have a residual cough, cardiac dilatation, slow pluse, amnesia, and/or some degree or psychic disturbance. The patient may be especially vulnerable to a pulmonary infection. Treatment is:

1. Remove immediately to fresh air.
2. Keep quiet and warm.
3. Provide artificial respiration, preferably by the arm-lift back-presure method, without interruption until normal breathing is restored.
4. Administer oxygen if indicated (remember H_2S is flammable!)
5. A doctor may administer specific injections.

6. Conjunctivitis may be relieved with special eye drops.
7. Watch for pulmonary complications and infection.

Since dangerous concentrations of hydrogen sulphide cannot be determined by the intensity of the odor, the presence of traces of H_2S can be readily detected by wet lead-acetate test paper or the cadium chloride solution test (bright yellow precipitate). A number of automatic gas-analyzed equipment manufacturers can supply apparatus for monitoring an area for hydrogen sulphide.

1. Environmetrics Inc.
   Marina Del Rey, California 90291
   Has an 0-50 or 0-10000 ppm continuous recorder, zero to full scale in less than 10 seconds, at a base cost of $1750; installed with all extras, alarm, recorder, etc., $2400.
2. Special Systems Engineering
   Mesa, Arizona 85201
   Has a continuous H_2S sensor for about $1500.
3. Mine Safety Appliances Inc.
   201 N. Braddock Avenue
   Pittsburgh, Pennsylvania 15208
   handles the MSA TOXGARD monitor with an optional alarm unit to provide audible and visual signals before the level of toxicity reaches maximum allowable concentration. The cost with alarm and recorder is about $870.

NOTE: Mention of manufacturers' names and/or equipment does not imply endorsement by the Arizona Bureau of Mines. None of this equipment has been purchased or tested by the Arizona Bureau.

Industrial canister-type gas masks with full face pieces will afford protection against concentrations of H_2S not exceeding 2 percent by volume. In any case, the oxygen content of the air must be not less than 16 percent. If the wearer detects any odor, he must leave the area immediately because this is an indication that the mask is not functioning properly or that the vapor concentration is too high.

In case a man goes into any confined area such as a tank in which it is suspected the atmosphere may possibly be contaminated with a poison gas (like hydrogen sulphide) or in which there may be a deficiency of oxygen (i.e., less than 16 per cent), a "life-line" must be employed. A stout rope is tied to the man entering the area and two or more men stand by outside in a safe area, prepared to evacuate or haul the worker to safety in case he collapses or otherwise becomes incapacitiated.

COAL GASIFICATION

Considerable attention has been focused on the developing United States energy shortage. Because gas is the easiest fuel to use and transport, and by far the least offensive in pollutants, the demand for natural gas has increased dramatically in the last twenty-five years. At present it satisfies about one-third the nation's energy requirements. Production exceeded discoveries for the first time in 1968, and the imbalance between discovery and production has been greater in the years that followed.

The reserves of natural gas in the Southwest are such that it will be necessary to either curtail usage of natural gas or provide a synthetic gas. El Paso Natural Gas Company is not making contracts for new industries and may be forced to curtail natural gas to some of the industrial consumers now served from their pipe lines.

Gas distributing companies are considering gasification of coal as a source of fossil fuel to substitute for natural gas. The Utah Natural Gas Corporation has announced plans for the construction of a coal gasification plant in 1975 which would produce 250 million cubic feet of gas per day with possibly three other units later. Construction of the plants is dependent upon the feasibility study as well as the effect on the ecology of the area. The synthetic gas produced by the Utah Natural Gas Corporation would be distributed by Pacific Lighting Corporation of California, and Texas Western Transmission Corporation of Houston.

The El Paso Natural Gas Company has anticipated that there will not be sufficient natural gas to meet future needs and have conducted research projects on gasification of coal since the mid-fifties. Recently the company announced plans for a coal gasification plant to be constructed near Farmington, New Mexico. It is scheduled to go into production in 1976. Their pipe lines cross several of the undeveloped coal deposits in Arizona and New Mexico and could carry synthetic as well as natural gas.

The United States is importing natural gas from Canada to augment our present consumption. Recently the National Energy Board of Canada denied applications for the export of 2.7 trillion cubic feet of additional gas to the United States. Canadian supplies of natural gas have been estimated at 1.1 trillion cubic feet less than reasonably foreseeable domestic needs and existing export contracts require in the next 25 years. Consumers will need, even with their continued present supply, a substitute for natural gas.

Although atomic energy will be a source of energy for electrical power production, as natural gas and oil reserves decline, the United States will have to rely more heavily on coal as its principal source of fossil fuel.

DOS CABASAS MINING DISTRICT

By virtue of a notice July signed and posted at three prominent places in a proposed mining district dated October 20th, a meeting of miners was held at the above named camp on the date first above written Mr. W.F. Bennett was chosen chairman and J.B. Brannick secretary of the meeting; a mining district was then formed and organized to be known as the Dos Cabasas Mining District which district embraces and includes the following described and bounded territory vis.

Art. 1. Beginning at mouth of Goodwin canyon along the base of the mountains, West Rail Way Pass, Thence South to the base of the mountains, thence East to the line of Goodwin Canyon, the place of beginning.

Art. 2. We appoint the county recorder of Pima county district recorder of the Dos Cabasas mining district.

Art. 3. We adopt the United States laws approved May 10th 1872 in full.

Art. 4. $5.00 per day for each and every 8 hours work shall be allowed on account of the expenditures required on mining claims in this district.

Art. 5. These laws cannot be changed in any manner except at the annual meeting and then only by a two-thirds of the miners present entitled to a vote.

Art. 6. The foregoing laws shall be in force and effect from and after this 20 day of October, 1878. The foregoing laws were passed by the meeting and it was resolved to send copies of the meeting to the ARIZONA STAR, Tucson, A.T. and the Grant County Herald, Silver City, N.M., with request for publication. The meeting then adjourned sine die ' W. F. Bennett, Chairman, J. B. Bronich, Secretary. Committee on laws—Lawrence Casey, Richard McGregor, Thomas Hall, Charles Williamson, James A. Hart.

*Quote from the ARIZONA WEEKLY STAR, November 7, 1878, spelling and punctuation retained, as well as obvious typographical errors.

NEW COURSE OFFERED

Subsidence engineering was offered on a trial basis the fall semester by the Department of Mining and Geological Engineering. The Department has been trying to anticipate potential changes in the mining industry and to prepare its students to function in a challenging future. Subsidence engineering is one logical outgrowth of this concern.

continued on page 6

New Courses (continued)

Eventual exhaustion of accessible surface orebodies will eventually force mining back underground. Multiple use requirements and environmental pressure can only speed the reversal of the present trend toward open pit mining. The reduction of surface disturbance possible with underground mining may eventually prove to be of sufficient importance that recent proposals limiting surface mining, such as one to ban strip mining of coal in West Virginia, may be passed.

The subsidence engineering course was designed to prepare the students to evaluate subsidence effects, surface and underground, and methods of reducing these effects. Specific topics included study of room and pillar, complete extraction, abutment arch zones, cut-and-till, cemented fill, multiple level mining, block caving, subsidence profiles, and measurement techniques.

The class lab project involved testing of cemented classified mill tailings. The class determined the progressive changes in fill properties with multiple loading cycles which result from multiple level cut-and-fill mining. The purpose of the lab project was to predict the reduction of surface subsidence from cut-and-fill as opposed to block caving.

THE SOUTHERN ARIZONA FRONTIER OIL AND GAS EXPLORATION– WHAT'S THE IDEA?

As far as oil companies are concerned, southern Arizona remains a geologic frontier, a question mark. Whereas the northern part of the state, the Plateau province, has given up 12 million barrels of oil, the southern part, the Basin and Range province, has yet to give up its first barrel. Because of a geologic record of the existence of nearly 7,000 feet of Paleozoic marine rocks in the extreme southeastern corner of the state, Cochise County has usually been credited with some oil and gas potential. The geologic complexities, however, have been such that there has been a dearth of serious exploration drilling. Now, however, a serious drilling venture has been initiated by the Guadalupe Exploration Company 20-25 miles east of Douglas not far from both New Mexico and old Mexico. The hole has been spudded on a structure reflected in outcropping Permian marine strata. This appears to be a well-equipped venture capable of providing a fair test of the immediate region. (Subsequent to the intial writing the hole, according to the Arizona Oil and Gas Conservation Commission, has been plugged and abandoned at a depth of 5679 feet, reportedly in probable Cambrian rocks.)

Elsewhere in southern Arizona, the Humble Oil and Refining Company has attracted much attention by announcing the acquisition of over 1,000,000 acres (over 1500 sq. miles) of State, Federal, and Fee oil and gas leases, principally in Yuma, Maricopa, Pinal, and Pima Counties. The magnitude of this leasing activity by a single company is an Arizona record and it is interesting to note that the leased area stands in considerable geologic contrast with Cochise County to the east and southeast in that the former has a paucity of outcropping marine strata.

The idea is the thing–that's where it all starts–what is the idea?

The beginnings of an idea are as difficult to isolate as the beginnings of life, wars, inflation, etc., but it might be accurate to think that the "idea" is, fundamentally, geological. Southern Arizona geology is exceedingly complex and the unraveling of its many mysteries comes slowly.

Geologically, one of the newest developments is the recognition of large masses of salt in some of our valleys in the Basin and Range province. In our first issue of *Field Notes,* the statement was made that "In addition to the direct and indirect economic aspects of this valuable resource (salt) are the fascinating geologic questions that are being raised".

Eaton and others of the U.S. Geological Survey refer to the salt mass near Luke Air Force Base northwest of Phoenix as part of a "salt structure." Elsewhere in the world, much oil is produced in close proximity to large masses of salt that have distorted their overlying cover of sedimentary rocks by upward movement of salt that takes place by plastic flow. The U.S. Gulf Coast region contains over 300 known salt structures (often called domes), many of which are productive of oil and/or gas. The 15-or-so cubic miles of salt near Phoenix is indeed a phenomenon worthy of attention as regards its geologic implications. Its age and manner of origin are of special import because these factors are vital to an understanding of past geologic environments, the associated products of which might remain preserved in some of our valleys or basins. As yet there does not appear to be conclusive evidence as to whether the salt originally formed in a marine or a continental environment, although Eaton, *et al,* think that the low bromine content is suggestive of original deposition in a Tertiary or older, saline lake.

It could be fair to say that, although there are still more questions than answers, the current leasing interest outside of Cochise County is contingent upon the idea that eventual geologic answers might be favorable to the possible existence of heretofore largely unsuspected occurrences of oil and/or gas in southern Arizona's Basin and Range province.

When this initial exploration activity has run its course, whatever the results, another increment of knowledge will have been added to a fascinating and important subject, the geologic history of southern Arizona.

PUBLICATIONS

THESES

This listing of recent theses is a supplement to the one found in "Fieldnotes" Vol. 1, No. 1. The subject matter of the list has been expanded to include studies pertinent to Arizona mining and geological engineering as well as pure and applied geology, to which the first list was restricted.

University of Arizona

ABU-TAHA,Mohammad (1971-MS) Efficiency of two water wells: 95 p.

CALL, Richard D. (1972-PhD) Analysis of geologic structure for open pit slope design: 201 p.

CARRIGAN, Frank (1971-MS) A geologic investigation of contact metamorphic deposits in the Coyote Mts., Arizona.

CHAMPNEY, Richard D. (1971-PhD) Studies of geologic structures by paleomagnetic methods: 100 p.

CLAY, Donald W. (1970-PhD) Stratigraphy and petrology of the Mineta Formation in Pima and eastern Cochise counties, Arizona: 183 p.

DAVIS, Jerry D. (1971-MS) The distribution and zoning of the radioelements potassium, uranium, and thorium in selected porphyry copper deposits: 130 p.

DOWIS, John (1972-MS) Shaft sinking economics: 145 p.

EASTWOOD, Raymond L. (1970-PhD) A geochemical-petrological study of mid-Tertiary volcanism in parts of Pima and Pinal counties, Arizona: 212 p.

EDMISTON, Robert (1971-MS) Thermal gradients and sulphide oxidation in the Silver Bell mining district.

GISLER, Patrick M. (1971-MS) Identification of some opaque minerals by direct measurement of polarizing angles: 55 p.

HATHEWAY, Allen (1971-PhD) Lava tubes and collapse depressions.

HREBAR, Matt (1971-MS) Business risk analysis in preliminary evaluations of mining properties.

JANBEK, Tayseer (1971-MS) The recharge-discharge aspects of Green Valley, Pima County, Arizona: 93 p.

KENDORSKI, Frank (1971-MS) Influence of jointing on engineering properties of San Manuel mine rock: 126 p.

LANEY, Robert L. (1971-PhD) Weathering of the granodioritic rocks in the Rose Canyon Lake area, Santa Catalina Mountains, Arizona: 201 p.

LYTLE, Jamie L. (1971-MS) A microenvironmental study of an archaeological site, Arizona BB:10:3, Whiptail Ruin: 66 p.

MORRIS, Marvin (1971-MS) Quantitative factors in mineral exploration: 89 p.

PUCKETT, James C., Jr. (1970-MS) Petrographic study of a quartz diorite stock near Superior, Pinal County, Arizona: 48 p.

STEWART, James C. (1971-MS) Geology of the Morningstar Mine area, Greaterville mining district, Pima County, Arizona: 79 p.

TOUQAN, Omar (1971-MS) Hydrological and mechanical characteristics of soil in the area of salt deposits, northwest Phoenix, Arizona: 94 p.

VAN BLARICOM, Richard (1971-MS) Induced polarization and resistivity modeling of dikes and other selected structural features: 100 p.

VIDAL, Jose Rabasso (1971-MS) Geology of an upper paleozoic sequence in north-central Canelo Hills, Santa Cruz County, Arizona: 54 p.

OTHER PUBLICATIONS

MINES AND MINING IN ARIZONA

The University of Arizona library has extensive holdings on mining and mineralogy in Arizona rich in interest to the mining profession in Arizona and to historians. These include state and federal publications, company and individual record books, journals, papers, maps, materials which belonged to Arizonians and correspondence with outsiders, such as, Benjamin Stillman and William F. (Buffalo Bill) Cody concerning mining ventures in our state.

The following are selected as of special interest from Library bulletin Vol. 1, No. 2:

Alexander, William Burnham
A collection of W. B. Alexander's manuscripts showing mining claims and workings in Arizona. Tucson, Arizona, 1900-1920. Collection includes 98 sheets of maps, plans and profiles, which were drafted by W. B. Alexander.

Alexander, William Burnham
Reports on tonnage in Pima and Santa Cruz Counties, Arizona. Tucson, Arizona, 1906. Typescript.

Arizona. University. Library. Map Collection. Carto-bibliography of Arizona mines. Compiled by Phylis Marie Carnahan. Tucson, University of Arizona Library Map Collection, 1969-71. An unpublished list which includes the names of 1600 mines. The name of the mine, county location and indication of township, range and section are given for each entry. Compiled for reference purposes.

Arizona Copper Company, Ltd.
Records, 1882-1921. 117 volumes and boxes. Mining Company of Edinburgh, Scotland, operating in the Clifton-Morenci area of Arizona. Journals, ledgers, cashbooks, voucher and wage records, cost statements, production records, and supply and financial inventories. Includes records relating to the operation of the Arizona and New Mexico Railway Company and the Clifton and Metcalf Hospitals and to accidents to mining personnel and industrial compensation payments.

Arizona Mining Company
"Articles of agreement" drawn up in London, August 25, 1869, by which Charles D. Poston, as attorney for the Arizona Mining Company, transferred to Roswell Sabine Ripley of London, for the price of 100,000 pounds sterling, all the real and movable property and mineral rights pertaining to the Arivaca Ranch and the Heintzelman (or Cerro Colorado) Mine.

Cody, William Frederick, 1846-1917.
Papers, 1911-1932. 1 box. Scout and showman. Chiefly correspondence between Cody and Ernest J. Ewing relating to operations at the Campo Bonito Mine, Oracle, Arizona, property of the Cody-Dyer Arizona Mining and Milling Company. Includes letters of others connected with the company, photos, and some financial records and legal papers.

Detroit Copper Mining Company
Records, 1882-1919. 18 volumes. Journals, payrolls, time books, and ore and freight records of a mining company operating in the Clifton-Morenci area of Arizona. Includes financial accounts of the Morenci Hotel.

Gird, Richard
Official map of the Territory of Arizona with all the recent explorations. San Francisco, A. Gensoul, Pacific Map Depot, 1865.

Harshaw Mining Company
Records, 1880-1882, 1908. Harshaw, Arizona, 1880-1908. 2 volumes. Volume 1: Contracts and assay reports. Volume 2: Ledger regarding equipment and supplies.

Henderson, Alexander S., 1859-1944.
Papers, 1893-1963. 4 volumes and 24 boxes. Resident of Patagonia, Santa Cruz County, Arizona, engaged in retail trade, politics, and mining activities. Store papers include financial records, correspondence, inventories, advertisements for merchandise. Mining material consists of legal papers, assay reports, ore settlements, letters, notices of mine locations in Satna Cruz County.

Lawler, John, 1889-1932.
Papers, 1889-1932. 14 boxes and 6 volumes. Prescott, Arizona, businessman with extensive mining interests, chiefly in the Eureka Mining District, Yavapai County, the most important of which was the Hillside Mine.

Mines and mining in Arizona; newspaper clippings, 1904-1912.

Reagan, Benjamin W.
Miscellaneous papers pertaining to the Silver King Mine, Pinal County, Arizona, 1876-79. Prospector and one of the discoverers of the Silver King Mine. Includes assay reports, financial papers, legal papers, 3 photographs, and various additional items relating to the settlement of the Reagan estate in the 1880's.

Sigma Gamma Epsilon
Arizona index map of geologic theses. Compiled by E. A. Schmidt. Tucson, Arizona, Department of Geology, University of Arizona, 1969. Map showing areas covered by theses completed at College of Mines, University of Arizona.

Staunton, William Field, 1860-1947
Papers, 1852-1947. 7 boxes. Mining engineer. Correspondence, diaries, financial records, photos, clippings, maps, and other papers, relating to mining and to Staunton's personal activities in Arizona and California while associated with various companies, chiefly the Tombstone Mill and Mining Company, Tombstone Consolidated Mines Company, the Congress Mine, Imperial Copper Company, Silverbell, Arizona, and Verde Central Mines, Inc., Jerome, Arizona.

Stevens, Thomas N., 1882-1966.
Papers, 1914-1964. 3 boxes. Mineral surveyor. Personal and business papers (correspondence, legal and financial records) pertaining to work with the U.S. General Land Office, various mining companies, and individuals in regard to land surveys to be used chiefly in patenting mining claims. There is also material concerning property in Tucson, Arizona, and landscaping.

Stoddard, Isaac Taft, 1851-1914.
Papers of Isaac T. Stoddard and Celora Martin Stoddard, 1894-1943. 7 boxes and 3 volumes. Businessmen and politicians. Correspondence, legal papers, financial records, maps, geologists' reports on the Stoddard Copper Company and the Copper Mountain Mines Company in Yavapai County, Arizona; records of the Stoddard Incorporating Company and its dealings with mining firms.

Continued on page 8

Publications continued

Tenney, James Brand, 1884-1959.
History of mining in Arizona, by James Brand Tenney, Assistant Geologist, Arizona Bureau of Mines. Tucson. 1927-29. 2 volumes. Original typescript. "This work has been edited and prepared from Mr. Tenney's original manuscript by the Special Collections Department, University of Arizona Library, 1959-60."

Tip Top Copper Company, Helvetia, Pima County, Arizona. Papers, 1903-1931. Includes payrolls, reports, correspondence, financial records, legal papers, and related materials pertaining to the Tip Top Mine in the Helvetia Mining District, Pima County, Arizona.

Tucson Mining and Smelting Company, Ltd. Records, 1890-1900. 2 boxes. Correspondence, business records, legal papers, and related material pertaining to the operations of an English mining company in the Silver Bell Mining District, Pima County, Arizona Territory; together with records of its predecessor, the Canada del Oro Mines, Ltd.

Twin Buttes Mining and Smelting Company. Records, 1904-1928. Records of mining operations in the Twin Buttes area, Pima County, Arizona, consisting of administrative correspondence and papers, bills, ledgers, financial records, labor reports, time cards, payrolls, and maps for the various mines of the Twin Buttes Mining and Smelting Company and of subsequent lessees and owners, including Bush-Baxter, Glance Mining Company, Midland Copper Company, and San Xavier Extension Copper Company. Includes records and forms pertaining to the construction and operation of the company's subsidiary railroad from Tucson to Twin Buttes, Arizona.

United Verde Copper Company
Records, 1886-1889. Correspondence and other papers relating to the operation and financing of the mine at Jerome, Yavapai County. Letters are chiefly from Eugene M. Jerome, secretary-treasurer of the company, and Frederick E. Murray, agent and mine superintendent, many of them concerning the actions of Frederick A. Tritle, ex-Governor of Arizona, in regard to the mine.

Wiggin, Albert E.
Report of a trip made by Albert E. Wiggin and J. B. Johnson to Globe and Miami, Arizona, in 1916 to study the various plants, smelters, and mills of the Inspiration Consolidated Copper Company, the International Smelting and Refining Company, the Miami Copper Company, and the Old Dominion Copper Mining and Smelting Company.

Atlases - Maps

Arizona. University. Library. Map Collection. UA map news monthly. Compiled by Stephen Bahre. Tucson, Arizona. 1969. Includes new map, atlas, and reference titles, which are acquired each month by the Map Collection. Special summer issue includes Arizona index and status maps.

Bahre, Stephen Alan
Known occurrences of minerals in the Four Corners States. Tucson, Arizona, Division of Economic and Business Research, University of Arizona, 1970.

Baumann, Jules
Prescott and Tributary Mining Districts, Yavapai County, Arizona. Compiled from official records and other resources. Chicago, Rand McNally, 1895.

Cox, Gustavus
Topographical map of Pioneer Mining District and adjacent county, Pinal County, Arizona Territory. Compiled from actual surveys and reliable information and drawn by Gustavus Cox. New York, George H. Adams, 1882.

Pacific Air Industries, Long Beach, California. Aerial photographs of the Papago Indian Reservation, Arizona. Prepared for Hunting Geophysical Services. Long Beach, California, 196-?

Roskruge, George James
Helvetia Mining District. Surveyed July 18th to October 2, 1899, by George J. Roskruge, U.S. Deputy Mining Surveyor. [Tucson, Arizona] 1899.

[San Xavier Mining and Smelting Company] Map of the Santa Cruz Valley region, Arizona Territory, including Calabasas, Tubac, San Xavier mines, Tucson and Santa Rita Mountains. San Francisco, Britton, Rey and Company [1869].

Schmidt, E. A. (compiler)
Arizona Index map of geologic theses (1969).

U. S. Geological Survey
Geologic atlas of the United States. Washington, 1984-1945.

U. S. Geological Survey
State topographic map indexes to published quadrangles. Washington, 1879-

Wilson, Eldred Dewey
Geologic map of Arizona, by Eldred D. Wilson, and Richard T. Moore, Arizona Bureau of Mines and John R. Cooper, U. S. Geological Survey. Prepared cooperatively by the Arizona Bureau of Mines and the U. S. Geological Survey. Washington, U. S. Geological Survey, 1969.

Young, R. J.
Map of Greenlee and Copper Mountain Mining Districts, Graham County, Arizona. Compiled and drawn from official records and recent surveys by R. J. Young and Lamar Cobb. Clifton, Arizona, 1901.

NEWS FROM AND ABOUT OTHERS

ARIZONA GEOLOGICAL SOCIETY

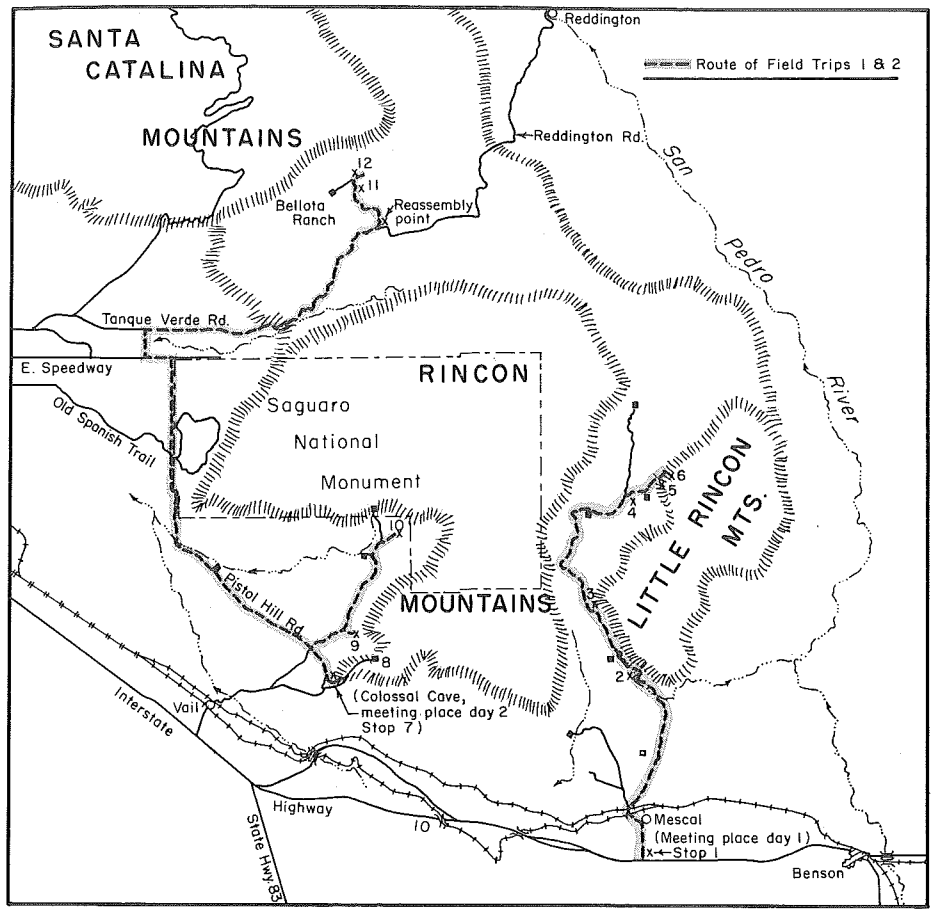
The November, 1971 program of the Arizona Geological Society featured two all-day field trips to the Rincon Mountains to the east of Tucson and a discourse on the structural geology of the Rincon Mountains at the monthly meeting. Leader for the field trips and speaker at the meeting was Dr. Harald Drewes of the U. S. Geological Survey. Drewes is well-known and recognized as an authority on the geology and structure in south-central Arizona. Currently he is mapping the geology of the Happy Valley Quadrangle.

The first field trip, attended by 80 participants, was directed to the eastern flank of the Rincon Mountains, in particular, the Happy Valley area and the northern part of the Little Rincon Mountains. The second field trip, with 52 in attendance, started in the Colossal Cave area at the southwestern edge of the Rincon Mountains and proceeded along the western flank, ending in the Bellota Ranch area in Reddington Pass at the north end of the range. Interest in the talk by Drewes drew close to 150 people to the meeting.

As outlined by Drewes in the prepared road log (words in parentheses added):

"The Rincons and Little Rincons are much alike geologically; they are parts of a single large gneiss dome. The rocks of the core of the dome are a gneissic complex of Precambrian intrusive and sedimentary rocks; those of the carapace (a protective, shell-like rock covering) are mainly of Paleozoic age but also include Precambrian granitoid rocks and Apache Group and Mesozoic sedimentary rocks. The carapace rocks are everywhere allochthonous (not formed in situ); the core rocks are autochthonous or para-autochthonous (formed in situ or nearly in situ). The allochthonous rocks consist of three main thrust plates. The lowest plate consists mainly of metamorphosed Paleozoic rocks, the middle plate is of (Precambrian) granodiorite, and the upper plate consists mainly of unmetamorphosed Paleozoic rocks.

"A large north-trending normal fault of Miocene (?) to Pleistocene age separates the Rincon block from the Little Rincon block. Since Miocene (?) time, the allochthonous carapace has been eroded from the uplifted Rincons; however, it is still (partially) preserved in the



Arizona Geological Society, Rincons field trip – November 1971.

Little Rincons (and also in various places along the western flank of the Rincons and in klippen which are isolated, erosional remnants of a thrust sheet, in the Reddington Pass area). Immediately east of the San Pedro Valley (in the Johnny Lyon Hills), most of the rocks are of the carapace, but some of them appear to be autochthonous."

In the areas visited or described by Drewes, the various Precambrian formations of the gneiss dome complex included, in sequence, Pinal Schist, Continental Granodiorite, and a 2-mica quartz monzonite. Aplite dikes and sheets of undetermined but probably late Precambrian age cut rocks of the complex. In the lower, metamorphosed thrust plate, Drewes has mapped Bolsa Quartzite and Abrigo Formation (Cambrian), Martin Formation and Escabrosa Limestone (Devonian and Mississippian), Horquilla Limestone (Pennsylvanian) and some rocks believed to be as young as Scherer Formation (Permian). The middle plate of granodiorite of Rincon Valley is dated radiometrically as Precambrian (1540±60 m.u.). It appears to be somewhat discontinuous and badly shattered but does not exhibit gneissic foliation. The upper plate, generally unmetamorphosed, contains or shows from place to place, sedimentary formations as old as the Precambrian Dripping Spring Quartzite or Pioneer Shale and as young as Cretaceous Bisbee Formation. Some gravel units, classified as Pantano Formation of Oligocene to Miocene age, occur around the edges of the Rincon Mountain dome where protected from erosion. Quaternary basin-fill gravels largely cover the valley floors. A few Tertiary intrusive stocks, probably Oligocene in age, have been mapped along the eastern side of the mountains but appear to have little effect on the main structural problems.

The combination of folding, thrust faulting, block faulting, uplift, probable gravity sliding, and erosion make an interpretation of the structural relationships and history of the area difficult to decipher. Drewes' current interpretation, derived from observed and inferred field evidence in the Rincon and adjacent areas, suggests Laramide underthrusting of the lower plate and overthrusting of the upper plate in respect to the middle plate of granodiorite. At a minimum, the upper and lower plates appear to have moved some ten miles from southwest to northeast, and if the geologic features east of the San Pedro River are considered a part of the same general structure, a possible minimum of twenty miles.

Drewes admits that his interpretation does not completely answer some puzzling geologic occurrences in the area but he believes it to be the most plausible explanation from the evidence so far revealed from his field mapping. He offers it as a challenge to local geologists and encourages their undertaking of further detailed study of the unique geologic problems associated with this fascinating region.

Besides the obvious geological benefits, the field trips afford an opportunity to initiate and renew acquaintances within the geologic fraternity.

MAGMA COPPER COMPANY

SAN MANUEL, AZ. – Wayne H. Burt, San Manuel, was elected President of Magma Copper Company, effective January 1, 1972, at a meeting of Magma's Board of Directors in New York City. He was also elected to the Board at the meeting.

Burt will serve as chief executive officer of Magma, a wholly owned subsidiary of Newmont Mining Corporation. He succeeds Wesley P. Goss who becomes Chairman of the Board of Magma, replacing Roy C. Bonebrake who retires on December 31, 1971.

Burt joines Magma in 1969 following an assignment as General Superintendent of Smelting and Refining for the Utah Division of Kennecott Copper Corporation in Salt Lake City. He had extensive previous experience in the copper industry in Chile, Nevada, Utah and Arizona. Burt was executive vice president of Magma prior to the election.

NATIONAL SCIENCE FOUNDATION

The National Science Foundation (NSF) is offering support to undergraduate groups wishing to organize environmental studies, according to the University of Arizona Research Bulletin.

The bulletin, published by the UA Office of the Coordinator of Research headed by Dr. Edward N. Wise, states that the program is designed to give students full-time research assistance, preferably for projects during the summer of 1972.

Limited to 10 to 12 weeks, the SOS (Student Originated Studies) undertakings must deal with the environment, be inter- or multidisciplinary, be conducted by a group (minimum of five), be student originated, planned and directed and have a faculty adviser.

NSF has stated that the projects must emphasize productive ways for students to express concern for the environmental well-being of the nation as well as providing opportunities to demonstrate

continued on page 10

Science Foundation (continued)

readiness to assume increased responsibility for their own educational development.

Deadline for research proposals is Nov. 1, 1971, according to the bulletin. More details are available in the UA coordinator of research office on the fifth floor of the Administration Bldg.

NOTICE FROM ARIZONA LAW REVIEW

Donald W. Hart, Managing Editor of the *Arizona Law Review,* informs the Editor of Fieldnotes that Volume 12, No. 2 containing the *Seminar on Mexican Law of Real Property* advertised in the September, 1971, edition of *Fieldnotes* is no longer available from the Review's office. Reports may be obtained from Fred B. Rothman and Company, 57 Lenning Street, South Hackensack, New Jersey 07606, price $3.50.

Another recent work published by the *Arizona Law Review,* Volume 12, No. 4 which may be of interest to our readers of *Fieldnotes* is entitled *Property Taxation of the Mining Industry in Arizona* by Desmond Kearns, a law student and Registered Professional Engineer (Mining). A *limited* number ofcopies are on hand at the Review's office, University of Arizona, Tucson, Arizona 85721, price $2.00, or they may be obtained from Rothman and Company at the address shown above, price $3.50.

U.S. GEOLOGICAL SURVEY

Building has begun on the national center home of the U.S. Geological Survey. The $44,118,000 center is to be located at the "new town" of Reston, Virginia. Completion of the facility is expected in early 1974.

About 2,200 employees of the Geological Survey will be housed in the building located on a wooded 105-acre site, 18 miles from Washington, D.C. The facility will permit consolidation of U.S.G.S. headquarters elements now scattered in more than 30 buildings, some as far as 27 miles apart, in the metropolitan Washington, D.C. area.

NAVAJOS NOW HELPING TO PRODUCE "TOPO" MAPS

A Department of the Interior news release reports that Navajo Indians are operating and managing a new cartographic facility located on the reservation at Fort Defiance, Ariz., to produce scribed and engraved maps for the national topographic map series. The operation is under the sponsorship and supervision of the U.S. Geological Survey, part of the Department of the Interior.

The Facility was established following a period of intensive training of a group of Navajos by USGS topographic specialists at Fort Defiance. On August 19 of this year, the USGS ended on-site supervision of the Facility, where the Navajo trainees said that they were "ready for business."

Roy F. Thurston, Pacific Region Engineer, USGS, Menlo Park, Calif., and a key official in the organization and training effort, said that "according to contractual arrangement with the Navajos, we expect about 60 maps to be engraved this year."

Thurston reported 26 maps have been sent to the Navajo Facility; 15 have already been engraved and returned for reproduction to the Survey's Branch of Cartography. The first Navajo-engraved map was the Park Mountain, Nevada, quadrangle map at a scale of 1:24,000 (1 inch equals 2,000 feet).

"The maps," Thurston said, "are acceptable quality to meet the standard established for our National Topographic Mapping Program."

"The installation," he said, " is adequate for a force of 15 engravers and a supervisor. This is about the size and type of installation that we envision as a practical adjunct to our Color Separation Section. We have encouraged further expansion of facilities for non-Survey contracts; however, this will be up to the Navajos.

U.S. BUREAU OF MINES

The Division of Education and Training under the Deputy Director of Health and Safety established a district office serving Arizona at Reno, Nevada. The district office, currently, has a staff of ten engineers to provide training in safety at mines and related mineral production activities in Arizona, California, Nevada, and Hawaii. The activities of this division are to be increased, compared to the past. Training courses will continue to be offered on request, as in the past, for first aid and mine rescue, with new courses to include dynamics of accident prevention, self rescuer, and mine gas detection. Demonstrations offered include static electricity and magic of fire.

Courses are available upon request for groups of five or more persons, depending on the scheduling of instructors. During the first week of December, two members of the district office visited as many mines as possible to acquaint operators as to the new organization, but for any who were not contacted, inquiries for additional information and requests for training can be directed to Bureau of Mines, Division of Education and Training, Quenton L. Wilcox, Chief, 1605 Evans Avenue, Reno, Nevada (89505), or by calling 702-784-5396.

A two volume engineer's guide to compliance with recently lowered limits in underground uranium mines has recently been published. Volume 1 (published in 1970) offers a more general, less technical discussion of the radon daughter control problem. Volume 11, published in November, is a more technical discussion of controller of employee exposure to alpha radiation in underground uranium mines. Volume 1 is available for 40 cents and Volume 11 for $1.00 at the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

ENGINEERS CONVENTION IN MEXICO

The *IX Convencion National Asociacion de Ingenieros de Minas, Metalurgistas y Geologos de Mexico,* sponsored by the Sonora chapter, was held in Hermosillo, Sonora, October 24-30. Registration reached approximately 1,400 which taxed the facilities in Hermosillo. The engineers represented the mineral industries throughout Mexico and included a few from the United States and Canada.

Approximately 75 technical papers were presented dealing mainly with exploration and geology, mining, chemical and metallurgical engineering, and mineral economics of Mexico. The papers will be assembled and printed in monograph form.

Pre-meeting field trips were made to large potential copper areas, La Caridad near Nacozari, Sonora, and to Cananea. After the conference the mineral districts of Santa Rosalia, Baja California, the Tungsten mines near Baviacora, Sonora, and the graphite area southwest of Hermosillo were visited.

NEW MINERAL FOUND

Zapatalite (71-23)
$(Cu_3Al_4(PO_4)_3(OH)_9.4H_2O$.
by S.A. Williams
(Phelps Dodge Corp., Douglas, Ariz.)

The mineral is dissolved by cold dilute acids, decomposed by 20% KOH.

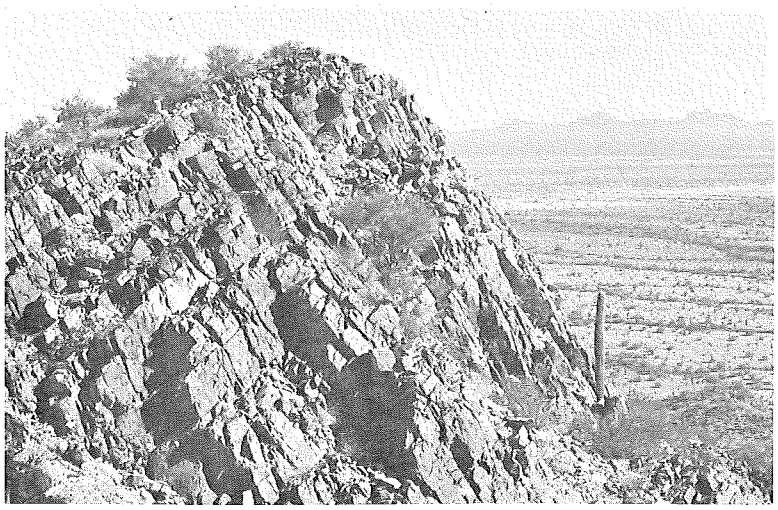
The x-ray pattern shows strongest lines 11.60 (10), 7.62 (10), 6.82 (7), 5.75 (7), 3.04 (5), 2.95 (4), 2.88 (4), 2.53 (5). These are indexed on a tetragonal cell with a 15.22, c 11.52A., Z = 6. G. calcd. 3.017, measured (Berman balance) 3016 $\pm$ 0.026.

Color pale (faience) blue, streak pale blue. H. 1½. In thin section pale green, with feeble dichroism in green, absorption E>O, ns (Na) ϵ 1.635, ω 1.646. Usually optically uniaxial, neg. but may be biaxial neg. with variable 2V. Cleavage basal, good.

The mineral occurs as porous, spongy masses, filling vugs in silicified and

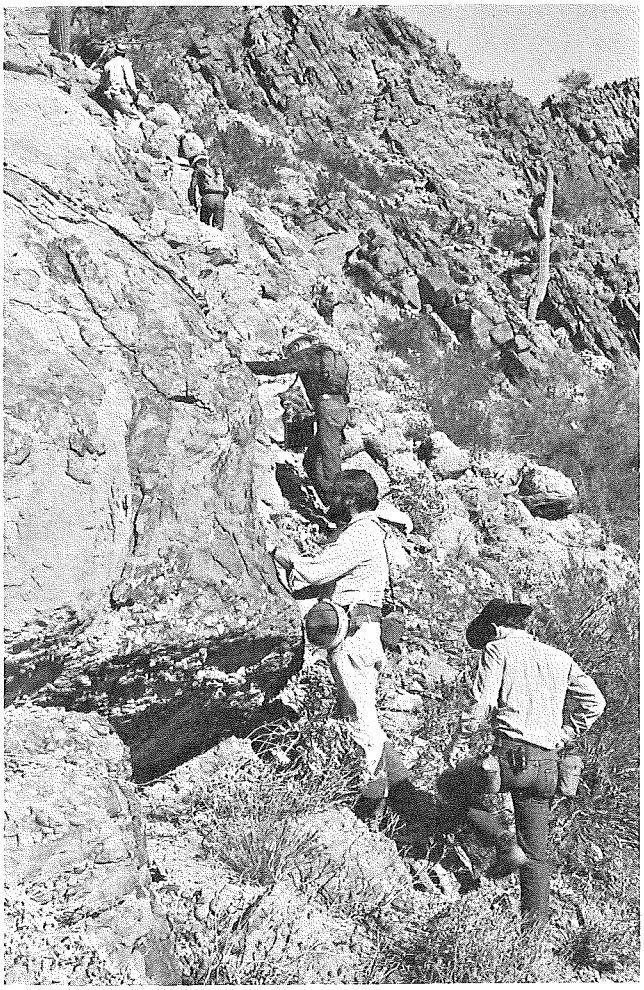
Continued on page 12

MISCELLANEOUS GEOLOGIC ACTIVITIES IN ARIZONA



Outcrop of northwest tilted younger Precambrian Dripping Spring Quartzite, Slate Mountains, Pinal County — Looking NE.

The study of faults is an important part of geologic investigations. Geologist examining a steep, west dipping fault exposed in Rincon Valley near Tucson.



Foot by foot examination of the base of the Dripping Spring Quartzite — Slate Mountains.

A south dipping fault along State Highway 87, Mazatzal Mountains, central Arizona. Tertiary sediments on the south are faulted down against older Precambrian Alder Series — Looking north.

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

_____
(Name)

_____
(Street or Box No.)

_____
(City) (State) (Zip)

_____
(Business or Professional Affiliation)

brecciated limestone, northwest of Cerro Morita, 27 km. S. W. of Agua Prieta, Sonora, Mexico. Associated mineral are libethenite, chenevixite, beaverite, alunite, pseudomalachite. Grain sizes of the mineral seldom exceed 0.5 mm. normal to C and 0.2 mm. parallel to c. Total amount less than 0.5g.

The name is for Emiliano Zapata (1879-1919), a popular hero of the Mexican Revolution. Type material will be preserved at the University of Arizona and the British Museum of Natural History.

FIELD NOTES

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

ARIZONA BUREAU OF MINES
THE UNIVERSITY OF ARIZONA
TUCSON, ARIZONA 85721