FIELDNOTES FROM THE ARIZONA BUREAU OF MINES

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MINERALS EXPLORATION AND LAND-USE PLANNING

INTRODUCTION

by
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Principal Geologist

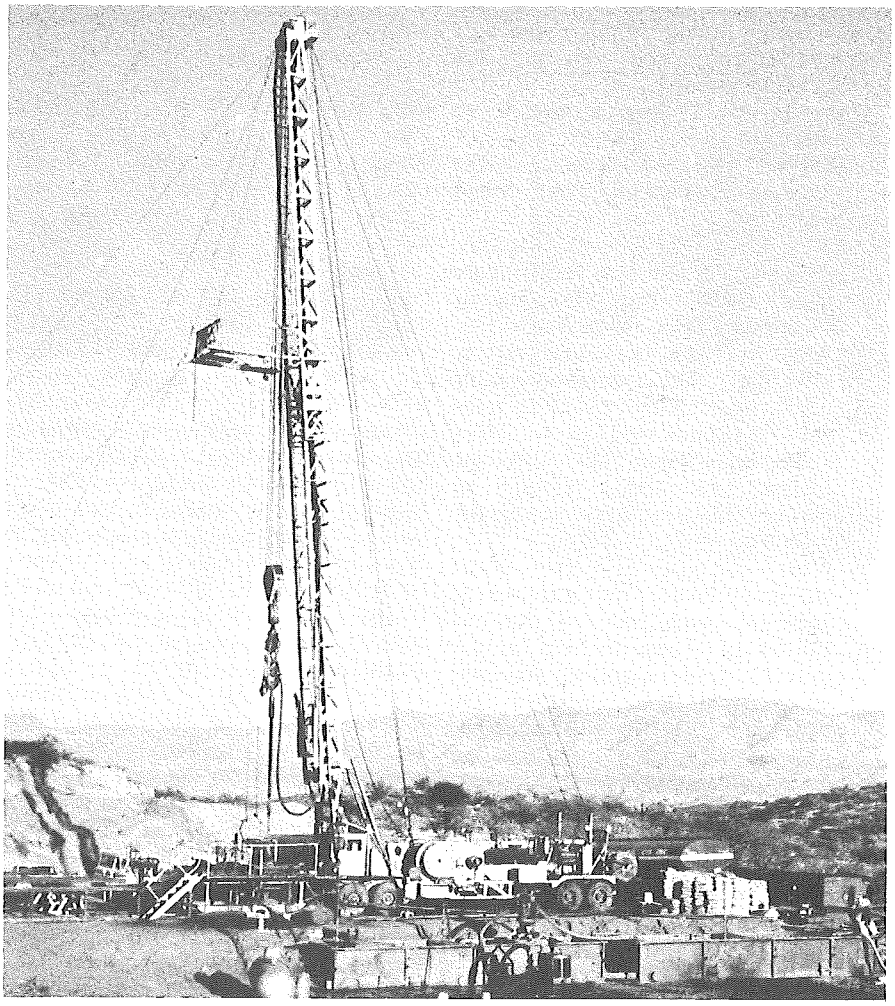
During the past fifteen years or so, Arizona has been growing at a phenomenal rate. According to figures supplied by the Valley National Bank, the population of the Phoenix metropolitan area increased 32.6% during the 10-year period 1960-1970 and the population of the Tucson metropolitan area by 23.5% during the same period. This large influx of people has caused a great deal of pressure for the development of land for urban use. As a result, there has been considerable conflict with other land uses, such as agriculture, ranching, recreation, and mining.

The growing seriousness of these land-use conflicts has been recognized by the State Legislature and the Governor, and in May of 1973, the Environmental Planning Commission was established to undertake an in-depth study of the problem through hearings and other research, and to develop a land-use policy and program whereby the State can grow and prosper in an orderly manner.

For quite some time, the Arizona Bureau of Mines also has been very much aware of the problems developing for the land-use decision-makers, and has discussed several of the conflicting land-uses which will have to be considered, and some of the geologic factors that will bear heavily on any decisions made in the use of land. Such subjects as geologic hazards, archaeological resources, and buried mineral deposits, and the ways in which they will affect or conflict with other potential land-uses, have been discussed in previous issues of FIELDNOTES.*

Much has been said in recent years about a "quality environment" for the American people. Certainly, when many people think of a "quality environment", they immediately think of clean air, clean water, pristine-country, unmarred by the works of man, and, perhaps, roadsides that are not littered with beer cans and soda bottles. Taken in its total, however, the quality of one's environment also is enhanced by those niceties of life such as running water, a hot shower, refrigerated homes, and a deep freeze in which to store fresh foods. These items also contribute very heavily to a "quality environment" in a civilization such as ours, and they would be impossible to have if it were not for our minerals industry which produces the raw materials from which all of these amenities of civilization are manufactured.

Because Southern Arizona is one of the more richly endowed areas on the face of the earth as far as copper mineralization is concerned, the minerals industry has a considerable interest in Arizona, and the activities of the minerals exploration geologist will continue to be



Test drilling an area of suspected mineralization. In some cases, the appearance of drilling such as this is the first, obvious indication that a particular area is the subject of a mineral exploration project.

*Vol. 2, no. 3, Geologic Hazards and Land Use Planning; Vol. 2, no. 4, Copper Mining and Arizona Land Use Planning; Vol. 3, no. 1, Archaeological Resources and Land-Use Planning; Vol. 3, no. 4, Bedrock Shoulders and Land Use.

actively pursued, particularly in the southern portion of the State. Thus, conflicts between his interests and those of other land-use activities will continue to be felt. However, the science, or art, if you prefer, of mineral exploration consists of a sequence of activities and not all of the individual parts of the process need conflict with other land uses. Nor, in many cases, is it necessary that they cause irreparable damage to the terrain. It is because of this complex nature of the exploration program that I have invited a number of experts in the field to comment concerning exploration, so that a broader understanding of this activity can be gained by those who find themselves sometimes at odds with the minerals explorationist.

When I invited these gentlemen to contribute to this edition of FIELDNOTES, I asked them to center their comments on the four broad categories:

1) What favorite techniques, methods, or types of equipment they feel are most useful in exploration as dictated by their experience.
2) What are the important factors affecting their decision-making when choosing between likely areas for the same exploration dollar. Examples might be geologic factors, economic factors, or perhaps the past production of the area.
3) What broad types of projects might be undertaken by government agencies, such as the Arizona Bureau of Mines, to help delimit potential mineral bearing areas. As an example, I suggested the possibility that the Bureau might undertake a seismic study to define areas of buried pediment (see FIELDNOTES, V. 3, No. 4, Dec. 1973).
4) Make any comments you might wish on land-use priorities in Arizona. That is, attempt to define, in a broad way, areas of the State, on the basis of relative probability for mineral deposits, that should be scrutinized carefully before any restrictive land-use classifications are made.

Thus, it is within these guidelines that the following articles were prepared, and it is hoped that a better understanding of the roles of the explorationist and his needs will be carried to a broader segment of the population of Arizona; a population which either directly or indirectly benefits from the minerals industry of the State.

G. A. Barber, Vice President - Geology and Technology of the General Mining Division, The Anaconda Company, is a 1951 graduate of the University of Arizona. Since joining Anaconda upon graduation, he has served as a geologist at its Grants, New Mexico Uranium Operation, Chief Geologist Southwest U.S. and Mexico, Exploration Manager of the Company, and was appointed to his present position earlier this year.

Mr. G. A. Barber

Mr. Barber received the Professional Degree in Geological Engineering from the University of Arizona in 1966, and has authored a number of professional articles during his career. He resides in Tucson with his wife Elvira and four children.

Mr. Barber's observations, which combine the viewpoints of management and technology, follow.

"If you dislike waiting in line for gasoline for your car, you're going to hate waiting in line for the car itself." This statement was recently made as a preface to a news article entitled, "Minerals Shortage Feared." The word "feared" infers a pending situation, but unfortunately such is not the case, as a minerals shortage now exists in the U.S. We currently depend on foreign imports for over 75 percent of our manganese, aluminum, nickel, platinum, tin, chromium, titanium, and cobalt resources, and for over 50 percent of our zinc, gold, antimony, mercury, and bismuth requirements. Such dependencies result in an unfavorable balance-of-trade and create a situation whereby significant political and economic pressures on the United States are produced, as witnessed by the recent Arab nations petroleum embargo. A drastic reduction in the supply of imported commodities would have a detrimental impact on the U.S. economy in normal periods, and could be disastrous during physical and economic conflicts.

The reliance on foreign metal supplies should be adequate stimulus for establishing a logical policy for the development of our domestic raw materials. Yet, efforts by the minerals industry to discover and develop additional reserves in the United States are weakened by the need to continually engage in time-consuming and expensive defensive maneuvering to survive the increasing pressures by government and private organizations to curtail exploration and production of new domestic mineral resources. An example of this pressure is the procedure adopted in the reclassification of public lands as "withdrawn from mineral entry." The fact that known economic ore deposits or geologic evidence of additional concentrations represent only a minute portion of the earth's crust warrants extreme caution in withdrawing areas from examination and potential development. At present, mineral withdrawals are being made based on a minimum of geologic evidence, or even arbitrarily. All available technology and skills should by utilized to exhaust the possibility that a particular area has no mineral potential prior to withdrawing it from mineral exploration and possible development. Once such a determination is made and an area withdrawn, it is virtually impossible to obtain a reappraisal which could result in possible reclassification at a later date. Therefore, organizations involved in the interpretation of geology as related to mineral deposits must accept the responsibility of contributing appropriately to the careful examination and appraisal of those areas under consideration for withdrawal. Such organizations include both Federal and State agencies such as the U.S. Geological Survey and the Arizona Bureau of Mines, as well as private mining companies. Universities, through graduate study projects, can also make a significant input.

In order to make a thorough evaluation of the mineral potential of an area, numerous factors must be considered in the selection of specific study areas. Private companies' exploration programs are designed to satisfy corporate requirements. Generally, specific minerals are sought, and minimum requirements regarding the preferred size of the sought-for deposit and the stage to which the discovery might be developed are established. The last criteria is commonly overlooked but is important, as some firms are organized only for the purpose of discovery, and will sell, joint venture, or otherwise dispose of a deposit rather than invest capital for development.

Once the corporate objective has been defined, the political climate of potential target areas must be considered.

Assuming that the program is within the United States, consideration must be given to the attitudes and policies manifested by particular State governments, local communities, and private citizen groups. It is both counter-productive and frustrating to invest significant amounts of time and capital in a successful exploration program only to find that tax laws, zoning, or other restrictions prevent development of the deposit. Indiscriminantly applied environmental restrictions have become increasingly important as a deterrent to exploration and potential development of economic mineral deposits.

After selecting an area of interest, all possible field and laboratory methods available to the explorationist must be considered in making the evaluation. These may range from utilization of satellite photos and side-looking radar for detection of broad structural lineaments and alteration patterns, to sophisticated laboratory studies involving detailed analytical techniques. For example, composition of a particular mineral assemblage and its relation to the ore formation environment is critical in interpreting where concentrations of metals may exist. Continuing studies of ore deposits presently being mined and application of resulting interpretations are proving invaluable in exploration programs. Although no two deposits contain exactly the same rock assemblages, alteration patterns, or other geologic-mineralogic relationships, certain similarities commonly can be recognized, and analogies can be drawn to assist in selection of specific drilling targets.

Decisions as to hole spacing, type of drilling equipment to be used, sampling procedures, and other related evaluation techniques are determined by the type of mineral occurrence and will vary with particular programs. Upon commencing a project, factors such as available time and funding for the exploration effort, the maximum amount of sample material required for geologic, metallurgical, and rock mechanic studies, for example, and the indicated depth of the deposit, must be carried out as efficiently as possible. Intense competition among drilling companies and other groups providing service to the mining industry has resulted in the development of improved techniques, and in some instances, reduced exploration costs. Deeper drilling incorporating wedging of holes is an example of more for the drilling dollar.

Once a significant mineral concentration is discovered, its appraisal involves numerous factors beyond the calculation of geologic (metal-in-ground) and mineable (extractable) reserves. Metallurgical testing, mine and plant design, environmental considerations, economic studies, and market analyses are all fundamental to the determination as to whether or nor a mineral deposit can be developed into a mine. In order to evaluate these parameters and their numerous actual and potential variables, computer techniques are now widely being used to design and perform feasibility studies. Prior to this state of analysis, a mine planning-production evaluation would require literally man-months. We are now capable of making comparable studies in hours, or in some cases, minutes.

The point at which the exploration phase of a deposit evaluation is considered complete and mine development begins varies with each project. There is generally an economic incentive to bring a property into production as rapidly as possible in order to recover both the exploration-development investment and avoid high interest payments. Mining, unfortunately, is a capital intensive industry. The cost of making an ore discovery has steadily increased over the years and more sophisticated exploration programs require continually increasing expenditures. A study made by the Minerals Resource branch of the Canadian government indicates that the average cost of discovery of significant deposits in Canada had risen from about $2 million per deposit in 1955, to $6 million per deposit in 1965, and to an estimated $15 million per deposit in 1970. Based on this trend and growing inflation in recent years, the average exploration cost of a significant discovery could now be $25 million. Increases in metal prices partially compensate for the steadily rising cost of exploration and development, but not in direct proportion to the greater risk factor, or actual dollars invested.

If the mining industry, which depends on successful mineral exploration, is to continue as one of the basic contributors to the U.S. economy, encouragement and assistance must be provided by those agencies at the Federal and State levels through basic geologic-economic studies. A coordinated program with appropriate contributions from government agencies, university geology departments, and private industry can provide better geologic information applicable to exploration programs. Not only will such coordination provide maximum data for utilization by all interested parties, but it also avoids expensive duplication of efforts.

In summary, major changes in mineral objectives and economics in recent years have resulted in the development of more sophisticated and costly exploration techniques. If the United States is to meet its basic mineral requirements from domestic reserves, private industry must continue its technological advancement. Earth science organizations in the public sector will need to assist not only in specific scientific endeavors, but also, and perhaps more importantly, in clarifying the requirements for practical land use classifications. The government itself can supply the necessary incentives through an enlightened land use policy. Let us realize the impracticality of encouraging exploration and mineral development through consumer demands, only to have areas of ore potential withheld from study.

Mr. H. J. Steele

H. J. Steele received his professional education at Oregon State University, where he earned a B.S. in geology in 1937. He has been associated with Newmont Mining Corporation enterprises ever since, and for the past 10 years has been in charge of much of Newmont's exploration activities in Arizona. Prior to 1965, he spent more than 20 years in various phases of mine operations at the Magma mine, Superior, Arizona, and at Magma's San Manuel property. Mr. Steele is well versed in the "nuts and bolts" of mineral exploration, and he shares some of his expertise with us in the following article.

Minerals exploration techniques are basically founded on knowledge of the earth's crust and an understanding of what is physically observed. The sophisticated tools and methods developed during the last one or two decades, including the computerized compilation, sorting, and categorizing of large volumes of geological and geophysical data, represent tremendous scientific advancement over methods of 20 to 30 years ago. Even so, the majority of knowledgeable, working exploration people recognize the limitations of these

tools, and realize that truly definitive quantitative methods are still a long way down the road. Geophysical methods, remote sensing, photogeology, statistical studies of mineral deposits designed to find some common denominator to apply to less well known areas, all have their place, but over-emphasis of this approach is dangerous.

Basically, we are drawn to an area by what we might consider encouraging signs derived during reconnaissance type investigations based on experience and literature research, supplemented by limited field work. We question more or less in this order:

1. In what geologic – metallogenic province does the area fall?

2. What is the regional geologic setting – particularly the structural framework – the rock distribution, presence or absence of post mineral cover, and the evidence for mineralization, however subtle?

3. Do rock sequences favorable as hosts to mineralization exist, or are they likely to exist in the district, even though possibly obscured by faulting or other geologic events, or, as in some areas, excessive vegetative ground cover?

Pursuing this approach to mineral exploration, careful and precise geologic mapping in and adjacent to an area of interest suggested by the prior reconnaissance work is next in order. The introduction of mineralizing solutions which formed the metalliferous deposits of the southwest invariably left its signature in the form of alteration of the component minerals of the rock; and this alteration will occur in varying degrees and at varying distances from the deposit. These phenomena, among others, have to be observed on the ground, recorded, and every attempt must then be made to put the information in its proper context. There is no substitute for careful field work.

As an example of tools to aid in the interpretation, microscopic analysis and measurement of chemical and physical properties of the materials sampled are all of great aid in the continuing study of a given problem. At a point somewhere along this line of procedure, having gained a certain insight into the occurrence and distribution, and the physical, chemical, and electrical properties of the rocks of a given area, we look to geophysical methods as an important means of assisting in the interpretation of what was originally observed and sampled. Dependent on geological circumstances; instrumentation for measuring magnetic variations, variations in electrical response, seismic properties, and gravity characteristics of the rock masses and/or mineral concentrations becomes an important additional tool to exploration. Finally, after weighing the evidence, drilling or digging a hole in the most likely spot is the final test of the total effort.

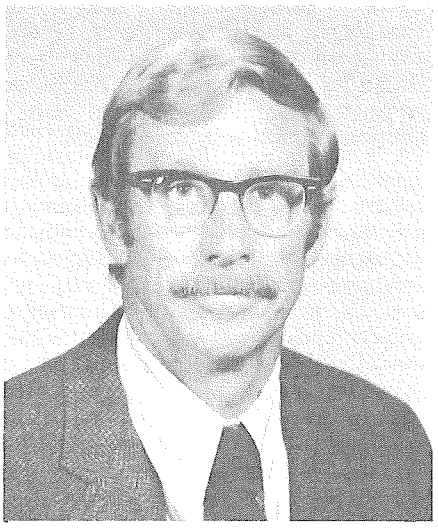
While we are searching for the best place to spend our exploration dollar through the methods summarized, or some variation thereof, the wise expenditure of tax dollars contributes heavily to the effort. Examples of this are the very fine work done by State agencies such as our own Arizona Bureau of Mines which has compiled county and statewide geological maps, and the geological mapping of the United States Geological Survey and its other wide ranging research. The contributions to geology by such agencies are virtually impossible for private exploration groups to achieve. Greater coverage in all phases of their geological and geophysical research is certainly desirable and important.

The foregoing comments on minerals exploration are intended to emphasize that such efforts have to be concentrated in areas of a particular geological environment, one where those ingredients necessary for the formation of an ore deposit are present. This obviously may be in conflict with other interests if it is in, or adjacent to an area suitable for population centers, farming, recreation, or other values. When this is the case, land use conflicts develop. The demand for metals, however, is not likely to be rolled back, and the only place from which this demand can be satisfied is from the earth and, more specifically, from that particular position on the earth where these metals occur. Thus, land-use priority in Arizona, in common with the rest of the United States, has become a very important and, unfortunately, a problem highly charged with emotion. The mining industry, and the mineral exploration necessary to sustain the industry, are in the peculiar position of being pressed for more production of metals for the "good life" while being told to please go away.

As pointed out previously, there are certain provinces in Arizona where the potential for important mineral deposits is relatively high. In contrast, there are vast areas with low potential. Land use priority rating should be consistent with these facts, and such a broad rating factor is not inconceivable. The two major population concentrations in Arizona are dramatic examples, with Tucson lying in one of the major copper producing districts of the world and Phoenix located in a low mineral potential area. Land priority in Pima County generally should be rated with a high mineral-probability factor and development planners should be appraised of this fact. This is not less logical than rating areas within drainage patterns as having a high or low flood probability, and so advising development planners and the public.

We strongly advocate the areas in the southwest characterized by mineralized clusters and alignments where geological factors indicate potentially mineral-bearing ground remain open for mineral entry and exploration, subject to the mining laws of the United States in effect at the time of entry. We believe that State and Federal geological agencies can contribute greatly to priority rating of land uses relating to mineral potential and that they would not in any way represent special interest groups. We believe that mineral exploration in all phases should be carried on with a minimum of disturbance to the area of interest, but not be restricted by punitive regulations, whereby efficient exploration procedures would be impossible or even prohibited because of resultant unreasonable costs.

For the past 5 years, Albert J. Perry has been President of Perry, Knox, Kaufman, Inc., a small Tucson and Spokane based minerals exploration company. PKK explores for both metallic and non-metallic minerals, principally in the Western United States (including Alaska) and British Columbia.



Mr. Albert J. Perry

Prior to the formation of PKK, Mr. Perry was Manager of the Minerals Division, The Superior Oil Company. His other associations as a geologist have been with Union Carbide Corporation and The New Jersey Zinc Company. Mr. Perry has been involved in minerals exploration for a total of 17 years. He received his professional education at Washington & Lee University and the University of Colorado.

Herewith are Mr. Perry's comments on mineral exploration and land-use classification.

Most Arizonans know that this State is number 1 in the United States in copper production. Some even know that we are number 2 in the output of silver. What few know is that Arizona has the capability of producing metals at a rate considerably in excess of its current output. Metals imports are likely to decline in the future and we may have to unleash this increased production capability. Imports are expected to fall off due primarily to two factors: 1) the rapid development of the emerging nations and the increased need for metals for their own growth, and 2) the "minerals blackmail" position that we expect will be taken by some producing countries, *a la* the petroleum embargo. The need for added domestic production of metals means additional metals exploration. This increased exploration, combined with the skyrocketing Arizona population, will result in increased competition for land use – making mandatory good land use planning and a system of land use classification.

Exploration – What It's All About

Before consideration can be given t(land-use planning with respect to metals, there must be some conception of what metals exploration involves. Let's take a look at this exploration from the following viewpoints: 1) time involved in minerals search, 2) personnel required, 3) financial needs, and 4) exploration techniques.

1) Time involved in minerals search – In the days of Tombstone and Chloride and the other colorful camps of Arizona we did, as the movies often depict, have prospectors with a burro or pack string, subsidized by a local entrepreneur, wandering about looking for a good lead. Because of his transportation limitations – his feet or those of his trusty horse – the early day prospector did not cover the vast areas searched today. With a little luck, however, he probably found some sort of favorable sign and staked out a lode or placer within the period of a few months or at least within a couple of years.

Students of exploration have made different estimates of the time now involved in finding a major ore deposit. Those times range from 5 years to about 15 years for a search involving not a single geologist or engineer but the entire regional exploration department of a company – that department ranging in size in the case of a small company to from 3 to 5 geologists and with the larger company to a score or more scientists. The time we talk of is for exploration only – with another 3 to 10 years often being required for development and other pre-production work, assuming that markets and price continue to be favorable.

2) Personnel required – As mentioned above, several people at least are involved in most exploration efforts. Not only do we have geologists in exploration today; but engineers, geophysists, mineralogists, geochemists and a vast team of technicians who wring information from the rocks and from data developed. The Arizona Department of Mineral Resources lists 49 companies as having exploration offices in Arizona. Adding to this the untold number of companies that work here without permanent base and the hundreds if not thousands of Sunday prospectors who acquire mineral rights thru claim location, and it is obvious that our Arizona rocks are literally alive with exploration people.

3) Exploration funding – "Burro Bob" our legendary prospector was probably subsidized by his backer in the amount of several hundred or at most several thousand dollars. The last grizzled character with burro I saw was in 1956, in the Circle Cliffs Area southeast of Utah, and there were mighty few of that type left then. Today's company prospector requires a minimum of $150,000 a year to function effectively – and amounts in addition to that to engage in any substantial drilling. Few companies explore in Arizona with less than $500,000 a year as a minimum operating budget, and most of the substantial companies have $1 million plus to spend. To further illustrate the expense of exploration; it cost one company $6 million to explore a medium sized copper deposit, after the general area of search had been reduced to a few square miles.

4) Exploration techniques – Perry, Knox, Kaufman, Inc. is a small minerals exploration company. Some of our work is done on our own account. In these instances expenditures are necessarily small and our techniques somewhat different from those of a large company. On the other hand, some of our exploration is done in conjunction with major natural resource companies. In those cases our exploration approach is very little different from that of any of the larger exploring groups; so we are generally acquainted with procedures used by most modern prospectors in Arizona.

Arizonans are aware of only a minor amount of the exploration that goes on within the State. Most first stage exploration involves airborne work –aerial photography, aerial magnetics and just plain looking out of the window of a helicopter or slow flying aircraft. From work of this type we can determine something of the character of the rocks (exposed and buried). We can follow mineral trends and sometimes establish alteration outlines. Colorful and sometimes meaningful gossans can be defined. Much of the work of this type is expensive, but if properly done, it can be very informative and result in the elimination of large areas as unfavorable or at least as less favorable than others.

Once some target areas have been delineated at least some ground work is immediately required. Rock exposures, if present, are scrutinized and sampled. Geologic mapping is commenced. Ground geophysical techniques are employed (including ground magnetics, gravity, electromagnetics and induced polarization, to mention a few). This work is undertaken with the exploring party generally having some interest in the mineral rights if not the surface of the land as well. Many potential prospect areas are eliminated by this phase of work – and without any alteration of the surface (no pits, trenches or roadbuilding).

Assuming some encouragement with the first two stages of exploration, then comes that exploration which generally first excites the public. We drill. In some cases we excavate by trenching or sinking shallow shafts, but in present times this latter work is done in the minority of instances. Roads are generally constructed during this stage of exploration.

It is only with success with initial drilling and/or shaftsinking that work really gets serious and major amendments are made to the surface. Federal and State agencies now have strict regulations about restoration, assuming unsuccessful exploration. In most situations some restoration is also called for upon completion of mining.

Land Use Planning/Classification

Some modern prospectors, like ranchers, cotton farmers, pecan growers and recreationists would like to have the entire State in which to roam unrestricted to "do their thing". This is obviously not possible, or even desirable. Generally, geologists cannot say that no mineral is possibly present in a given geographic area, but they can say with some certainty that some areas are more favorable for exploration than others. We can do this by several means, including that of projection of favorable trends,

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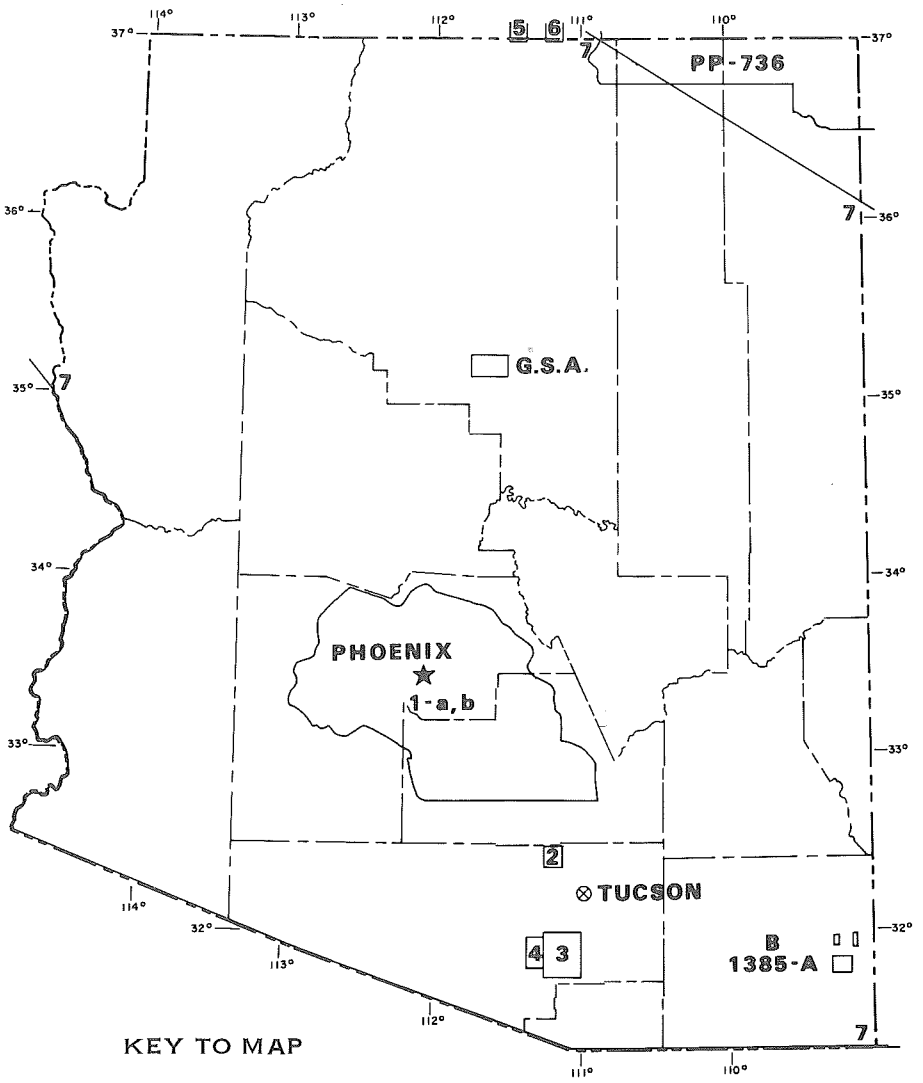
NEW GEOLOGIC MAPS OF ARIZONA



NOTE

The following maps are sold at the price indicated by the U.S. Geological Survey and should be ordered from,

U.S. Geological Survey
Map Sales Office
Bldg. 41, Federal Center
Denver, CO. 80225

1. - a. W. R. Osterkamp: Map showing depth to water in wells in the Phoenix area, Arizona, 1972; U.S.G.S. Map I-845-D, Scale 1:250,000, price .75 cents.
   -b. U.S. Geological Survey: Arability map of the Phoenix area, Arizona; U.S.G.S. Map I-845-E, Scale 1:250,000, price .75 cents.
2. 1973. U.S. Geological Survey: Map of slopes and their environmental significance in the Marana Quadrangle, Arizona; U.S.G.S. Map I-846-A, Scale 1:24,000, price .75 cents.
3. 1973. John R. Cooper: Geologic map of the Twin Buttes Quadrangle, southwest of Tucson, Pima County, Arizona; U.S.G.S. Map I-745, Scale 1:48,000, price .75 cents.
4. 1973. Harald Drewes and John R. Cooper: Reconnaissance Geologic map of the west side of the Sierrita Mountains, Palo Alto Ranch Quadrangle, Pima County, Arizona; U.S.G.S. Map MF-538, Scale 1:24,000, price .50 cents.
5. 1973. Fred Peterson: Geologic map of the Southwest Quarter of the Gunsight Butte Quadrangle, Kane and San Juan Counties, Utah, and Coconino County, Arizona; U.S.G.S. Map MF-306, Scale 1:24,000, price .75 cents.
6. 1973. Fred Peterson and B.E. Barnum: Geologic map of the Southwest Quarter of the Cummings Mesa Quadrangle, Kane and San Juan Counties Utah, and Coconino County, Arizona; U.S.G.S. Map I-759, Scale 1:24,000, price .75 cents.
7. 1973. L.R. Kister: Quality of ground water in the Lower Colorado River Region, Arizona, Nevada, New Mexico and Utah; U.S.G.S. Atlas HA-478, Scale 1:1,000,000, 2 sheets, price $1.00 per set.

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PUBLICATIONS

NOTE

The following U.S. Geological Survey publications are sold at the prices indicated and should be ordered from,

Superintendent of Documents
U.S. Government Printing Office
Washington, DC 20402.

1973. M.G. Johnson: Placer Gold Deposits of Arizona; U.S.G.S. Bulletin 1355, 103 p., 1 plate, price $1.00.

1973. Harald Drewes, *U.S. Geological Survey,* and Frank E. Williams, *U.S. Bureau of Mines,* with a section on Aeromagnetic Interpretation by Gordon P. Eaton: Mineral Resources of the Chiricahua Wilderness Area, Cochise County, Arizona; U.S.G.S. Bulletin 1385-A, 53 p., 1 plate, price $1.35. (Area shown on adjoining map.)

1972. J.E. Case and H.R. Joesting: Regional Geophysical Investigations in the Central Colorado Plateau; U.S.G.S. Professional Paper 736, 31 p., 3 plates, price $5.60. (Area shown on adjoining map)

1972. Harald Drewes: Cenozoic Rocks of the Santa Rita Mountains, Southeast of Tucson, Arizona; U.S.G.S. Professional Paper 746, 66 p., price $1.50.

1973. J.T. Nash: Microprobe Analyses of Sericite, Chlorite, and Epidote from Jerome, Arizona; U.S.G.S. Journal of Research, Volume 1 Number 6, pp. 673-678, price $2.75.

1973. J.T. Nash and C.G. Cunningham, Jr.: Inclusion Studies of the Porphyry Copper Deposit at Bagdad, Arizona; U.S.G.S. Journal of Research, Volume 2 Number 1, pp. 31-34, price $2.75.

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OPEN FILE

1973. Richard A. Sheppard: Zeolites and Zeolite Ore from Union Carbide Corporations EZ No. 225 Placer Mining Claim, Graham County, Arizona; U.S.G.S. Open File

Report, 38 p. A Copy of this report may be seen at the Arizona Bureau of Mines office in the Geology Bldg. room 324, University of Arizona, Tucson.

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THESES

Inquiries concerning the availability of the following theses should be directed to the University or College department under which they are listed. THEY ARE NOT AVAILABLE FOR DISTRIBUTION FROM THE ARIZONA BUREAU OF MINES.

ARIZONA STATE UNIVERSITY

Geology Department

1973. Susan Leslie Anderson: Investigation of the Mesa Earth Crack, Arizona, Attributed to Differential Subsidence Due to Groundwater Withdrawal; MS, 111 p.

UNIVERSITY OF ARIZONA

College of Earth Sciences

1972. John Coleman Balla: The Relationship of Laramide Stocks to Regional Structure in Central Arizona; Ph.D., 132 p.
1972. William Charles Butler: Permian Conodants from Southeastern Arizona; Ph.D., 130 p.
1972. William Perry Durning: Geology and Mineralization of Little Hills Mines Area, Northern Santa Catalina Mountains, Pinal County, Arizona; MS, 91 p.
1972. Sue Ann Reid: Microfauna from Selected Pennsylvanian (Naco) Sections in South-Central Arizona; MS, 299 p.
1973. Kenneth Walter Bladh: The Clay Mineralogy of Selected Fault Gouges; MS, 70 p.
1973. John Douglas Chakarun: Geology, Mineralization, and Alteration of the Jhus Canyon Area, Cochise County, Arizona; MS, 89 p.
1973. Constance Nuss Dodge: An Analysis and Comparison of Pebbles from the Chinle and Morrison Formations, Arizona and New Mexico; MS, 49 p.
1973. John Milton Van Fleet: Geomorphology of the Box Canyon Drainage Basin, Santa Rita Mountains, Pima County, Arizona; MS, 47 p.

College of Mines

1972. Calvin C. Brown: Geologic Influence on Blasting; M.S.
1972. David A. Hastings: Analysis of Geophysical Data from the Point of Pines Area, San Carlos Indian Reservation, Arizona; MS.
1972. Abdellatiff A. Qahwash: An Electrical Resistivity Survey in the Avra Valley, Pima County, Arizona; M.S.
1972. James P. Savely: Orientation and Engineering Properties of Jointing in the Sierrita Pit, Arizona; MS.
1972. Ronald J. Tanunbaum: Geological Engineering Survey of the Tucson Basin, Pima County, Arizona; MS.
1973. Yousef M. Massanat: Compressibility and Rebound Characteristics of Compacted Clays; Ph.D.
1973. Somchai Kurupakorn: Preliminary Investigation of Upper Sabino Canyon Dam, Pima County, Arizona; MS.
1974. Richard V. Wyman: The Relationship of Ore Exploration Targets to Regional Structure in the Lake Mead Metallogenic Province; Ph.D.

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OTHER NEW PUBLICATIONS

1974. Geology of Northern Arizona, (with Notes on Archaeology and Paleoclimate); For Geological Society of America Meeting, Flagstaff.
Part 1. Regional Studies.
Part 2. Area Studies and Field Guides

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1. Selected Paleozoic Stratigraphic Sections in Arizona, by Edward A. Koester. Includes an index map of localities as well as a booklet itemizing the locations, authors, and units measured. Available for $1.75.
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3. The commission has issued a supplement to Arizona Bureau of Mines Bulletin 185 "Arizona Well Information." It is Titled: "Arizona Well Information – Supplement I," and was compiled by James R. Scurlock.

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THE GEOLOGY OF GRAND CANYON AND A GEOLOGIC MAP OF GRAND CANYON

A softcover book of over 200 pages on the **GEOLOGY OF GRAND CANYON** will be available in June 1974. This book covers the Grand Canyon from the Precambrian to the Cenozoic with articles by E. D. McKee, C. B. Hunt, Trevor D. Ford, Peter Huntoon, W. K. Hamblin, Edwin H. Colbert, Edwin H. Brown, R. S. Babcock, George Billingsley and others. Cost $5.00 + .25c postage.

Also, a new geologic map of the Grand Canyon will be available around October 1974. This map is on the scale of 1:48,000 and will replace the outdated map of the canyon. $3.00 + .50c postage.

Both of these will be published by the Museum of Northern Arizona and the Grand Canyon Natural History Association.

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1957. "Geology of the Southwestern San Juan Basin," New Mexico Hardbound - 198 p. price $3.50.
1959. M. Dane Picard: "Isopach Relations, late Pennsylvanian, Aneth Area, Utah." price $1.50.
1963. "Shelf Carbonates of the Paradox Basin." price $10.00
1969. "Geology of Natural History of the Grand Canyon Region - Powell Centennial," Hardbound - 212 pages includes color printed geologic map of Grand Canyon. price $12.50.
1971. "Geology of Canyonlands and Cataract Canyon, Utah," Softbound - 89 p. price $4.00.
1973. Memoir: "Cretaceous and Tertiary Rocks of the Southern Colorado Plateau," Hardbound - 218 p. price $14.00.

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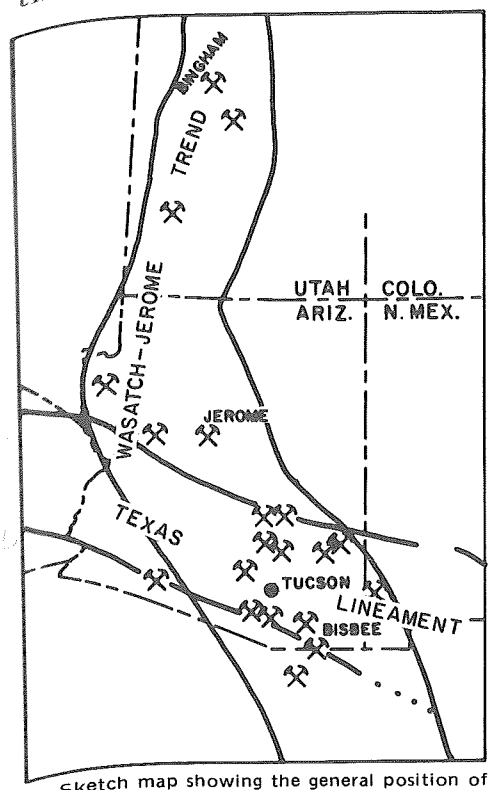
U.S. Geological Survey: Recently published U.S.G.S. Bulletin 1394-A, entitled "Changes in Stratigraphic Nomenclature by the U.S. Geological Survey, 1972," includes a chapter that should be of interest to Arizona geologists desirous of keeping up with

Tertiary stratigraphic developments. The item, by Krieger, Cornåll, and Banks, is: "Big Dome Formation and revised Tertiary stratigraphy in the Ray - San Manuel area, Arizona." It contains helpful illustrations and includes results of K-Ar age dating. Price $1.00 from, **Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.**

MINERALS EXPLORATION *Continued*

such as the Texas Lineament or the Wasatch-Jerome Trend. Areas of former mining or heavy prospecting are telltale indicators of possible potential. From these areas we can for the present

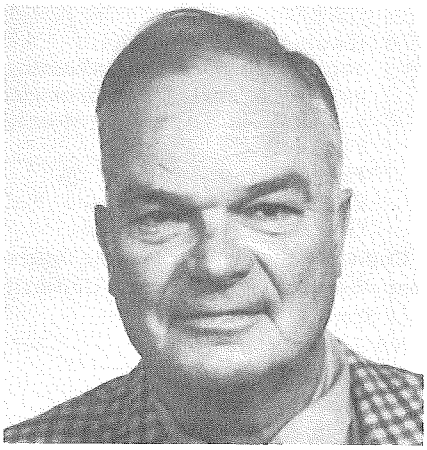


Sketch map showing the general position of the "Texas Lineament," and the "Jerome-Wasatch Trend" in Arizona. Most of Arizona's major copper deposits occur within the boundaries of these two, rather general belts of higher-than-average mineralization.

eliminate certain downfaulted blocks where gravels of a thickness of 3000 to 5000 feet or more mask any possible mineral reserve. Further areas, those of post mineral volcanic cover of excessive thickness, can also be cast out. Also rejected are heavily populated areas and substantial permanent installations such as Kitt Peak Observatory. What remains should be considered favorable mineral hunting ground and care should be taken before removing these lands from exploration by declaring them wilderness, by reserving them for military use, by establishment of parks or recreation areas, or in any manner segregating them from multiple use.

The recent publication of the U.S. Geological Survey, *Potential for Copper Deposits in the Eastern Three-Quarters of the Nogales 2° Quadrangle, Tucson Area, Arizona,* Map I-844-G, illustrates what government agencies can do in the way of commencing the segregation of mineral lands from those less well endowed.

Maintenance of our current standard of living and modern technology requires increasing amounts of metals. We should and we will be required to rely more on domestic supplies. With our increasing population and the resulting land competition, planning for land use is a necessity. Geologic factors are a prime consideration in determining what use should be made of land and obviously are essential in delineating lands prime for mineral exploration. We must plan and we must plan geologically. The Arizona Bureau of Mines should come forward with a proposal for the evaluation and classification of lands within the State – now, before it is too late!



Mr. C. Philip Jenney

Mr. C. Philip Jenney received his professional education at Columbia and Princeton Universities and was employed in mining exploration and development by major mining companies from 1934 until he entered into consulting work in 1955. Since then he has practiced in Arizona and has directed several exploration programs for client companies. Although quite familiar with Arizona ore deposits, Mr. Jenney, who is a Canadian citizen, is able, perhaps, to bring to us the viewpoint of an "outsider."

Fortunately, the crunch of metal shortages is still somewhat ahead of us. We have experienced some of the storm clouds of an energy-shortage that may well be of long duration, but the average American citizen seems to be taking this in stride. The extremist view of the pseudo-environmentalist has come into vogue in the last few years, aided greatly by its extensive exposure in the news media. In all honesty, however, no one wants our air and water polluted; and who, in principal, is not in favor of retaining the original beauty of America intact for the benefit of future generations? But, what a large segment of the public apparently does not realize is that you cannot block the construction of an Alaska pipeline, in order to preserve the beauty of the Alaska tundra, and at the same time continue to consume fuel at an ever-increasing rate; not that is, unless that public can afford to pay the higher prices that will be demanded for foreign raw materials, and to accrue the huge deficits in our balance of trade that will result.

Among the more effective methods of counteracting this trend, is to expand our exploration efforts at home and, thus, develop our own sources of these critical resources. In this light, it is well-known that Arizona, and particularly the southeastern portion of the State, is one of the few places on earth so richly endowed with copper mineralization. During the past 20 years the rate of discovery in this area of minable copper deposits has been extremely high, and most exploration geologists agree that many additional copper deposits remain to be found. Most of these discoveries, however, will be at ever-increasing depths, and will be "blind," that is, they will be found concealed under various thicknesses of cover. Thus, greater geologic expertise and the increased application of numerous, sophisticated sensing devices will be required to locate them.

In developing the geologic expertise and the various "sensing" devices, there are several fields of research in which government agencies could be of particular assistance:

1. The development of more detailed geologic maps delimiting potential mineral-bearing areas, with particular emphasis on determining the thickness of alluvial material that might be found to cover potentially mineralized bed-rock. These are the areas in which explorationists are going to have to concentrate future search efforts.

2. Funding of research projects, for example, in drilling technology. The diamond drill is still the most important tool in the mineral explorationist's bag of tricks. Costs are skyrocketing and very few improvements have been made in recent years. Examples of areas in which new developments are needed include:

   a. The design of more-portable equipment. Each year, more rugged and inaccessible terrain is encountered in the search for mineral deposits, and lighter

equipment, which could be moved by helicopter, for example, would eliminate the need for access roads.

b. Development of methods to increase core recovery.

c. Development of a method of down-hole bit changing. This could appreciably cut the time and effort spent on any one hole.

The biggest hurdles, however, that the geologist will be required to surmount are those resulting from his competition for the use of land. These include:

1. The withdrawal of large blocks of public domain from multiple use, including mineral entry, for such uses as wilderness and primitive areas, recreation areas, and military testing grounds.

2. Ever-increasing urban development.

3. Restrictive tax laws. House Bill 2104 recently submitted in Arizona, if passed, would have seriously restricted the development of copper deposits on State land. This Bill among other things, provided for a royalty on copper production from State lands of 1 percent of the gross value of the ore for each 0.1 percent of the copper content of the ore.* Very few copper exploration companies would consider an exploration program on such terms. However, it would have been no more restrictive than the present exploration rules in British Columbia, where the recently elected government has established escalated royalties based on the price of copper, and "windfall" profits. In British Columbia, *after* you have spent your millions on discovering and developing a large copper deposit, the Minister of Mines will decide what taxes you will pay on the operation. As a result, there is practically no current exploration in British Columbia and it will probably be years before the governing body of the province finds out why no new mines are coming into production.

Another impediment to the work of the explorationist, is that people presently residing in an area of discovery (whether original settlers or their descendants) are sensitive about their rights, relative to those of outsiders, to the mineral wealth that might exist beneath their surface holdings, even though their title may not include mineral rights. The fact that they and their ancestors have lived on the surface covering these minerals for several generations without discovering or exploiting the minerals, usually has little effect on their thinking.

*It should be pointed out that the State Land Commissioner, who is charged with managing all State trust lands, although favoring a royalty based on gross value, was strongly opposed to the specific formula contained in H.B. 2104. R.T.M.

In summation, if we can have an intelligent Land Use classification, arrived at by cooperation of all groups interested in sensible land-use, with as little disturbance of the environment as possible, we can continue to have the quality of life that we have had in the past, and hope to have in the future. If we continue fighting for our own individual, and often selfish interests, we may well end up with chaos.

Mr. Kenyon Richard

The following article was written by Mr. Kenyon Richard who for the past 6½ years has practiced as a consulting geologist in the fields of mineral exploration and mine development. The major part of his consulting work has been in foreign locals, principally Peru, Australia, the Philippines, Equador, and Canada. He is no stranger to Arizona, however. After receiving his professional education from the University of Nevada, he searched for and studied Arizona's mineral deposits extensively during 22 years of association with the American Smelting and Refining Company. Important copper deposits in Arizona with which he was connected include Silverbell, Mission, Sacaton, and North San Xavier.

Among other things, I have been asked to comment on decision-making factors, land priorities, field techniques and possible governmental projects – all as affecting exploration land-use.

The collisions in recent years among land-users are caused mostly by lack of understanding of relative *values* of different land-*uses,* by ignorance of existing laws, by inequities of certain old laws due to the then unforeseeableness of modern conditions, possibly by the expediency apparent in some of the newer legislation enacted, and lastly, because land use collisions usually involve extremists. In this context an extremist is one with an exaggerated, selfish, and limited viewpoint. Usually he is vociferous and thus fair game for the news media.

Though somewhat personalized – that is, "slanted," as are most other journalistic pieces – the following definitions may be informative because they impinge on philosophies of land-use and techniques of exploration. Also, they will in themselves answer some of the original questions posed:

An **orebody** is a mass of rock, large or small, containing valuable minerals which can be extracted at a reasonable profit after the costs of such items as exploration, capital, mining, and taxation, among others, have been met. These costs currently are quite large.

A **reasonable profit** is zero for the marxist, perhaps 2 percent for the socialist and 10 percent for the industrial entrepreneur; this latter figure is about the return on investment realized by most major mining companies. Incidentally, 10 percent is not sinful, it *is* sinful, however, to put money and brains to work for less.

A **mineral deposit** is an accident in nature which has resulted in an unusually high accumulation of certain valuable elements in one tiny place in the earth's crust. There are millions of mineral deposits but only a very few of them contain, or constitute orebodies. This fact is not realized by many politicians, many jurists, many mining investors, most prospectors, and practically all other people who have no direct knowledge of exploration. Actually, all exploration philosophies and techniques have a common purpose: sorting the orebodies from the mineral deposits. This requires lots of elbow room in the sense of land-use classification.

The term **mineralization** is so common, and has so many subtleties and shades of meaning, that even old pros in the mining business at times confuse one another in its usage. There are a great many areas of rocks which can be loosely termed mineralized but which have no obvious value under foreseeable commercial conditions. The mining geologist should be free to walk around, to look over these areas unimpeded, and to run geophysical surveys in order to separate the valuable from the less probable areas of mineralization.

A **geologist** studies rocks. There are about a million kinds of rocks but only about a thousand kinds of geologists. Very few of them even claim to understand mineral deposits.

A **mining engineer** digs rock.

A **mining geologist** "really digs" altered and mineralized rocks.

A **prospector** digs everything. He is a rock-hound with great energy, an innate sense of geology but a sanguine imagination.

The **rank-amateur prospector** is a masochist as well as a hazard to relatives and friends. He is set for self-destruct. He often blows his entire bank-roll and credit on a completely worthless mineral deposit, disdaining professional advice; he is completely unaware of the extremely high ratio between insignificant mineral deposits and orebodies.

Some **mining promoters** may use unethical tactics on occasion, but rarely are any of them outright dishonest. Sometimes the mining promotor acquires mineral rights of shaky legality, without really intending to explore or develop. Usually, though, he contributes importantly to the mining business. Most often the mining promoter is a necessary entrepreneur, whether with formal technical training or not.

A **mine manager** makes a reasonable profit or he is dead. He is unpopular with everyone because he is tough. Remember, though, he is the man who produces the metals without which *no* civilization of *any* kind could exist.

Explorationist is a new, but good term. The explorationist is a combination of engineer, mining geologist, financier, administrator, lawyer, land-use expert, and many other things. Actualy, he is the real pro in the mining exploration business. He has been around long enough to have made a lot of valuable mistakes – valuable, that is, inasmuch as he is not about to make the same ones again.

A **land-use planner** tries to draw lines on maps delimiting each land-use. Because all land-uses in Arizona are expanding, he is faced with an ever-increasing dilemma of devising map symbols to represent the multiplicities of land-use.

An **environmentalist** is an amateur ecologist with an evangelistic desire to maintain all untouched nature as his personal preserve. He spends most of his time enjoying the materialistic benefits of civilization but is quite immune to explanations about what makes civilization function if such includes, say, cutting a road through his favorite untouched campsite, hunting ground, or scenic attraction in order to reach a drillsite needed to maintain the validity of a group of claims covering a mineral discovery.

An **ecologist** is a real expert about all aspects of nature. He is well-informed and very well-intentioned. Unfortunately, the death of his first guppy was so traumatic that he tends to forget that a million species have already died out, and new ones are developing and flourishing daily.

Decision-making seldom involves a choice, say, of which one of several prospects should be drilled and which factors are most important in choosing. Rather, *all* easily recognizable pertinent aspects of a particular prospect are first studied. If it seems worth additional attention, *then* you try to get money for the work. If money is spent and the further study shows things still to be favorable, you go after more money; and so on. Each prospect is different. There are no set rules that I use in determining which factors – geology, history, mining method, metal price, or whatever – take precedent. When large programs are budget-controlled, it may seem that choices are made depending on some customarily favorite factors. Basically, however, this is not true, according to my experience. Top management often gets into budgetary pinches which restrict the amount of exploration they can undertake at a particular time. However, the *real* reasons for cutting back or eliminating certain projects and favoring others rarely filter down through their organizations or out through the industry.

For me, it is quite impossible broadly to draw lines around specific areas in Arizona and say that these, and only these, should be open for mineral exploration. Nor, am I able to draw lines around the most favorable exploration areas. New geologic ideas and new industrial imperatives continually and unexpectedly arise. For these reasons, prospecting and preliminary exploration should be excluded only from within existing city limits, and the existing boundaries of parks and monuments. Further, any future contemplated changes in these boundaries should be subject to public hearing at which explorationists may state their case before the appropriate legislative and/or executive bodies of government – city, county, state, federal – prior to any changes being made, whether by new laws or by executive regulations.

There has been some effort to provide legislative "protection" for suburban land-*holders* against incursion by prospectors and explorationists. Such laws would have to be written very carefully, if at all, for two reasons:

(1) There should be no opportunity for indiscriminate and/or inexpensive acquisition of a mineral right by a house-holder just because he has a surface right and a house, or by a promotor who wishes to obtain mineral rights cheaply by building a crude shack. The reason for this is simply. An orebody is more valuable to society, manifold, than a house, or, for that matter, it can be more valuable than a whole town or city.

An astronaut recently expressed amazement when he realized that the portions of the earth actually inhabited and being used by people constitute such small spots. Usually there are, or were, technological reasons for this, such as easy water supply, a good natural port, or a good climate, or the coincidental close occurrence of orebodies, for example of iron ore, coal, and limestone for cheap steel-making, which, incidentally, got the United States started on its way to becoming a world power. The real reason now, however, is that people like to cluster. They tend to go from farm to hamlet to town to city to metropolis to megalopolis. Reversals of this trend have been miniscule in number. As recognized for decades by logical sociologists, this mass transfer usually is done for illogical reasons, and it upsets many sensible sociological principles. But it really raises hob with land-use programming. Good land-use laws are enacted to fit existing local conditions. People then start moving around willy-nilly, and soon the land-use laws become obsolete. That is one of Arizona's major dilemmas: How to provide for the influx of people, and at the same time not destroy its basic mining industry – and attendant exploration programs – which pays such a big chunk of the taxes which support the services demanded by the newly arriving people.

(2) The old-time prospector and mining engineer stayed up in the mountains with his mines. Now, however, the mining exploration companies have moved down into the flat country and are searching for – and occasionally finding, although at great expense and long odds – large orebodies beneath covering gravels and, incidentally, beneath potential home sites. These activities of necessity impinge on farmers and home owners because the explorationists need elbow room of two kinds. First, depending on the nature of the basic geologic theory involved, a lot of room is needed for the "search" phase. Second, he needs some kind of title (not perpetual, but long enough to out last depression-caused shut-downs) to a smaller area of ground which contains the orebody, and upon which he can place his plant and dumps.

Elbow room, type one, may include from one to a dozen square miles and need involve only a temporary "right." The State mineral leasing laws are pretty well written in this regard, but the Federal Mining Act of 1872 is quite inappropriate. Even most mining people dislike the major parts of the Federal laws. For many years tremendous legal and legislative efforts have been made to change these laws equitably; all have been unsuccessful. There are two factors contributing to this impasse: One, the law of 1872 was one of several measures intended to populate the West and it did

just that. For good measure, it also installed a very tough breed – the weak ones having died of over-exertion – which is extremely reluctant to see any change in the mining laws. Two, it provides a means for gaining land title in perpetuity. This is unfair; any isolated group of mining claims should not be "holdable" without significant production for more than a couple of decades. However, this second factor seems to be the principal hangup of the lawyers and legislators working on these revisions.

Probably the most controversial aspect, however, of the Federal and State mining laws and regulations, are those specifying location and assessment work. Compliance entails building roads for access and cutting pits and drillsites for location and assessment requirements. This work usually can be done circumspectly, and, due to valid complaints in recent years by ecologists and environmentalists, it usually is now being done in careful manner. However, for nearly a hundred years the prospectors and the environmentalists rarely collided because there was ample room for all, and as a result, mining claim work was done carelessly. Too, the modern amateur prospector in his excitement often goes tearing around heedlessly, making a mess with a bulldozer. In contrast, the environmentalist tends to be too sensitive to every little scratch in the desert, and the home owner has an imperfect understanding of his rights. These collisions are so complex that it seems they cannot be cured by enforceable legislation. The holder of a small surface right or, say, a Taylor Grazing lease should get specific legal advice about the *limitations* of his "rights" before setting up operations. The environmentalist should back away from his extremist's position. He cannot have civilization and all outdoors both. To keep his "indoors" functioning he must relinquish some of his "outdoors." On the other hand, the prospector and the mining geologist must use their "rights" with consideration. In fact, they should do *more*. Even though not required to do so by law, they should on purely moral grounds make efforts to "clean and restore" after abandoning an exploration area. Most large open pit mines simply cannot be restored or cleaned up, but to many people views of Bingham Canyon and Morenci are both spectacular and beautiful. I noticed recently that a popular tourist motel in Silver City had give-away maps to the overlook of the Santa Rita open pit, but no maps were on hand showing roads into the quite beautiful back country there.

It has been asked what could be done by government agencies to help delimit potential mineral bearing areas. First, I do not believe there should be an effort to *delimit*. In actuality, the increasing ratio of cost vs. success is already pretty self-limiting, and will get more so. The functions of government should be directed toward narrowing the exploration targets within large mineral-bearing areas. (Maybe this is only a difference in word choice, not intent).

I have one particular suggestion. The otherwise excellent State Geologic Map

Ray Manley Commercial Photography, Inc.

Open Pit, Morenci Branch, Phelps Dodge Corporation. The Morenci mine has produced over 3.5 million tons of copper since the pit was opened in 1937. In order to produce that copper it was necessary to excavate over 1.3 billion tons of ore and waste rock. The actual area of the pit is approximately 1 square mile. **(Photo courtesy of Phelps Dodge Corporation).**

needs to be augmented in two respects. This would be particularly useful both to the explorationist and those who will continue to insist on confirming or excluding mineral exploration:

(1) The stratigraphic separation and statewide correlation of pre- and post-mineral layered volcanic rock sequences should be undertaken. The pre-/post-mineralization temporal boundary should be porphyry copperr alteration-mineralization. Mineralization of other ages and origins seems inconsequential. Because mineralization ages differ from one porphyry copper district to another (Bisbee especially), new field mapping will be tricky; but age dating is proving very useful.

(2) Lines should be mapped around all zones of disseminated or stock-work-veinlet sulphides. Of course, this would mostly be done by the interpretation of the outcrop evidences of original sulphides in the form of cavities, indigenous limonites and boxworks. Ubiquitous, transported, or exotic limonites derived from minerals other than sulphides would be ignored. No distinction should be made as to the abundance, the species, or the origin of the sulphides; nor, should any separation of hydrothermal alteration mineral assemblages be attempted. Where drillhole or underground information is known or reasonably suspected, outlines should be projected beneath cover rocks.

To compile these two features will require new field mapping, but by no means would it entail re-mapping the entire state, at least in the beginning. The new data would be combined with old (the present State Map, Arizona Geological Society Highway map, U.S. Geological Survey publications, company maps, and whatever other data is available). The scale of the maps should be on the order of one inch equals one or two miles and the maps should consist of selected areas of, say 300 square miles. Most would be irregular in shape. County or township boundaries should not be considered as limits. The selected areas would consist of a group of small portions of the state, and probably would not be contiguous.

The map of each small area should be published *as soon* as the field and office material seem reasonably ready, even at the risk that errors of interpretation might be discovered by later fieldwork in nearby areas.

This would be a big project – not something that could be handled by a couple of geologists working part time for a year or two. This kind of information would, however, be of major importance in alleviating those land-use problems which result from conflict between the mineral explorationists and other interests.

SUMMARY

by

Richard T. Moore

A basic premise of these discussions has been an a priori assumption that our society will continue to demand and use the products of the minerals industry. There are, of course, segments of our society that do not hold with this assumption, and they, therefore, would not agree that minerals exploration is a necessary endeavor. However, it is to the remaining portion of our population, and I personally am convinced that this portion represents by far the majority, that the following thoughts are addressed.

Because ore deposits are, as one of the contributors to this discussion has stated, accidents of nature, occurring only in specific locales, and sparingly at that, it is necessary that those deposits be mined where they are found. This may sound like a trite truism, nevertheless it cannot be avoided.

There has been ample evidence in recent years that some of the land administering agencies of our federal government are not interested in whether or not valuable mineral deposits might occur in specific areas under their jurisdiction. The number of wilderness, primitive, and game refuge areas that have been proposed before any evaluation of the lands for mineral character has been made, and all of which exclude mineral entry as one of the multiple uses, gives strong evidence for this.

On this basis, it would seem to me that major efforts should be made to retain as much of our public lands as possible open to mineral exploration, and that the concepts of multiple use should be at the very foundation of any land-use policy and program established for the State of Arizona. Further, in those cases where it is felt that special usages should predominate to the exclusion of other uses, I feel that the mineral potential of such areas should be carefully examined prior to their withdrawal, in order that our society not be denied access to potentially valuable mineral deposits so essential to its continued existence.

FIELD NOTES

Volume 4 No. 2 *June 1974*

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