FIELD NOTES FROM THE ARIZONA BUREAU OF MINES

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COPPER MINING AND ARIZONA LAND USE PLANNING A GEOLOGIST SPEAKS

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Ed. Note: This is the second article in a series on the factors influencing land use planning decision making.

INTRODUCTION

Copper deposits of Southern Arizona constitute a nearly unique resource on this planet. There are few other known locations were the forces and processes of nature combined to form such a concentration of metal in such a restricted region. The great number of discoveries on the Island of Luzon during the past ten years suggest that a small part of the Phillipines are similarly endowed and, although of a different origin, similar concentrations of copper are known in the Democratic Republic of the Congo and in Zambia in south-central Africa. Also, other large deposits of the type found in southern Arizona occur in the western hemisphere, but nowhere are these deposits found in the known abundance and concentration as in this part of the American southwest.

In deciding the best use of the gradually vanishing undeveloped land in the United States, many problems are being created by expanding population and man's requirement for a quality environment. Not the least of these requirements is the requirement for the preservation of certain areas in their natural state. Curiously, concern for the future of mineral resources has not appeared to be a factor in many of these decisions. In Arizona, the problems of land use involve another variable which must be considered: the presence of large bodies of ore. The professional voice of the exploration geologist seems to have been strangely muted while the debate on these decisions continues. Although the debate continues concerning the level of atmospheric contamination acceptable in extracting and processing copper, and heated words are being exchanged between various interest groups about land and mineral law reform in state and national capitals, the knowledgeable citizen hears or reads little, if any, strictly geological information in reports of these debates. He is generally presented statistics of economics and production, and the occasional sweeping generalization that copper deposits occur in the ground and must be mined to extract the metal.

The problems of contamination resulting from processing and extraction are rightfully those of the present, and their consideration is long overdue. Solutions, however, must be in terms which recognize the uniqueness of the known and potential copper occurring in this region. Equally important are the problems of land use and land acquisition. Many known and certainly some as yet undiscovered copper ore bodies exist in southern Arizona; these *must* be considered when land use decisions are being made and before the "system goes critical". Geologic understanding and the role of the professional geologist must no longer be ignored if wise policy is to be made. It should be the duty of the interested policymaker, the lawmaker, and his constituents to acquire, if not an understanding, at least an appreciation of the occurrence and distribution of certain natural resources in Arizona, the United States, the Western Hemisphere, and the world simply because world mineral economics and technology are becoming increasingly important in political decisions. Arizona cannot isolate herself from these broader aspects of mineral resource occurence and use. The decisions and plans which must be made must recognize that a major resource exists which is not only State, but national in scope, and that copper, as well as other metals, occurs only in certain regions and often to the exclusion of other metals.

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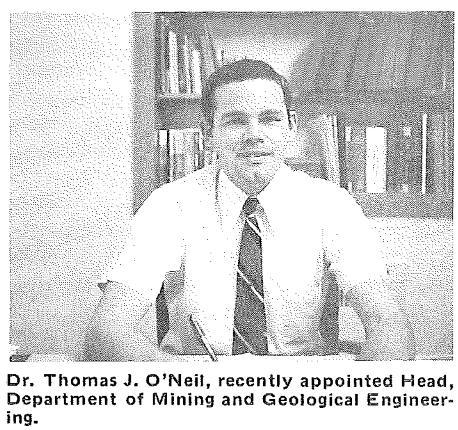
A NOTE FROM THE DIRECTOR:

DEPARTMENT HEAD NAMED

It is my pleasure to announce the appointment of Dr. Thomas J. O'Neil as Head, Department of Mining and Geological Engineering, College of Mines, The University of Arizona.

Dr. O'Neil, who is a specialist in the field of mineral economics, has been a graduate student and full-time faculty member of the Department of Mining and Geological Engineering since 1968. Prior to coming to The University of Arizona, Dr. O'Neil received a B.S. degree in mining engineering from Lehigh University, Bethlehem, Pennsylvania, and an M.S. degree in mining engineering from Pennsylvania State University, University Park, Pennsylvania. He has been a development engineer for Ingersoll-Rand Company, Rock Drill Division, and an industrial engineer for Kennecott Copper Corporation, Utah Copper Division.

Dr. O'Neil has been an active participant in professional society and College activities. He is currently the national secretary of the Mining and Exploration Division of the American Institute of Mining, Metallurgical and Petroleum Engineers, and a registered Professional Mining Engineer in the State of Arizona.



Dr. Thomas J. O'Neil, recently appointed Head, Department of Mining and Geological Engineering.

GEOLOGIST SPEAKS *Continued*

METALLOGENIC PROVINCES AND COPPER DEPOSITS

Most metals which man extracts occur in abundance in discrete (well defined) regions termed *Metallogenic Provinces.* Several metals may occur together in deposits in one region or province *(polymetallic provinces),* or provinces may contain only one metal. The copper deposits of southern Arizona compose a polymetallic province because they also contain as by-products molybdenum, zinc, and some gold and silver. For hundreds or thousands of years man has recognized the discrete nature of the occurrence of metals. However, it has been only during the past decade with the increased number of discoveries that the discrete nature of many provinces has been revealed, and that geological, geophysical, and geochemical data have provided what geologists now consider a firm basis for beginning to understand where and why discrete provinces might occur.

Historically, the recognition of a metallogenic province has had lasting political and economic implications. We are now concerned with the present and future importance of copper in Arizona. Curiously, this region indirectly figured in a major political decision based on concepts of metallogenics nearly 200 years ago. A belief propounded by the Greeks that gold resulted from the interaction of the sun's rays with certain types of fluids in the earth was propagated into the late part of the second millenia. With this belief, Spain concentrated her efforts at conquests in the New World to those regions where the sun's rays were strongest. After several hundred years of fruitless search based on this concept, Spain relinquished all territorial rights in the western hemisphere north of the Gulf of California in the treaty of 1790. (Godwin as cited by Adams, 1938, p. 283). Hopefully, our understanding of the processes of natural concentration of metals has advanced during the past 180 years. Hopefully, also, our growing understanding will aid in the development of policies which will further the clean, intelligent, and wise extraction of those metals which occur in this region, long ago mistakenly ignored by Spain.

There are more than thirty presently known copper deposits in southeastern Arizona and adjoining parts of Mexico and New Mexico. Of these, only ten were being mined in 1953; the remaining 21 deposits represent discoveries or rediscoveries made since then (see Table 1). All but four occur in southeastern Arizona. Not all of these are presently being mined or developed, but it seems certain that most have the potential for ultimate development and extraction. It takes only a simple arithmetic operation to appreciate the fact that since 1953 the rate of discovery in this region has been more than one per year, a record of discovery unparalleled in any other region of comparable size. The fact that these discoveries have been and continue to be made in this small part of the southwest attests to the unusual geologic quality of this region.

Table 1
MAJOR COPPER BODIES IN CONTIGUOUS SOUTHEASTERN ARIZONA, NEW MEXICO, AND SONORA

Producing Prior to 1953

Ajo	
Bisbee	
Castle Dome	
Cananea	
Chino (Santa Rita)	
Copper Cities	
Inspiration	
Magma	
Morenci	
Silver Bell	
	(10)

Production Since 1953

Christmas	
Esperanza	
Mission	
Pima	
Sierrita	
San Manuel	
Twin Buttes	
	(7)

Discoveries and Developments

Copper Creek	
Helvetia	
La Caridad	
Lake Shore	
Kalamazoo	
Poston Butte (Florence)	
Red Mountain	
Rosemont	
Sacaton	
Safford (KCC)	
Safford (P.D.)	
Morenci (Metcalf)	
Tyrone	
Vekol	
	(14)

Producers in northwestern Arizona
(Not Shown on Map)

Mineral Park	
Bagdad	
	(2)
Total	33

Exploration continues in this part of the North American continent because a large number of deposits occur in this region and thus the probability for discovery is certainly higher than in most other parts of the continent, and indeed, in most other parts of the world. The copper bodies which are being sought and which have been found belong for the most part to a distinct genetic type of deposit termed "porphyry copper". Although differing to varying degrees in the details of their geology, most of these deposits are broadly similar to each other in the way they came into being, in the nature in which the rocks containing copper have been modified, and in the amount of copper which they contain. They are correctly termed large, low-grade copper deposits. Despite their "low-grade", however, they represent very anomalous amounts of copper when the earth as a whole is considered.

The amount of copper in the deposits of Arizona is variable but averages between 0.4% and 0.6% (8 to 12 pounds of copper per ton of rock). The processes which act in and below the earth's crust produced this concentration. Parts of some deposits in Arizona have been upgraded to smaller volumes of around 1% copper or 20 pounds of copper per ton of rock by processes which have acted at the surface of the earth in the geologic past by dissolving and re-precipitating this lower grade copper. It is noteworthy that much of this copper has been mined in the past several decades and extraction of copper is now, in large part, that of the lower ore grades. Although of lower grade, the copper in these deposits is still present in amounts of from 8 to 12 pounds per ton of rock. This represents the end product of a natural upgrading of copper from 0.02 pounds per ton in the deep rocks of the earth to 12 pounds per ton in a copper deposit—an enrichment of 600 times the amount of copper present in the deep rocks below the crust! Clearly, unusual processes must have acted to bring this about, and although it is beyond the scope of this article to discuss modern arguments and thoughts about those processes in any detail, it is undeniably true that it has happened, *and only in special places on earth.* Southern Arizona is one such place.

One important aspect of this amount of copper in the rocks of Arizona deposits deserves further comment. This amount of copper, 0.4-0.6%, is the result of a complex sequence of geologic events. Nature has exceeded this level of concentration in only a few copper bodies. Consequently, man has to work with rocks containing this small amount of copper. There is no way to upgrade or increase the amount of copper in these rocks, and we certainly cannot wait the millions of years necessary on the off chance that nature would upgrade it further. It should go without saying that the more copper in a rock, the more valuable it becomes, and those who search for and extract copper would desire nothing better than to find and produce copper from rocks of higher metal content. The fact that copper can be profitably produced from rocks of such low grade is basically a reflection of the necessity to do so but is also testimonial to the quality of man's technology and his imagination in devising low-cost extractive techniques.

Figure 1 shows the location of all operating large copper mines in southeastern Arizona and adjoining parts of New Mexico and the State of Sonora, Mexico. In addition, the map shows other known bodies of copper mineralization of this region that are either prospects where the amount of copper contained can be economically extracted or copper bodies presently undergoing development. Several characteristics of this map deserve comment.

First, the distribution of these mines and mineralized bodies is not erratic. They occur as features of a broad arcuate belt as illustrated in Figure 2. This belt starts near Nacozari, Sonora, and extends from there northwestward into Maricopa County, where it turns eastward, extending across Arizona into southwestern New Mexico. This belt and the copper deposits within and closely adjacent to it ignore county, state, and international boundaries. That more deposits occur in Arizona than in Mexico or New Mexico within the belt may simply reflect the lack of thoroughness with which those adjoining regions have been explored. We do not yet know if copper bodies of the sort which occur in the arcuate belt occur in any great quantity outside of or within the area enclosed by the belt in southern Arizona and adjoining regions, but the possibility is real.

Second, it is noteworthy that the known ore deposits occur as separate bodies of copper mineralization; that is, the bodies are isolated. There is no indication from geology as it is presently known and understood that there is any continuous mineralization by copper in economic quantities in this belt. It *is* significant that in many instances the copper deposits apparently occur in clusters. Such clustering is known in the Sierrita Mountains southwest of Tucson, where at least four separate bodies occur in a restricted area. Other clusters occur in the Globe-Miami area, and there is strong suggestion of clustering in the San Manuel-Copper Creek region, as well as in the group of deposits near Safford. Exploration is far from complete in and around many of the deposits of the region, but when it has been completed, it is likely that presently known bodies in many parts of the belt will be revealed to have been parts of a cluster of copper ore bodies. Reasons for the clustering are not known, but it is an important aspect of our knowledge of the nature of occurrence of copper bodies not only in this region but others as well.

Third, the ore deposits shown on the map reflect, with only one possible exception, the position of *old* mining districts. This in itself is a potentially valuable tool in land zoning decisions. Up to this time all the copper bodies except for the one at Sacaton reflect the results of thorough and sometimes deep exploration of some areas where mineralization was already

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Fig. 1. Map showing principal copper mines, development, and prospects in the Southwestern Copper Province.

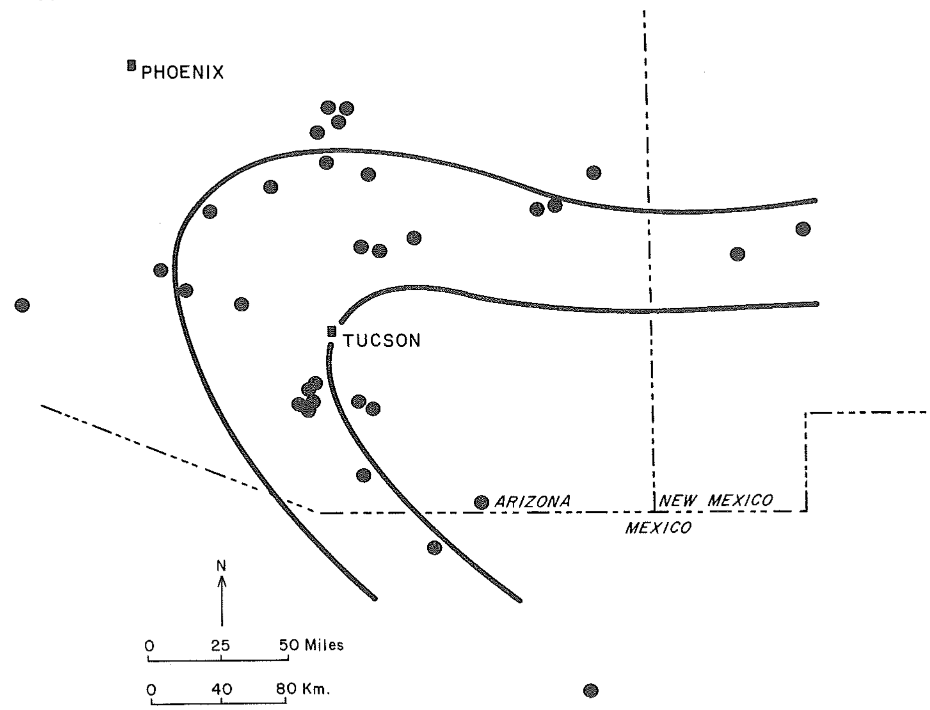
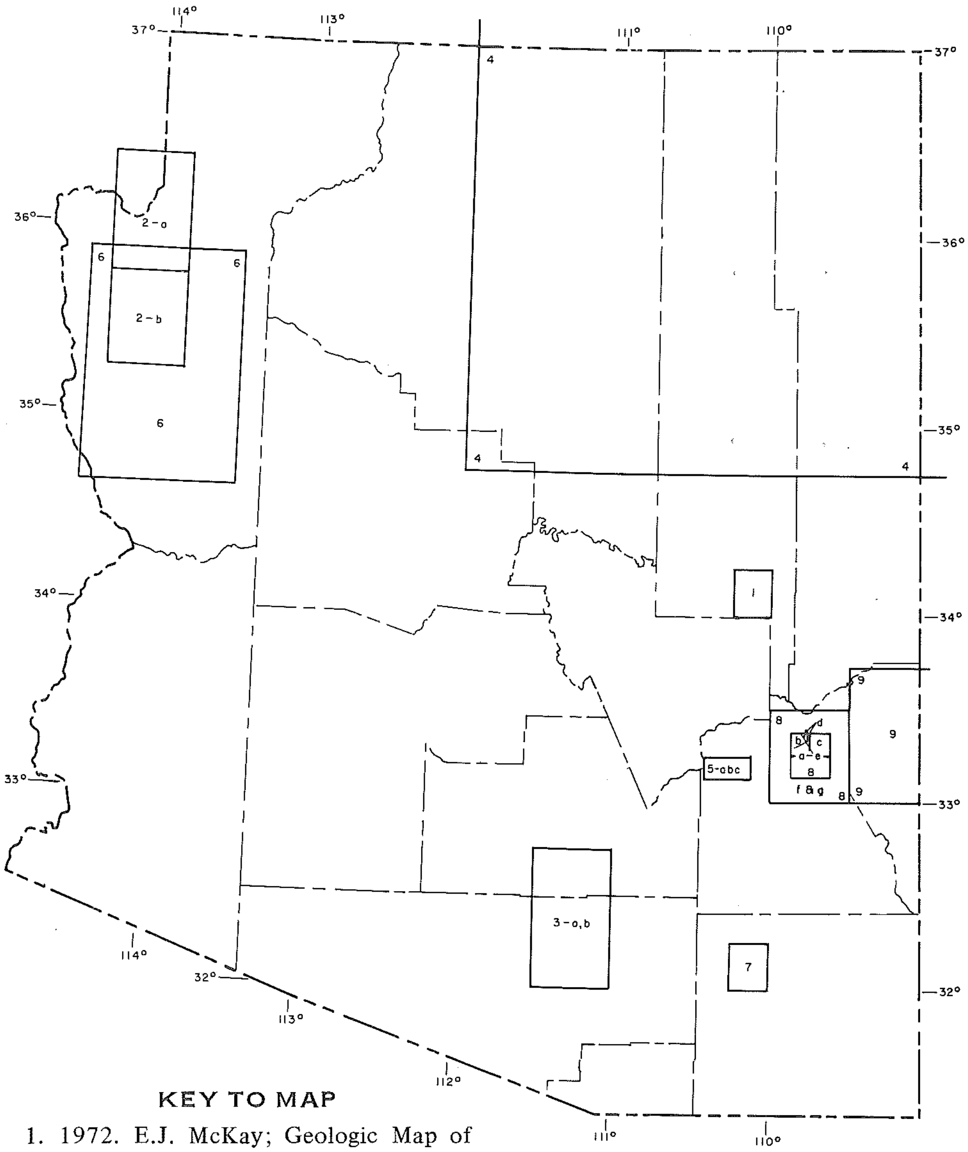


Fig. 2. Provisional geologic boundaries of the southwestern copper deposits.

NEW GEOLOGIC AND AEROMAGNETIC MAPS OF ARIZONA



KEY TO MAP

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8. 1972. C.S. Bromfield, G.P. Eaton, D.L. Peterson, and J.C. Ratte; Geological and Geophysical Investigations of an Apollo 9 Photo Anomaly Near Point of Pines, Arizona: U.S.G.S. Open File Report.
   (a) Fig. 1. Reconnaissance Geologic Map, Point of Pines Region, San Carlos Indian Reservation, Arizona: scale 1:62,500.
   (b) Fig. 2. Geologic Map of the Point of Pines West Quadrangle, San Carlos Indian Reservation, Arizona: scale 1:24,000.
   (c) Fig. 3. Geologic Map of the Point of Pines East Quadrangle, San Carlos Indian Reservation, Arizona: scale 1:24,000.
   (d) Fig. 4. Geologic Sections, Point of Pines East and Point of Pines West Quadrangles, San Carlos Indian Reservation, Arizona: scale 1:24,000.
   (e) Fig. 5. Structure Map Point of Pines Region, San Carlos Indian Reservation, Arizona: scale 1:62,500.
   (f) Fig. 6. Complete Bouguer Gravity Map of the Point of Pines Region, Arizona: scale 1:62,500.
   (g) Fig. 7. Preliminary Aeromagnetic Map of Point of Pines, Arizona 1970: scale 1:62,500.
9. 1972. U.S. Geological Survey; Aeromagnetic Map of the Morenci-Monticello Area, Southeastern Arizona and Southwestern New Mexico: U.S.G.S. map series GP-838, scale 1:250,000.

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THE UNIVERSITY OF ARIZONA

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E.J. Baldwin, (1971 Ph.D.); Environments of Deposition of the Moenkope Formation in North-Central Arizona: 208 pp.

K.L. Bladh, (1972 MS); Petrology of Oleary Peak Volcanics, Coconino County, Arizona: 129 pp.

D.W. Blake, (1971 MS); Geology, Alteration and Mineralization of the San Juan Mine Area, Graham County, Arizona: 85 pp.

R.D. Champney, (1971 Ph.D.); Study of Geologic Structures by Paleomagnetic Methods: 100 pp.

R.K. Corbett, (1972 MS); A Method for Obtaining X-Ray "Powder Photographs" from Single Crystals: 52 pp.

T.J. Evans, (1971 MS); A Stratigraphic Study of the Toroweap Formation (Permian) Between Sycamore and Oak Creek Canyon, Arizona: 111 pp.

A.S. Gottesfeld, (1971 MS); Paleoecology of the Chinle Formation in the Petrified Forest National Park, Arizona: 87 pp.

F.T. Graybeal, (1972 Ph.D.); The Partition of Trace Elements Among Coexisting Minerals in Some Laramide Intrusive Rocks in Arizona: 220 pp.

J.A. Harrison, (1972 MS); The Mammals of the Wolf Ranch Local Fauna, St. David Formation, Cochise County, Arizona: 81 pp.

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R.C. Moores, III, (1972 MS); The Geology and Ore Deposits of a Portion of the Harshaw District, Santa Cruz County, Arizona: 98 pp.

E.A. Schmidt, (1971 Ph.D.); A Structural Investigation of the Northern Tortilla Mountains, Pinal County, Arizona: 248 pp.

GEOLOGIST SPEAKS *Continued*

known. The fact that one was found at Sacaton, apparently unrelated to previously recognized mineralization, however, is a fair portent of the future course of exploration and discovery of copper bodies in the arcuate belt. In some instances, old mining districts hold a high probability of having a deeply buried "heart" of copper ore somewhere near them, *but* there is also a high probability of discovery within the arcuate belt of copper deposits which have not yet revealed their presence in any way now recognizable.

Fourth, the arcuate belt of porphyry copper deposits is a belt of deposits of only one age and one type. Not included in this belt are copper deposits of other ages such as those at Bisbee, Ithaca Peak, near Kingman, and Bagdad. These deposits, together with a host of smaller base and precious metal deposits, occur within and near the area of the belt. Thus, the position of the belt as now defined should not be construed as the final outline of the position of known porphyry copper deposits. As discoveries increase in other parts of the region, it may be possible to better define the factors controling the location of other porphyry copper deposits in the areas adjoining the arcuate belt. The arcuate belt *is* an area in which the probability of discovering additional copper deposits of one age and type is very high. The areas adjoining the belt still manifest a good probability of at least some as yet undiscovered copper bodies occuring because of the presence within the area surrounded by the belt of Bisbee, and the presence of Ajo, Ithaca Peak, and Bagdad outside of it.

Finally, most of the copper deposits of southeastern Arizona occur in a region that once was the shallow shelf of an ancient sedimentary basin, although we cannot say for certain why they should be there, or if indeed there is any direct relationship. The basin, which extended through what is now most of Cochise County and into Sonora and Chihuahua Mexico, is no longer recognizable as such

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THE YOUNGER SET

The staff of the Arizona Bureau of Mines attempts to fulfill speaking requests, especially at schools. Among those asked to speak on a variety of geological subjects are David D. Rabb, Mining Engineer; Robert T. O'Haire, Associate Mineralogist, and Wes Peirce, Geologist, whose approach is to take along materials for the children to touch, taste, smell, hold, and see. The following thank-you letters were among those received by Dr. Peirce from members of Miss Jean Hansen's 4th grade class at Jefferson Park Elementary School in Tucson.

Tucson Ariz
November 3, 1972

Dear Dr. Peirce
Thank you for coming
I enjoyed it a lot. I like the
halite rock the very best.
The antelope was very interesting
How many teeth does a mammoth
have? Why is the rock
in the valley softer than the rock
in the mountains? How do you get
the halite rock out of the ground
How do you tell how old it
is?

Sincerely Brandt

A GOOD QUESTION ALWAYS PRECEDES A GOOD ANSWER. KEEP UP THE GOOD WORK, BRANDT.

Toucson Ariz.
October 16, 1972

Dear Dr. Peirce,

We all thank you for coming.
We all had different reasons to thank you for coming.
My reason was I enjoyed being with you.
I have always liked fossels.
One reason was I like to see how the rock formed around the animals or leaf.
I had never seen a real fossil until you showed me them.
My Mother and Father did not believe that I had eaten something 200, Milloin years old and had held a Milloin fosles in my hand

Gratefully yours,
Karen Elizabeth Martin.

EVEN MOMS AND DADS CAN STILL LEARN, SO BE PATIENT WITH THEM.

Tucson, Az.
Oct. 16, 1972

Dear Dr. Peirce,

I enjoyed your visit very much.
I had never known anything about fossils until you came to our school. I loved the mammoth tooth you brought. And I remembered that I tasted something over 200,000,000 years old and that I held something with over 1,000,000 fossils in it. I really enjoyed your visit.

Very Gratefully,
Abby Wina

DR. PEIRCE CONGRATULATES ABBY AND KAREN FOR CORRECTLY REMEMBERING SUCH BIG NUMBERS!

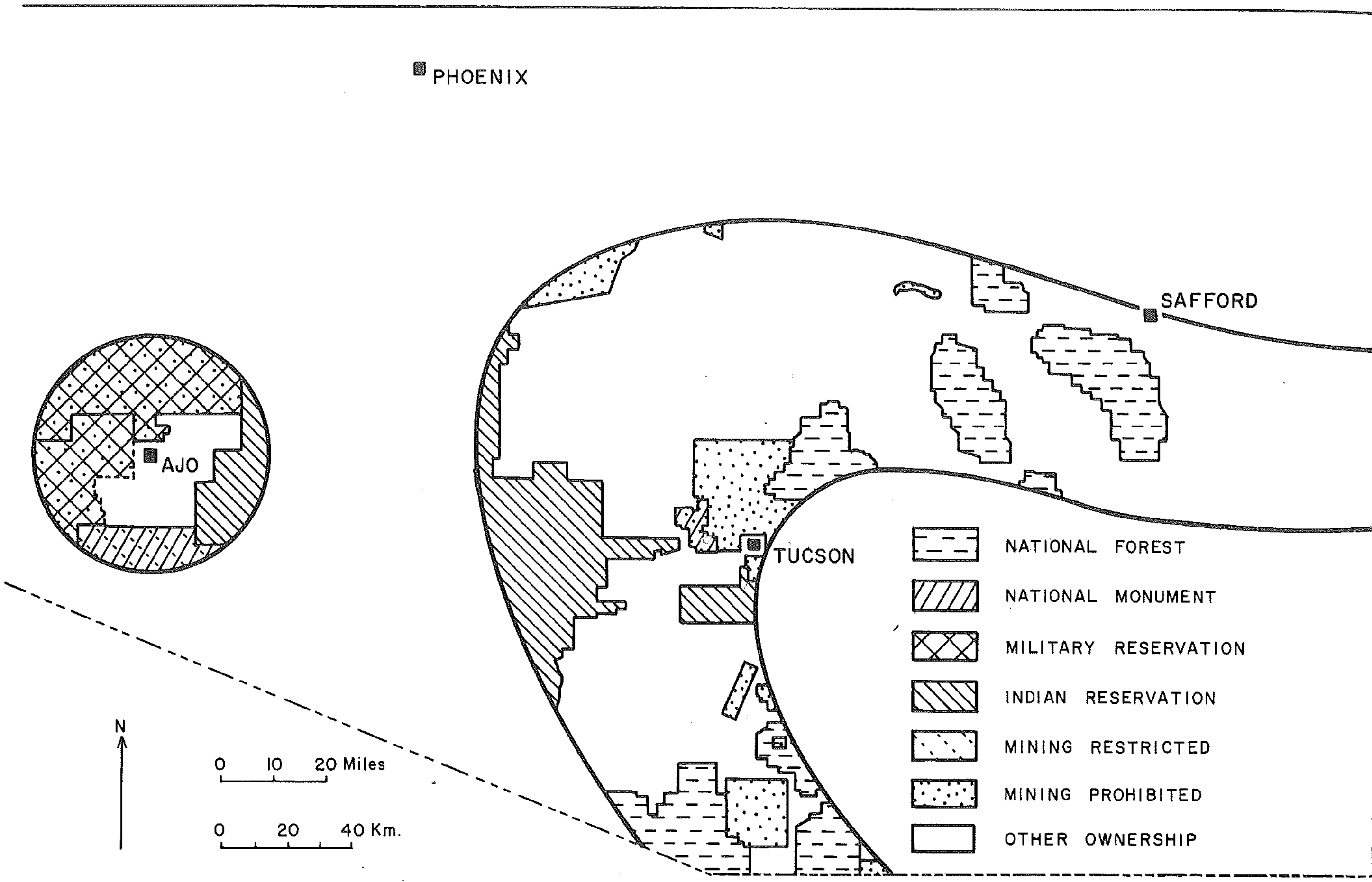

Fig. 3. Land ownership status within the Southwestern Copper Province and in the vicinity of Ajo (modified from land status map in Reference 2).

GEOLOGIST SPEAKS *Continued*

but is interpreted with a high degree of certainty from the distribution and thickness of rocks which formed in it. At about the end of the age of dinosaurs, the basin edge was the site of the evolution of a great number of volcanos. It was by these volcanic processes, which lasted about 15 million years, with their buried chambers of copper-bearing molten rock serving as a source, that nature formed the copper deposits of southern Arizona. Evidence for this is rather good—we can see the volcanic rocks near and about many of the deposits of southeastern Arizona, we can determine that they are of about the correct age to be related to the copper deposits, and in many places they contain copper mineralization. Where we see clusters of copper deposits, we are probably seeing the now-cooled granitic rock hearts of a cluster of ancient, long-gone volcanos.

Therefore, the arcuate belt containing the copper deposits can not only be drawn simply by including most of the known deposits of this region in the complete absence of geological knowledge, but also, it can be described in terms of lines grossly identifiable with rocks whose geologic importance is recognized.

LAND STATUS

The preceding discussion has been a summary of much geologic thought by many who have studied these deposits for a long time. There is not total agreement on certain concepts of genesis or formation of the deposits, but there is general concurrence that a large number of deposits occur here. Intense exploration underway here now attests to the general belief that more exist than have been found. There *is* a region in southeastern Arizona where, in comparison with most other regions on earth, the probability of finding copper deposits is very high. This *fact* leads to a consideration of the distribution of various types of land and land ownership in Southern Arizona.

Figure 3 is a base map outlining those areas with differing regulations governing mining. The gross outline of the arcuate belt of copper deposits in southeastern Arizona has been superimposed. As can be observed, the land types within the belt include virtually all types of lands set aside or recognized for some special purpose. Indian reservations, national forests, areas of definite mining prohibition, game and special ranges, and national monuments as well as a variety of public and privately held lands compose the varied ownership, and reflect the diverse nature of regulations governing or prohibiting land acquisition for mining purposes. The small scale of the map precludes showing a great amount of detail but this information may be gained from a study of the larger scale state publications (2). What is significant about this map and its superimposed geologic information is the great diversity of ways in which land is already designated for purposes other than extraction of mineral resources in a region now recognized as having an unusual and unique potential for copper mineralization.

SUMMARY

Regarding land status and potential ultimate use in southern Arizona, in my opinion the following comments and questions merit more than passing consideration *now*, in the early 1970's.

This nation, bounteously endowed with mineral resources and mineral wealth, seems always to have taken them for granted. So long as land was plentiful in the West, there seemed no reason to consider them otherwise. With few exceptions, when designating the status

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THE NEW AMERICA OF THE YEAR 2000 A.D.

The following is an interview with Dr. W.H. Dresher by KTUC Radio Station, Tucson, on May 30, 1972.

Dr. William H. Dresher,

Dr. Dresher, You were telling me earlier about "The Second America". What do you mean by this?

A number of recent events have caused us to realize that the United States isn't as healthy as it should be in providing for the material needs of its people—the recent repatriation of American interests in the copper mines of Chile, our recent reliance on the Soviet Union for chrome ore for use in our manufacture of stainless steel, our total dependence on Latin American countries for bauxite for manufacture of aluminum, and the growing list of other mineral imports required for American industry. These realizations coupled with the fact that Americans are still growing in number and our average standard of living is still increasing has caused our planners in Washington to become increasingly concerned. Dr. Vincent McKelvey, Director of the United States Geological Survey, coined the phrase, "The Second America" to emphasize the fact that, to satisfy the needs of our people, we must essentially double the physical resources of the United States between now and the year 2000. What Dr. McKelvey is saying is that we must duplicate the Nation's "entire physical plant"—replace obsolete and worn out highways, automobiles, buildings, communications systems, power plants, etc. as well as provide new facilities to accommodate the people who will be here by the year 2000 in an amount which will essentially double all of the production which we have accomplished to date—and we have only about 28 years to accomplish this if our standard of living is not to be severely reduced!

This is a startling realization. Why are we just now hearing of this?

This really isn't new. After W.W. II, a government study group—The Paley Commission—warned of this; however, we chose to establish our material priorities around defense and space accomplishments rather than around establishing a secure basis for the needs of our people. The Korean War, Sputnick, and the Vietnam War have diverted our attention from these issues. However, the fact remains that since 1948 we have *tripled* our consumption of energy—heat and electricity—per capita and with it the material goods which we consume so that today we have the highest standard of living in the entire world *but* we have the poorest prospects for maintaining it. As a nation, we are 5% of the World's population, occupy 7% of its land area, and consume 30% of its mineral and energy output. Yet, we do not have rich resources of minerals and fuels within our boundaries.

This is indeed an accomplishment for us, but isn't this a little unfair to the rest of the world?

This, of course, is the argument of the Environmentalists and the Conservationists and, to some extent, they are correct. We *are* using more of the World's goods than we deserve! Yet, who among us is willing to give up what he already has? Except for war time restrictions, we have never had to step back in our standard of living. You and I can certainly hold the line where we are. But that isn't the real problem before us. The problem is how to bring those "have nots" among us up to what you and I have. How do we provide for *these* people over the next 25 years? As for the rest of the world, the developing nations are beginning to emerge. This is one reason why our mineral imports are being restricted. These countries must develop their own manufacturing industry if they are going to catch up to us. They would prefer to sell us manufactured goods than raw materials and by doing so strengthen their own economy.

Wouldn't importation of finished goods be the answer to our problems? This would help us and help the developing nations.

Only partially, for we cannot afford to allow our domestic industry to become weakened. Last year was the first year we have had a deficit in foreign payments since 1894. We must balance our payments or face unemployment and deprivation ourselves. The deficit was partially caused by the 8 *billion* dollar shortage of U.S. mineral production. By the year 2000, this shortage is projected to reach 64 billion dollars—a cause for great concern. The steel industry has already been forced to lay off nearly 13,000 men with the permanent shut down of Jones and Laughlin Steel Corp., Bethlehem Steel Corp., and U.S. Steel Corp. facilities. President Nixon recently asked the major European countries and Japan to limit their exports of steel to this country for the next 3 years to help alleviate this problem. Our problems are just beginning. A serious recession could result if our domestic industry is not kept strong.

What seems to be the answer to these problems? What are we to do about them?

The answers are not simple. However, positive steps are being taken. *First,* the Congress of the United States passed an act, The Mining and Minerals industry in the United States, one which will operate through private enterprise with a minimum of Federal control. *Second,* the President has established a commission—The Natural Materials Policy Commission—to report to him by June, 1973 on a recommended course of action. This Commission is now in operation and considering several facets of the problem. *Third,* steps are being taken to improve our technology. Regardless of the outcome of any decision-making, one thing is clear: we must increase our level of sophistication and proficiency in providing raw materials for our manufacturing industry. The reasons for this are twofold: (1) increased domestic production of power and minerals could mean increased pollution, and we cannot tolerate any deterioration in our environmental quality in achieving our goals, and (2) domestic ores are plentiful but too low in grade to economically compete in the world market by the use of conventional technology. Therefore, the Senate and, last week, the House of Representatives in Washington, have now both passed bills to aid in mineral industry education and to establish mineral technology research centers in every state. The College of Mines of the University of Arizona expects to play a major role in the training of young men and women for the minerals industry and in the development of improved technology, both of which are

Continued on page 10

YEAR 2000 *Continued*

required to meet the challenge ahead of us in meeting the needs of "The Second America". Our young people have a challenge which has been unequalled in history . . . the challenge of assuring a quality life for every American while preserving our environment and our natural resources. For, if the solutions to the problems we have been discussing are to be found, they must be found during the working life of these young men and women.

GEOLOGIST SPEAKS *Continued*

of lands, their characteristic as specifically mineral-bearing or of high mineral potential has received little attention. With no intent to suggest that any special formal status be given southern Arizona and her known and potential copper resources, can we perhaps now at least recognize that there exists here a unique planetary resource? And cannot this recognition be "factored" into future decisions regarding all sorts of land use planning?

There has been an indifference towards the way the land has been spoiled in not only the extraction of mineral resources but sometimes the search for them. This indifference has resulted from our mineral wealth and the immense land in which to search for them. Public pressure and the recognition of some sort of problem have led to steps to improve this situation. We need only look to the future of the development of additional copper in this region, however, to gain some idea of the immense nature of the potential and continuing problems that extraction and processing will bring to the State.

It is perhaps a major understatement to say that the problems posed by the present and potential incompatibility of extraction and processing on one hand, and urban growth and maintenance of environmental quality on the other, are challenging. They are like no others known on earth at this time. It is fair to say, however, that the first steps towards their solution will come from an awareness of their existence on the part of the citizenry, state policymakers, and industry.

Do we not now, then, have a two-fold obligation, first, to recognize the value to Arizona and to the nation of the unique copper resource that is Arizona's and, second, to recognize the need *now* for imaginative planning for development of that resource with a minimum of environmental and esthetical impact? Problems are solved by cooperation. They cannot be solved by completely ignoring their existence, or by ignoring them until they have reached a point where their solution is attended by emotion and a lack of cooperation rather than reason.

Primarily, should we not now be considering the potential impact of sharply increasing demands on copper by present and developing technologically-oriented nations and its influence on Arizona copper during the next two decades or longer? Should it not now be possible to begin considering the problem in its entirety rather than the piecemeal fashion which is now and has been the pattern of the past? Is it not time to begin to consider the potential overall problems and take the first steps toward some wise policies and decisions?

Shouldn't we *now* become aware of the potential impact of the ultimate development and exploitation of most of the copper bodies known today over the next 15 years, and the continuing impact of the discovery and development of bodies not yet known? Are we undertaking any research now on the best ways to minimize this impact? Not to my knowledge.

Long range problems exist which we cannot yet even define. But for the present, could we not ask some specific questions? For example, should we not now be planning for the eventuality of development of copper bodies where the arcuate belt crosses the Tucson-Phoenix corridor? Already discoveries encroach upon the path of planned urbanization.

Is it too soon to consider the possibility of a "consolidated" smelting center in Arizona, developed and built by the producers of copper well away from areas of potential urbanization where, through present and developing techniques of low-pollution level processing, Arizona can ultimately derive the economic benefits from the processing of copper and its associated metals?

With a view toward maintenance of the esthetical qualities of the region and lowered extractive costs for ores, should we not now begin to recognize the advantages of certain methods of mining by underground breakage of certain types of orebodies and subsequent leaching of copper—or even extraction of copper by methods as yet unknown? And should we not be seeking the counsel of ground-water hydrologists on this problem. And is it not time for the federal government to become aware of the fact that major research and "breakthroughs" in extractive processes, not only for copper but for other resources as well, are sorely needed in the national good?

Should we not now adopt an extremely cautious attitude in acts which modify land status in this region through either zoning or withdrawal for some special purpose which result in restrictions and prohibitions on exploration and ultimate development of any mineral-bearing or untested lands in these mineralized regions of Arizona? And should not this same caution apply to other parts of the United States where we can identify metallogenic provinces of the other metals and minerals necessary to our well being?

On an international basis, should we not be considering these same problems with our neighbors to the south in Mexico? Prevailing southeasterly winds do not portend well for the Tucson or Phoenix region in the likely event more copper is discovered and processed in the arcuate belt south of the international border. We must again remember the Metallogenic Provinces are not aware of county, state, or national boundaries.

Finally, is it not time for far-seeing leaders to begin evolving far-seeing plans to accommodate the total resources of this region? There are few places on earth at this time where the juxtaposition of so many potentially incompatible activities have the potential for mismanagement and conflict. Given the proper education, the proper cooperation, and the ability to evolve the proper policies *before* the problems become critical, Arizona may be able to have her cake and eat it too!

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(1) Adams, F.D., 1938, BIRTH AND DEVELOPMENT OF THE GEOLOGICAL SCIENCES: Dover, New York.

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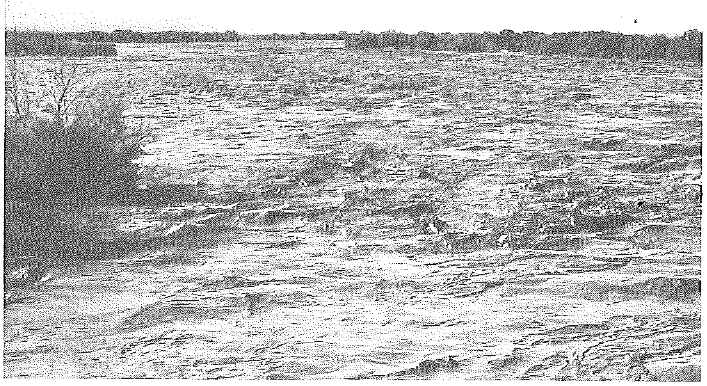
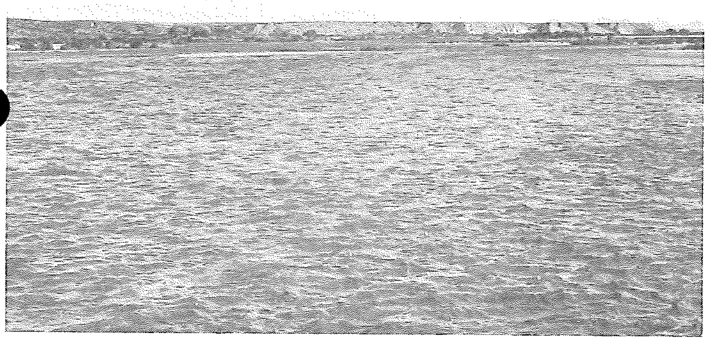
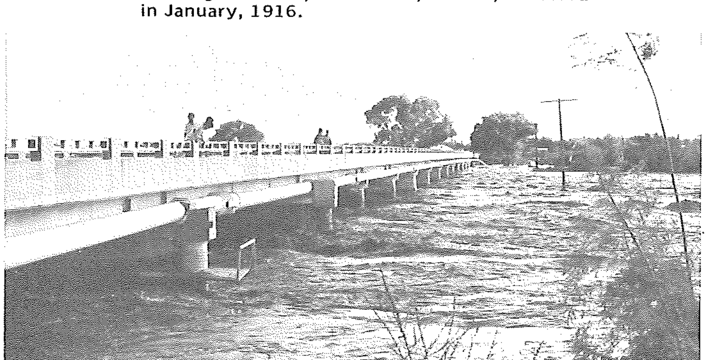
THE MIGHTY MISSISSIPPI? – NO – THE NORMALLY DRY GILA – DOING WHAT COMES NATURALLY

(H.W. Peirce pictures – Oct. 20, 1972)

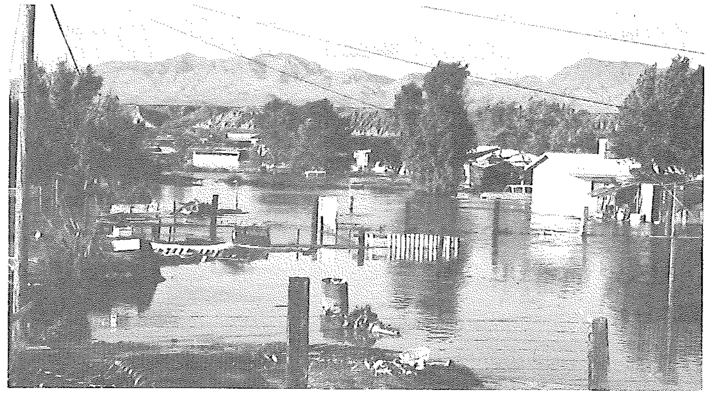




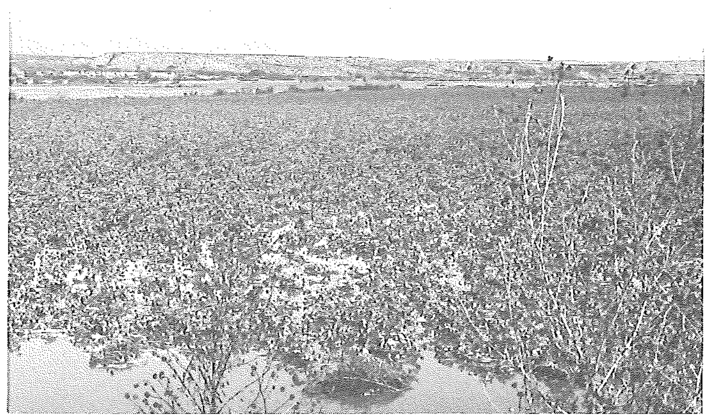
GILA RIVER FLOW AT SAFFORD, ARIZONA—NEAR FLOOD CREST
The U.S. Geological Survey, Tucson, estimates the peak flow at about 70,000 cfs (cubic feet per second). This is reported to be the highest flow since records began in 1914. The highest flow, about 100,000 cfs, occurred in January, 1916.



AS GOES THE BRIDGE SO GOES SAFFORD'S WATER SUPPLY (PIPE).



THE GILA FINDS ANOTHER CONFLICT ON ITS FLOODPLAIN.
The much photographed lowland community of Little Hollywood near Safford. It might be fair to say that a high river and a low community combined to produce these results.



THE GILA FINDS A CONFLICT ON ITS FLOODPLAIN—COTTON.
Whether floods are to be considered constructive or destructive depends upon one's viewpoint. The floodplain, exploited by man the world over, owes its flatness, fertility, and texture to natural processes associated with flooding. A long–range view suggests that floodplains are renewed by repetitive flooding events. Too, one's view would be affected by location, whether above or below a "protecting" dam, in this case Coolidge Dam, which is down-river. River channels are recharge zones for vital groundwater and flow is essential for renewal of water supplies. On balance, the longer ranging view is the more natural. It is possible that temporary crop losses will be made up by enhanced future production because of increased fertility, water supply, leaching of detrimental salts that collect in irrigated fields, etc.

GEOLOGIC HAZARDS —
CONTRIBUTE YOUR OBSERVATIONS

The Arizona Bureau of Mines, in the continuing interest of promoting safety and proper adjustment to geologic circumstances, presented GEOLOGIC HAZARDS AND LAND-USE PLANNING in Vol. 2, No. 3 of FIELDNOTES.

Our stated goal was to help stimulate awareness on the part of individuals searching for residential sites in Arizona. Although emphasis was placed on Tucson examples, the principles involved are widely applicable.

In the interest of gaining additional insight, we are asking you, the reader, and your acquaintances, to help assemble a more comprehensive file on geologically precarious or potentially precarious situations in Arizona.

We also are interested in, besides threats stemming from floods, erosion, rock falls, land slides, slumping, earthquakes, and volcanism, etc., manifestations of minor earth movements that result either in cracks in the ground or in man-made structures. We are especially interested in learning more about residence cracking in Arizona.

If you have a concern, or think that concern should be generated about any of these or other earth phenomena, we invite you to write to us—better sooner than later! Observe and report. Please address correspondence to:

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

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