FIELD NOTES FROM THE ARIZONA BUREAU OF MINES

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EVAPORITE DEVELOPMENTS
THICKEST ANHYDRITE IN THE WORLD?

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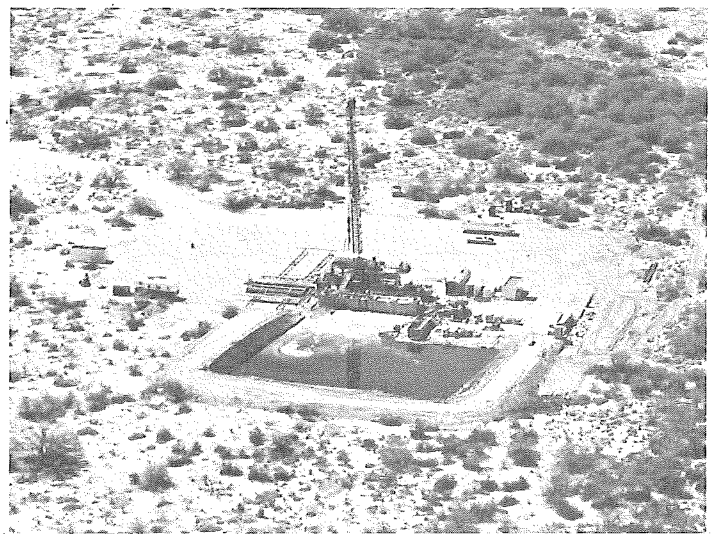
Recently, I delivered a paper, "Halite Masses In The Basin and Range Province, Arizona", at the Fourth International Symposium on Salt held in Houston, Texas, April 9-12, 1973.

Interest in these is high because their geologic history greatly influences the nature of possible associated resources. Salt, like any other rock or mineral, grows or accumulates in response to an environment. Learning about the applicable environment in which these mases grew is a prerequisite to judging the possibilities of there being associated substances of potential economic value. Much of Texas oil is closely related to salt phenomena—salt that originated from the evaporation of large volumes of sea water. On the other hand, the famous California borate (Twenty Mule Team) and brine occurrences (Searles Lake) represent salinity features developed from non-sea waters. Both the Great Salt Lake and Salton Sea represent concentration of salts by the evaporation of continental and not sea waters. The Salton Sea represents evaporation of normal Colorado River water that overflowed in the early 1900's. Repeated overflow and evaporation could result in evaporite accumulation to the point where the basin is filled. Should subsidence continue to create additional basin capacity, then a potential would exist for the build-up of thick primary evaporite deposits.

The two salt masses of current interest occur near Red Lake in Mohave County (see FIELDNOTES, Vol. 2, No. 1, p. 4) and near Luke Air Force Base a few miles northwest of Phoenix (Peirce, 1972). Both masses, being thousands of feet thick, are notable geologic features. Information about them is fragmentary but geologists are trying to piece the story together—sometimes with a healthy contrast in results. A new piece in the puzzle is given below. Exxon recently announced curtailment of their petroleum exploration effort in southern Arizona (FIELDNOTES, Vol. 1, No. 4, p. 6). After extensive geophysical work in selected valleys or basins, they drilled four holes. The first was drilled in Sec. 2, T8S, R8E near Eloy, Pinal County. Previous information had indicated that the here-named *Picacho Basin,* a slightly east of north depression about 30 miles long and 9 miles wide, contained some evaporites in the form of gypsum ($CaSO_4.2H_2O$) and halite (common salt—$NaCl$). Until Exxon's State (74) no hole had completely probed the rock sequence in the basin. Prior to the salt symposium meetings, I contacted an Exxon representative, Mr. Ben Stanley of Midland, Texas, in regard to the possible release of data about this hole. Mr. Stanley called to say that company officials had agreed to release certain data to me and that I was free to release it as I judged fit. These data, recorded below, were presented at the meetings. We wish to thank Exxon for their generous cooperation and Mr. Stanley for his expedition on our behalf.

Exxon's State (74) spudded on June 8, 1972 at a ground elevation of 1580 feet above sea level and terminated on July 14, 1972 at a depth of 10,177 feet. The elevation of the bottom of the hole is 8597 feet below sea level. The generalized section cut is:

DEPTH—FEET	ROCK TYPE
0-660	Sand and gravel
660-2335	Clay, monor gypsum and anhydrite halite 2140-2220
2335-8320	*Anhydrite* ($CaSO_4$), minor shale
8320-9060	Conglomerate
9060-9670	"Basalt"
9670-9880	Conglomerate (pebbles of gneiss)
9880-10177	Gneiss



Exxon's State (74), Pinal County, Arizona.

It is to be emphasized that almost 6,000 feet of anhydrite and but 80 feet of salt were cut. At Luke, the situation is reversed, there being at least 6,000 feet (estimated) of salt overlain by 60 feet (estimated) of anhydrite. It seems quite likely that the thick halite at Luke and the thick anhydrite at Picacho are linked through a closely related geologic history in central southern Arizona.

The Picacho hole is about five miles west of the Picacho Mountains, the southern half of which consists of gneiss (a metamorphic rock), probably of Precambrian age. The highest point on the gneiss is Newman Peak at about 4,508 feet above sea level. The relief on the surface of the gneiss, as determined by this peak and the top of the gneiss in the hole, is 12,808 feet. It is likely that the hole did not penetrate the deepest part of the Picacho Basin.

Mr. Stanley further indicated that the oldest materials above the Precambrian are no older than middle Tertiary and that there is no evidence to suggest that marine strata were penetrated. Although a search of the literature has not been made, he thinks it possible that this sequence of anhydrite might be the thickest yet known in the world.

In a paper given last year (Peirce-1972) I suggested that: (1) salt was formed and positioned in Tertiary time; (2) the salt accumulated in rapidly subsiding closed basins associated with the Basin and Range disturbance; (3) the salt is non-marine and late Tertiary in age; (4) salt is laterally partitioned from thick lacustrine (lake) limestones, thick fine-grained clastics, and possible thick sulfates.

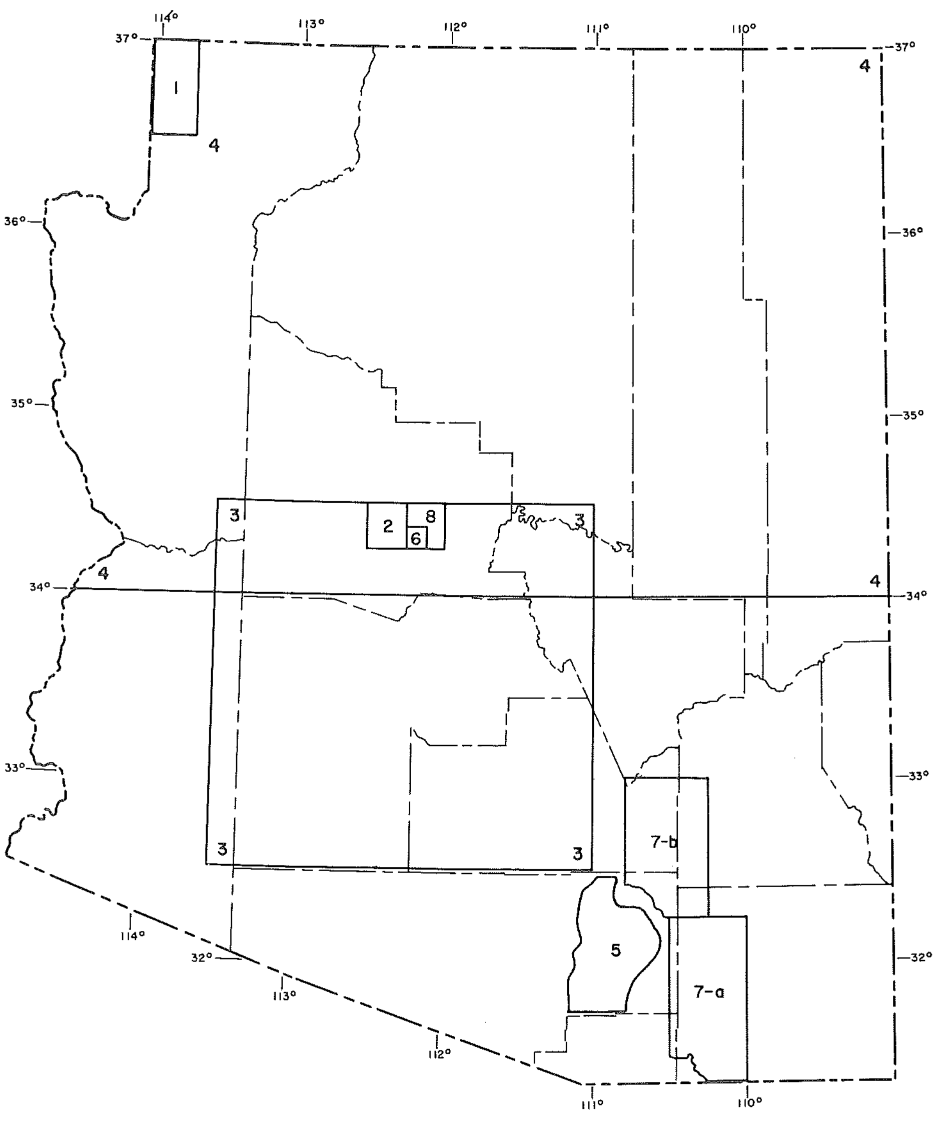
The data thus far obtained from the EXXON Picacho Basin test do not appear to modify these tentative conclusions.

The Red Lake and Luke Salt masses are being evaluated as possible underground storage sites for liquid petroleum products such as butane and propane. Salt in the Permian Supai Formation is already being utilized for this purpose along the Santa Fe Railroad east of Holbrook, Arizona. Caverns are developed by controlled solutioning of salt with water. Also, underground salt deposits are prime candidates for the development of waste disposal facilities. Kansas salt is being studied as a possible national site for the disposal of radio-active wastes.

Future drilling in Arizona will, either by design or accident, likely encounter additional evaporitic materials. Whether the more exotic types exist remains to be determined.

PEIRCE, H.W. (1972), THICK ARIZONA SALT MASSES-AUTOCHTHONOUS? (abs): Arizona Academy of Science, 16th Annual Meeting, Prescott, Arizona P.46/

NEW GEOLOGIC MAPS OF ARIZONA



NOTE

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

KEY TO MAP

1. 1973. R.T. Moore; Geology of the Virgin and Beaverdam Mountains, Arizona: Arizona Bureau of Mines Bulletin 186, 65 p., 24 plates, 7 figures.
2. 1972. C.A. Anderson and P.M. Blacet; Geologic Map of the Mount Union Quadrangle, Yavapai County, Arizona: U.S.G.S. Map GQ-997, scale 1:62,500.
3. 1972. G.P. Eaton, D.L. Peterson, and H.H. Schumann; Geophysical, Geohydrological, and Geochemical Reconnaissance of the Luke Salt Body, Central Arizona: U.S.G.S. Professional Paper 753, 28 p.
4. 1972. J.H. Stewart, F.G. Poole, R.F. Wilson, and others; Stratigraphy and Origin of the Chinle Formation and Related Upper Triassic Strata in the Colorado Plateau Region: U.S.G.S. Professional Paper 690, 336 p., 5 plates.
5. 1972. R.L. Laney; Chemical Quality of the Water in the Tucson Basin, Arizona: U.S.G.S. Water-Supply Paper 1939-D, 46 p., 5 plates.
6. 1972. C.A. Anderson; Precambrian Rocks in the Cordes Area, Yavapai County, Arizona: U.S.G.S. Bulletin 1345, 36 p., 2 plates.

7.a-b 1973. R.H. Roeske and W.L. Werrell; Hydrologic Conditions in the San Pedro River Valley, Arizona, 1971. Prepared by the U.S. Geological Survey in Cooperation with the Arizona Water Commission as "Arizona Water Commission Bulletin 4" 76 p. and 2 plates.

8. 1972. C.A. Anderson and P.M. Blacet; Geologic Map of the Mayer Quadrangle, Yavapai County, Arizona: U.S.G.S. Map GQ-996, scale 1:62,500.

NATION FACES SERIOUS MINERAL RESOURCE PROBLEMS; CHALLENGE TO SCIENCE AND TECHNOLOGY

The Nation's known deposits of mineral raw materials are seriously depleted and future supplies must come from subeconomic deposits or from potential resources yet to be discovered, according to a new report of the U.S. Geological Survey, Department of the Interior.

The report, a comprehensive, 722-page volume, evaluating the Nation's mineral supplies, including more than 60 mineral and energy commodities, stresses that for only a handful of mineral commodities – evaporite salts, gypsum, sulfur, and molybdenum – is the Nation in "excellent shape" for the long term. For a few others – asbestos, chromium, fluorine, and mercury – the country has only "scant reserves." For most other mineral commodities, the report emphasizes, our ability to meet projected needs to the end of the century will depend largely on:

* Development and continued application of new methods of finding ore in order to locate geologically available but as yet undiscovered sources,
* Development of new technologies for extraction of lower grade ores,
* Finding sources of energy to make such low-grade extraction feasible,
* Recycling and conservation in mineral production and use, and,
* Imports from foreign sources.

In a Foreword to the report, Secretary of the Interior Rogers C.B. Morton notes that minerals and mineral fuels ". . . are the physical source of most of the necessities, conveniences, and comforts of life in the United States today."

"As a part of our response to the Mining and Mineral Policy Act of 1970," Secretary Morton writes, "the U.S. Geological Survey provides in this volume the first overall assessment of mineral resources since that of the President's Material Policy Commission in 1952. For many minerals, the appraisals are preliminary at best, for not enough is known about their origin, distribution, or the geologic environments favorable for their occurrence to assess their potential now. But at the least, the appraisals represent a beginning, a take-off from which we can expect to enlarge our knowledge of our mineral-resource endowment with advancing science and exploration."

In commenting on the report, Dr. V.E. McKelvey, Director, USGS, said that there are some "sobering" implications to be drawn from our assessments.

"The fact is," McKelvey said, "that the future drain on our mineral supplies will become enormous. Even with a leveling off in growth in per capita consumption, it will be necessary to build a 'second America' within the next three decades in the sense of having to duplicate or replace the physical plant built during all our history. Most of the raw materials needed for constructing such an undertaking will be drawn in

Continued on page 7

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Bartos, F.M.; A Comparison of Ecology of Mountain Sheep.

Bennett, C.M.; Radius Effect of the Alkaline Earths on the Rate of Inversion of Aragonite to Calcite.

Evans, K.R.; Aeromagnetic Study of the Mexicali-Cerro Prieto Geothermal Area.

Hall, D.K.; Hydrothermal Alternation and Mineralization in the East Camp of the Turquoise District, San Bernandino, County, California.

Hampf, A.W.; The Geology of the Golden Rule Mine Area, Cochise County, Arizona.

Jansen, L.J.; Geology of the Sus Picnic Area, Tucson Mountains, Pima County, Arizona.

King, J.E.; Late Pleistocene Biogeography of the Western Missouri Ozarks.

Leventhal, J.S.; Chronology and Correlation of Young Basalts by Uranium-Thorium-Helium Measurements.

Loghry, J.D.; Characteristics of Favorable Capping From Several Southwestern "Porphyry" Copper Deposits.

Sauck, W.A.; Compilation and Preliminary Interpretation of the Arizona Aeromagnetic Map.

South, D.L.; Sulfide Zoning at the Lakeshore Mine, Pinal County, Arizona.

Totten, D.K.; Jr.; Biostratigraphy of Some Late Paleozoic Rocks in the Naco Hills Area Near Bisbee, Arizona.

West, R.E.; A Regional Bouguer Gravity Anomaly Map of Arizona.

Zauderer, J.N.; A Neo Glacial Pollen Record from Osgood Swamp, California.

THESIS ARIZONA STATE UNIVERSITY

1973. Noel B. Collins; Relationship of Black Calcite to Gold and Silver Mineralization in the Sheep Tanks Mining District, Yuma County, Arizona: MS Thesis, January 1973.

1971. Peter George Kokalis; Terraces of the Lower Salt River Valley, Arizona: MS Thesis Sept. 1971.

ISSUES AND DISCUSSION ON NATIONAL SURFACE MINING LEGISLATION

William H. Dresher
Director

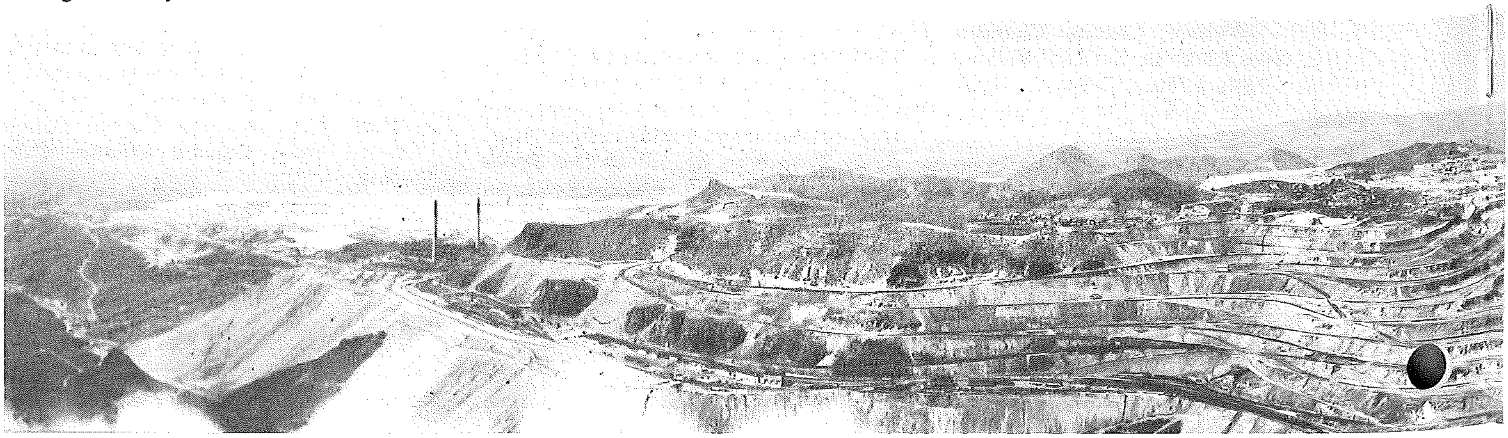
Committees in both the House and the Senate of the Congress of the United States are currently considering legislation which proposes to regulate surface mining activities within the United States in order to prevent or to substantially reduce the adverse environmental effects of mining operations. These bills have encountered a great deal of debate and discussion. A contingency of representatives led by Representative Udall (D.-Ariz.) and Representative Mink (D.-Hawaii) toured Arizona mining operations on May 20, 1973 to study the western, open pit mine aspect of the problem. Industry and government alike have voiced strong opposition to several aspects of the proposed legislation.

Much of the controversy surrounding surface mining (mining by opening the surface of the earth to expose mineral deposits) revolves around the subject of reclamation of the disturbed land once mining operations have ceased. A typical critique of surface mining would have it creating streams "murky with silt and toxic with acid", and "huge, ugly spoil banks, prone to landslide and with little vegetative cover" (LIFE, October 1, 1971). Such an impression, of course, was derived from the uncontrolled contour and auger mining (a form of strip mining used in hilly areas) of the Appalachian mountains. "Augured" areas, unfortunately, have been abandoned in this condition so that their consequences remain yet today in these areas. This impression, has created an impact on the mining industry which will be hard to overcome. This impression has caused legislation to be enacted in 19 of the 22 states in which coal is mined by surface methods and to be proposed in both the House and the Senate in the Congress of the United States for the nation as a whole. The western states of Montana and Wyoming, which have extensive deposits of near-surface coal are particularly apprehensive about having the conditions of the Appalachian mountain region brought to their states by strip mine operators who intend to develop the coal reserves of these states.

Both industry and government have voiced strong reservations to much of the legislation now under consideration. Mr. C.F. Beukema, Vice President, United States Steel Corporation, while speaking on behalf of the American Mining Congress before Senator Jackson's Committee on Interior and Insular Affairs hearing on surface mine legislation on March 14, 1973 said, "*. . . the American Mining Congress supports realistic surface mining regulations, but we believe that they must be realistic with due regard to their effects and consequences and a balancing of public interests.*" The federal government position has been voiced by the Department of the Interior. In his letter to James A. Haley, Chairman, Committee on Interior and Insular Affairs of the House of Representatives dated April 9, 1973, John P. Whitaker, Under-secretary of the Interior, stated, "*A number of legislative proposals before this Committee purport to solve quickly some of the environmental problems associated with surface mining by prohibiting surface mining outright or banning certain mining methods such as contour mining. As attractice as these mesaures might initially appear, easy solutions are often misleading. We believe the environment can be protected without resorting to drastic solutions which would certainly exacerbate the energy crisis facing this nation.*"

We here in Arizona have reason to be concerned both by the effects of surface mining—of which our many copper pits and the Black Mesa coal operation are major examples—and by the effects of the proposed legislation on our surface mining operations. Our concern must stem from the preservation of the beauty of the State and the quality of its environment as well as with the preservation of its economic base and quality of life. Let us look into some of the factors surrounding this issue.

First, on the national scene, surface mining in the entire history of the United States has disturbed only 0.177 percent of the land, and at least a third of that land has been judged reclaimed by the U.S. Department of the Interior. By comparison, urban areas covered 0.3 percent of the nation's land in 1965 and 49.6 percent of the U.S. in 1965 was considered to be agricultural land. Our nation's mines and our farms are the mainstay of our economy and are necessary for the continuance of our civilization as we know it. Mineral-derived products are essential to maintain our present society. Therefore, mining activities must be accomodated in our society.



UNDER PROPOSED LEGISLATION — A POTENTIAL $1-BILLION RECLAMATION PROJECT

Coal and metallic minerals are mined by the use of various forms of surface mining for several very good reasons:

1. Cost – Surface mining costs far less than underground mining. The costs of coal, as well as the costs of metals and minerals reflect in the cost of goods and the cost of living for all of us.
2. Safety – In the past two years, 345 men lost their lives underground, compared to 49 in surface mining, even though the tonnage of rock and mineral removed by surface mining methods far exceeds that removed by underground methods in the U.S.
3. The nature of the orebody – Many mineral deposits, particularly coal, are too close to the surface to permit their removal by tunneling methods because the soil and rock mechanics of the overburden will not support a tunnel roof.
4. Conservation – When the conservation of our nation's mineral resources is considered a factor, which is of increasing concern, surface mining methods can recover 60 percent more of a mineral deposit on an average than could be mined using underground methods.

While surface mining does constitute a major disturbance of land, the mining industry is not ignoring the problem. In 1971, over 81,000 acres were reclaimed by the coal industry. Some 99 percent of the nation's surface mined coal is currently being produced under land reclamation programs. While this reclaimed land is not of "Disneyland quality" (to quote one company official), much of it has been placed into recreational service–a use it was incapable of supporting before mining. The Ohio Power Company, the largest privately owned utility in the U.S., for example, has had a successful reclamation program underway since 1943. Ohio Power plants more than 1½ million trees a year in their reclaimed mining areas. Free campsites and fishing lakes are located through the reforested lands. There are 320 man-made lakes on Ohio Power land which are stocked and managed by the Ohio Division of Wildlife. Approximately 60,000 people visit these recreation areas per year–testimony to the effectiveness of the company's program of rehabilitation of mined land. In Pennsylvania, mined lands have been turned into pasture land and corn fields. The success of this program was recently attested to by William E. Guckert, director of mine reclamation of the Bureau of Land Protection and Reclamation, Department of Environmental Resources, Commonwealth of Pennsylvania. Guckert said before the U.S. Senate Subcommittee on Minerals, Materials and Fuels on November 16, 1971, *"I am no friend of the strip miner, but when they are doing a good job, you have to admire them." "The industry,"* said Charles F. Barber, Chairman of the Board of American Smelting and Refining Company, at a meeting at The University of Arizona on March 14, 1973, *"actually welcomes the establishment of regulations controlling the rehabilitation of strip-mined land."* In his testimony before the Committee on Interior and Insular Affairs on March 14, 1973, Mr. Edwin R. Phelps, president of Peabody Coal Company stated, *"Coal can be recovered by surface mining methods, while at the same time fully protecting our physical environment. Peabody and other responsible coal companies are doing it today."* He continued, saying, *"Last year we graded 9,063 acres and seeded 11,180 acres, while we mined or disturbed 8,577 acres."*

Thus, the evidence is that modern strip mining practice, as operated by conscientous companies, can and does return the land to a condition which is equal or better than that which existed before the mining operation took place. There are numerous examples in the eastern and midwestern states wherein the stripping of the coal from the land was not only of benefit to the fertility of the soil, thus increasing its agricultural yield, but also of significant value to the maintenance of forest lands and wildlife.

What then are the issues in the proposed legislation? The basic issues are:

1) That regulations which are feasible for mining practice in eastern United States, particularly in the Appalachian Mountain Region, have little bearing on the procedures which can be practiced in the arid western states;
2) That the procedures which are feasible for the various aspects of reclamation of land from a *strip-mining* operation have no bearing on what is economically or technically possible on an *open pit* mining operation.
3) That the degree of restriction imposed by the proposed legislation is predicted to impose a severe restriction on the domestic production of fuel and non-fuel minerals, thus intensifying an already critical national problem.

Proposed legislation varies in intensity on this latter issue. One bill, H.R. 1000, all but prohibits surface mining completely. Other bills require extended shutdown until required conditions are met. Some of these requirements are the responsibility of the state and not the companies involved in the mining operation; if the state fails to enact its own legislation within a specified period of time (and some state legislatures only meet every two years), surface mining activity in that state must cease. Some bills require such costly reclamation practices that the cost/benefit ratio will in itself cause surface mining operations to cease. This is of particular importance to open pit mining in Arizona and will be discussed in more detail later.

"Reclamation in the west", according to Dr. Robert R. Curry, Associate Professor of Environmental Geology,

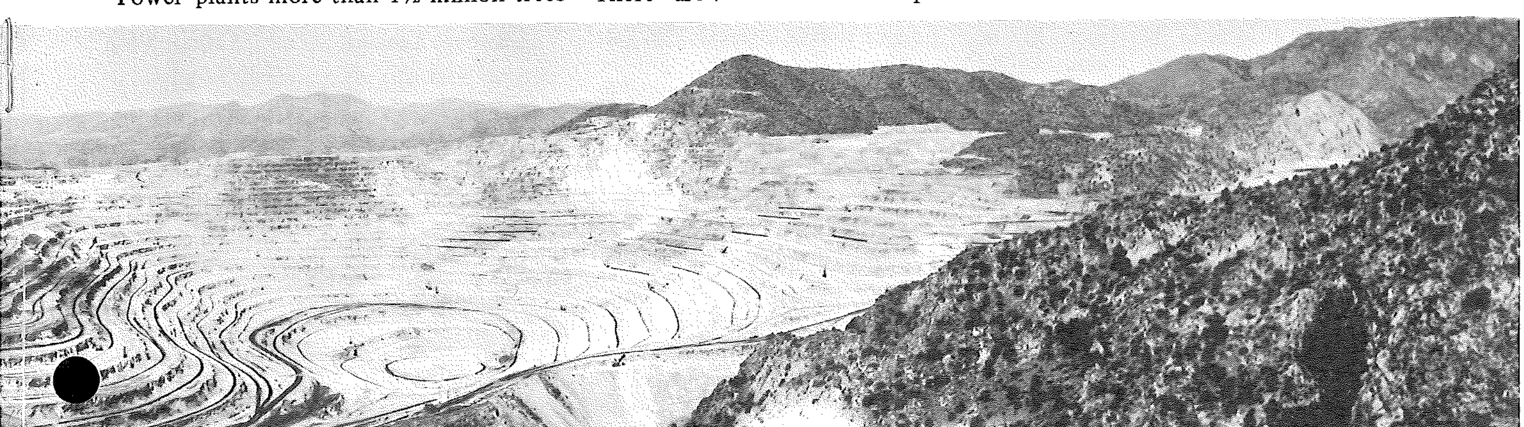


Photo by permission of Phelps Dodge Corporation

University of Montana, *"differs from that in the east primarily because of aridity during at least summer months, and because the ages of the land surfaces in the west are much less than those generally found in the surface-mine areas of the south and east. In the west, the total soil depths (and easterners would not even call much of our plant-supporting media soil) are on the order of inches and zonation of minerals and living plant and animal matter is extreme."* Stockpiling "top soil" and recovering the lands for reclamation in the manner prescribed by proposed legislation may, in some cases, do more harm than good. According to Professor Curry, *"The calcium carbonate layer underlying much arid land soil, if mixed with the nitrogen-rich organic layer, will destroy the biologic carbon-nitrogen balance. Hence, extreme care would be necessary to restore the ground cover to the same vegetative cover and nutrient cycles which were present before the surface was disturbed."* To properly restore the same vegetative cover may involve importation of nutrient materials to the site and, of course, adequate amounts of water to re-establish plant life.

Here in Arizona, the Peabody Coal Company has attracted much attention by its surface mine on the Black Mesa. In his testimony before Senator Jackson's committee on May 14, 1973, Edwin R. Phelps, president of the company said, *"The Black Mesa contains about two million acres; we will mine 400 acres a year for 35 years or a total of 14,000 acres. Grading and reclamation follow close behind the active mining operations. We will restore vegetation to the land. We are seeding not only native grasses but are experimenting with other species which have succeeded in our arid Colorado mines. These may furnish better forage for sheep which are the Indian's main source of income. We are also seeding legumes to add nitrogen to the soil. We want—and we expect—to make the land more useful than it was originally."*

The very great difference between strip mines and open pit mines is the major concern of Arizona mining operators for the proposed legislation. Open pit mining, which is used to extract most hard rock minerals, economically permits the development of otherwise unrecoverable low-grade ores and makes available much larger quantities of essential metals at reasonable costs. As pointed out by John B.M. Place, President and Chief Executive Officer, The Anaconda Company, *"The technology of open pit mining developed in the Western United States changed the mining industry. This method of mineral extraction is the most efficient, productive and safest method of mining known today."* An "indispensable tool in the conservation of mineral resources", open pit mining provides about 90 percent of the nation's production of iron, copper, stone, sand, gravel and phosphates, as well as significant quantities of gold, silver, molybdenum, nickel, and uranium. As open pit mine spreads over a relatively small area, produces enormous quantities of minerals in proportion to the area mined and is often worked for many decades, sequentially providing employment for two or more generations of people.

In contrast, strip mining has a brief but dynamic operation at any one location and can continue for miles in the removal of shallow, well-defined beds of mineral. In 1971, strip mining provided 50 percent of the 276.3 million tons of bituminous (soft) coal mined—of which 73 percent was utilized by electric plants.

Both types of mining have definite places in the mining industry, but as the Montana legislature recognized, they *are* two different types of mines and they therefore require different and separate laws, particularly concerning reclamation.

The cold, hard facts are that for every practical purpose it is financially, if not physically, impossible to reclaim an open pit mine to the extent prescribed by proposed federal legislation. The definition of reclamation according to Edwin R. Phelps, President, Peabody Coal Co., is "to return the land to beneficial use—to yield some other crop or some other benefit after it has yielded its crop of coal." Despite all criticisms of alleged past atrocities perpetrated on the land by strip mining in the coal industry, the truth is that strip mining is in a far better position to conduct complete reclamation than is open pit mining. There is no presently known "beneficial use" for an open pit other than as a source of minerals and as a scenic attraction. Over 25,000 people per year come to view the Phelps Dodge open pit mining operation at Tyrone, New Mexico—more than visit the nearby Gila Wilderness area. The Bingham copper pit of Kennecott Copper has been a major tourist attraction to Salt Lake City for many decades.

The issue of backfilling, as proposed in some legislation, an open pit mine has two aspects—the determination of when and if it is "mined out" and the tremendous cost in dollars, energy and labor involved in the prospective operation. Because of the gradation of values in the rock of most metal mines and the everchanging value of the ore due to world price changes and to technology improvements, an open pit mine is seldom regarded as being "mined out" Some mines are already in their second stage of development. These have progressed from underground workings of high grade ore to open pit workings of low grade ore. This transition was made possible by the development of technology to the point that moving large tonnages, as much as eighty thousand tons of earth per day, became economically feasible. Thus, while the once great copper mine at Jerome, Arizona is closed and that at Bisbee, Arizona is in the process of being closed, these mines cannot be considered to be "mined out". As economics or technology changes they may very well support large mining operations in the future. Restoration of the land contour of these mines to the degree required by Senate Bill 425, for example, would prevent these residual minerals from ever being economically exploited.

The economics alone of backfilling and recontouring a pit the size of the Lavender Pit in Bisbee, Arizona which is currently being phased out of production by Phelps Dodge would be staggeringly prohibitive for any group, company or individual—if indeed it were possible or desirable. And, the Lavender Pit is one of the smaller copper pits in Arizona. To revegetate would involve replacing topsoil—in other words, backfilling on a slightly smaller scale. To recontour the pit to approximately its original contour would be economically impossible and technically unfeasible. Out of curiosity, a number of companies have estimated the costs of backfilling and recontouring an open pit copper mine. Here are the results:

Anaconda	
Butte, Montana; Yerington, Nevada; Twin Buttes, Arizona	**$3-4 billion**
ASARCO	
Mission, Arizona	**$220 million**
Kennecott	
Bingham, Utah	**$7 billion and 66 years at 400,000 tons per day**
Phelps Dodge	
Morenci, Arizona	**$1 billion**
Lavender Pit, Bisbee, Arizona	**$100 million**

The cost effectiveness of rehabilitating an open pit mine to prepare it for the same uses the land was capable of supporting prior to mining is certainly questionable. The expenditure to rehabilitate the Mission mine just south of Tucson, for example, is an amount equivalent to $200,000 per acre of reclaimed land. This is to be contrasted by $800 per acre of land reclaimed after strip mining in West Virginia according to testimony by Representative James Kee on September 20, 1971 before the House Committee on Internal and Insular Affairs. Insofar as land uses in Arizona are concerned, cattle grazing, the state's largest land user, yields but $7.50 per acre per year and crop raising, the second largest user, yields but $230 per acre per year. Neither of these uses could afford land valued at $200,000 per acre if circumstances required the purchase of the land at this price. In other words, the question must be asked: if amounts of money of the magnitude listed above are to be expended by society just to put land back to its original condition, wouldn't it be wiser to spend this same money on projects which are more vitally needed by our society?

Although nearly every porphyry copper mine ever opened in the United States is still in operation, and many are projected to continue production beyond the year 2000, the question remains: How are these areas to be treated after shutdown? The mining industry would value your suggestions on this issue for, unless a reasonable approach is made to this problem, industry leaders warn that every surface mine in Arizona as well as in the rest of the nation will be forced to close.

While there are many people in Arizona who would advocate the closing of mining operations, serious consequences would result to the state as well as to the nation if this were to occur. In 1972 the mining and smelting industry employed nearly 30,000 Arizonans and paid them approximately $280 million in wages and salaries. The State received $55 million in taxes from this industry. In return, the industry produced most of the cement, sand, gravel and stone used in local construction, 54 percent of the copper consumed in the entire United States, worth $914 million and $17 million of gold and silver. In addition, the property owned by mining interests in the State represents 15.4 percent of the total accessed valuation of property in the State. Second only to gas and electric utilities, mining companies have invested $940 million in our state—money in which all of us as direct or indirect shareholders have a concern. Legislation affecting mining operations in Arizona must be of direct concern to each citizen.

RESOURCE PROBLEMS *Continued*

large measure from resources that are now only subeconomic, or not even discovered."

"But the compelling need for minerals is also matched by environmental problems," the Survey Director emphasized, noting that "for many minerals, our future production will depend on the mining of huge volumes of low-grade ores with adverse environmental impact unless we exert great care in their extraction and use."

In describing the potential mineral resources of the Nation, the report emphasizes an important difference between the meaning of the words *resources* and *reserves*, using analogies taken from the field of personal finance: "Mineral reserves, like the cash in one's wallet or bank account, are minerals in presently known deposits that can be mined profitably with existing technology under present economic conditions. Mineral resources, on the other hand, are like one's frozen assets and expected future income. Resources represent a part of the known low-grade deposits from which minerals can be recovered only through advances in technology or increases in price, plus the inferred vast numbers of deposits that have not yet been discovered, but whose presence can be reasonably predicted by geologic inference."

"Resources, thus, are only 'birds in the bush'; it takes research and exploration to bring them into hand," McKelvey said.

Some commodity highlights from the report:

OIL AND GAS: U.S. Oil reserves total about 36.3 billion barrels (33.7 onshore and 2.6 offshore). Reserves of natural-gas liquids total about 6.8 billion barrels. Total potential oil resources, onshore and offshore, for the U.S. are estimated at 2,900 billion barrels. Annual production of oil in the United States in 1972 was 3.3 billion barrels. Natural-gas reserves total 266.1 trillion cubic feet; estimated resources range between 1,178 and 6,600 trillion cubic feet. In 1972, the U.S. consumed 22.5 trillion cubic feet. Presently, the Nation imports 29 percent of its oil and gas requirements. While new source areas in the U.S. have been brought into production through combinations of business enterprise, economic pressures, technologic advances, and exploitation effectiveness, there is considerable room for continuation of this evolutionary advancement in all respects, especially on the continental shelf, much of which is unexplored. It is extremely difficult, however, to envision circumstances which would make the U.S. entirely self-sufficient in oil and gas.

NUCLEAR FUELS–URANIUM AND THORIUM: Domestic resources of uranium recoverable at present prices (totaling about 273,000 tons of U_3O_8) are sufficient to meet anticipated needs into the 1980's. Beyond that, however, needs are so great that tremendous efforts in exploration and research in ore-finding techniques will be required to find new resources. Identified subeconomic resources of uranium in phosphate rocks, black shales, and some igneous rocks are very large (estimated to be about 20 million tons of U_3O_8) but to obtain significant supplies from these resources would require mining and treating vast quantities of rock, disrupting large areas of ground at high unit costs. As for thorium, the current demand is small. However, future needs may be large as a fuel for high-temperature gas-cooled reactors, which are more efficient to operate and produce less thermal pollution. Although thorium resources are not well known because of the small current demand, they are sufficient for many years in the future. Development of a domestic thorium mining industry will depend on a large enough increase in demand to exceed the amount obtainable as byproducts from other types of deposits.

COPPER: Of the 2 million tons of copper used annually in the U.S., about one-half is used in electrical applications, about one-sixth in construction, and one-eighth in industrial machinery. In 1971, the Nation imported only 6 percent of its copper, but known domestic economic resources (76 million tons of copper metal) are adequate for about 45 years at current rates of consumption. Adequate supplies for a longer time or increased rates of consumption must depend on discovery of new deposits and development of extractive methods for very low-grade deposits.

GOLD: The U.S. produces only about 1.8 million ounces of gold a year, representing only about one-third to one-quarter of its needs. About 40 percent of the production is a byproduct from refining of other metals, chiefly copper. It is unlikely that the Nation will become self-sufficient to meet gold needs in the foreseeable future. Production from vast (about 300 million ounces) low-grade resources would require solution of formidable technologlical and legal problems.

MANGANESE: So essential is manganese to the manufacture of steel, that a simple phrase sums up the relationship: "When we can do without steel, we can do without manganese." The U.S. has virtually no domestic reserves. Known resources (960 million tons) are both very low grade and difficult to process. Geologic research might lead to discovery of new high-grade ore deposits in several regions. A promising means of relieving our dependence on foreign sources would be vigorous research to perfect techniques of recovering seafloor nodules, which would also provide a potential "bonus" in copper, cobalt, and nickel.

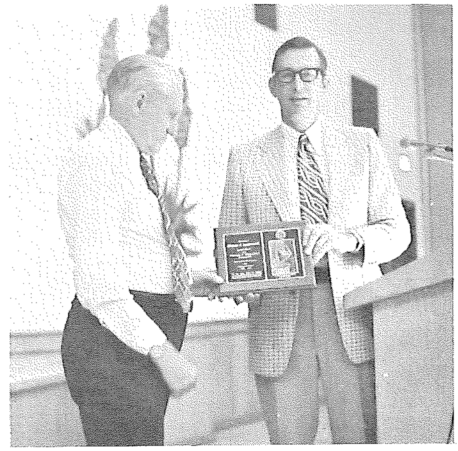
SILVER: This economically critical metal is used domestically at a rate of about 150 million ounces each year. Use in photography alone exceeds our annual production; other important uses are in electrical and electronic products and sterling ware. Of our known silver resources (2.2 billion ounces), almost two-thirds would be recovered as byproducts of mining copper, lead, zinc, and gold deposits. Thus, silver production has been decreased by recent closure of many domestic lead and zinc smelters. Production could be increased by discovery and development of new resources, and increased prices would encourage development of large known potential resources in low grade disseminated deposits (about 2 billion ounces).

A serious aspect of the mineral supply problem, the report points out, is the extent to which many commodity byproducts are literally being wasted because there is no apparent economic incentive for recovering them during ore processing. Some elements go into slurry ponds, some into slags, and some up the flue. Examples of such commodities are vanadium in iron deposits; selenium, tellurium, and gold lost through in-place leaching of copper deposits; fluorine, vanadium, uranium, and rare earths in marine phosphate deposits; cadmium, bismuth, and cobalt in lead ores; and several metals in coal ash.

The report, "United States Mineral Resources," published as USGS Professional Paper 820, consists mainly of chapters written by more than 90 USGS geologists, most of whom have had many years of experience studying the geology of mineral deposits, and more particularly, the commodities about which they have written. Each chapter of the report contains not only a synthesis of the state of knowledge of the geology of the commodity, but also an appraisal of the known resources, and an examination of the geologic possibilities for finding additional deposits.

Copies of USGS Professional Paper 820 (clothbound) may be purchased from the Superintendent of Documents, Government Printing Office, Washington, D.C. 20402 for $9.15 per copy domestic postpaid.

PROMINENT METALLURGIST RETIRES FROM BUREAU OF MINES



George H. Roseveare retiring Bureau Metallurgist, is presented plaque by Dr. W.H. Dresher, Bureau Director, honoring him for his many years of service to the Bureau and the people of Arizona.

George Harrison Roseveare was born in Michigan near the turn of the century but spent his boyhood in Phoenix, graduating from Phoenix Union in 1919. He received his Bachelors Degree in Mining and Metallurgy from the University of Arizona in 1923 and his Masters in 1929.

During World War II, George was part of the Manhattan Project and before he joined the staff of The University of Arizona in 1944, gained a great diversity of metallurgical experience in Mexico, California and Arizona.

As George Argall, Editor, WORLD MINING, wrote, "With the retirement of George Roseveare, the copper industry loses the advice and knowledge of an exceptional copper metallurgist. His contributions to hundreds of small Arizona copper producers have led to the development of many big mines . . ." Further, George established a reputation for experienced knowledge and precise, accurate test work in many metallurgical fields: cyanidation, amalgamation, fluo-solids roasting, special assays, gravity separations, crushing and grinding, and even ceramics; in fact, he was versed in all fields of ore testing, mineral beneficiation and analysis.

In September, after he visits a son and grandchildren in Indonesia, George will continue to be available for metallurgical consulting services.

FIELD NOTES
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