

Technology-The Future of Raw Material Supply

by

William H. Dresher

Director

The production and distribution of raw materials is a problem of global concern — a concern which affects the well-being of people everywhere, the economy and general welfare of all countries. Our problem is how to assure the availability of an adequate supply of raw materials and energy for future needs, in a viable, practical, peaceful, and economically sound manner. By an adequate supply, I mean the amount and kind of materials necessary to satisfy the essential needs of each country's growing population, each country's security and each country's economic health. In fulfilling this objective, we have a mandate from the populace of nearly every developed country to prevent degradation of the environment while providing these materials.

As technologists, we are dedicated to the betterment of mankind through improved technology. In the past, we have been remarkably successful on many fronts — food, medicine, space exploration, to name a few. When challenged, man's ingenuity has been truly phenomenal. In recent years we have slowly developed an awareness of two problems which have been steadily increasing in severity: the world's present energy crisis and its pending mineral crisis. Clearly, no one technology will offer the total solution to these problems.

The Value of Raw Materials

The crust of the earth, together with its seas and its atmosphere, is the source of all of mankind's primary wealth. More and more, wealth is defined in terms of utility — not in terms of an arbitrarily established monetary value. The recent action of the Organization of Petroleum-Exporting Countries (OPEC) in controlling the flow of petroleum has clearly demonstrated this to the petroleum-importing nations!

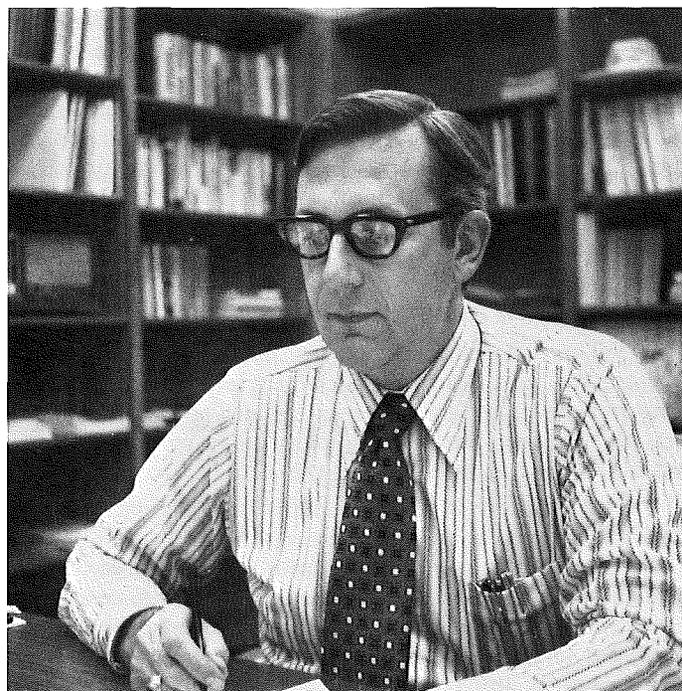
The history and development of mankind can be traced by studying the development of man's ability to use the earth's materials to his advantage — the food and fiber grown upon the earth, the stone and the minerals found within the earth, and even the constituents of the air above the earth. With the discovery of fire over a million years ago, man learned how to modify to his benefit the raw materials he found in nature. The working of clay and of native copper were some of the earliest of man's technologies. Man learned very early that agricultural materials were *renewable*, and he planted crops on an annual basis and raised cattle according to his needs. He also found that other materials were *nonrenewable*, and that he had to seek new sources as he depleted his known supply.

The military conquest of mankind can also be traced to man's needs for material wealth. History documents the importance of

mineral resources, starting with the golden age of Greece that was ushered in by military and political conquests financed largely by the rich silver deposits of Lavrion discovered in 483 B.C., and extending into more recent times to the rapid emergence of the U.S.S.R. as an economic and political power largely due to its vast mineral endowment. Mineral raw materials had an overwhelming effect on the course of European history during the millenium between the fall of the Roman Empire and the discovery of America. The settling of the western United States was largely spurred by the discovery of gold in California in 1848. The interest in developing the mineral resources of the western U.S. was so great that during the first fifty years of its existence, the Department of the Interior was familiarly known as the "Department of the West."

With developing industrialization, demands for raw materials outpaced their availability in many parts of the world. Whereas once explorers were sent out to locate precious metals to fill the coffers of the royalty of their homeland, beginning in the twentieth century geologists were sent to the far corners of the world to assure a supply of raw materials for the industry of their homeland.

Thus, we should realize that raw materials have been basic to manufacturing and service technologies, to national security and



Dr. William H. Dresher

to national and international economics since the beginning of history. We have no reason to believe that this will change.

The Scope of Materials

Today, the world "materials" is almost infinite in its scope of meaning — solids, liquids and gases; metals, glasses and ceramics; organic and inorganic; crystalline or polymeric; natural or manmade. All manufactured products are made of materials. But, the world of materials is so complicated that we have lost track of their origin. In the face of abundance in recent years, we have forgotten that *all* manmade products have their origins as natural materials. They started either as *renewable resources*, or *nonrenewable resources*. All primary raw materials must be derived from the natural resources of our world.

Problems Involving Raw Materials

A concern for the future availability of many industrial raw materials is finally developing. Ore grades are diminishing, concern for the environment has placed restraints on commercial development of some mineral deposits, and countries upon which we have relied for major mineral materials have become increasingly nationalistic, causing uncertainties in future supply. While the severity of the problem has not yet become apparent to most laymen, the relatively minor hardships caused by the petroleum embargo imposed by the OPEC nations have served as a forewarning of things to come. One major aspect of the problem is that many people, in the United States and elsewhere, have generally taken raw materials for granted. Relatively free trade with raw material-producing nations combined with the remarkable resourcefulness of technologists and industrialists has fostered this complacency.

Complacency

If the United States is any example, most people have lost sight of the importance of raw materials in their daily lives. In the two hundred years of the U.S.'s existence, we have moved from a *natural resource-based economy* — the exploitation of soil, timber, and minerals — to a *manufacturing-based economy*, and more recently to a *service-based economy*. But, what is little realized is that the service-economy, the pinnacle of the pyramid, cannot be sustained without a strong foundation; that is, the components of the economy which came first, the resource- and manufacturing-based components. While the essentiality of raw materials to industry is as high as ever, that essentiality has become invisible. Thus, the sudden shortages have come as a rude awakening.

The Endowment Nature of Mineral Resources

Mineral and mineral fuel resources, major components of our raw materials, are a legacy, an endowment left to us by the forces of nature which have operated over millions of years. Sooner or later, at any given level of technology, they will no longer be available for our use at a price we can afford to pay for them. I think it's important to emphasize these last two points — *level of technology* and *price*.

The literal notion of running out of minerals and mineral fuels is ridiculous. The entire planet is composed of minerals. The crustal composition of the earth averages 5 percent iron — an enrichment ten times greater than the average grade of copper ore being mined in the U.S. today! All of the natural gas and petroleum known in the world today constitutes only a small percentage of the known fuel mineral resources. The oceans

themselves contain more mineral valuables than mankind can ever conceivably utilize.

The problem is not one of literally running out of energy and materials, but one of *their availability under conditions which we are willing to accept* — there is a limit to how much money we can afford to pay for them and to the amount of environmental disturbance and atmospheric degradation we can or will tolerate in obtaining and using them. In other words, the problem is one of mineral *reserves*, *not* one of mineral *resources*. Reserves are defined as those resources which can be economically and ecologically obtained by existing technology. Technology thus plays a very important role in the availability of mineral-derived raw materials!

However, while nature has provided an ample supply of mineral and mineral fuel resources in the earth's surface, she has not provided an equal distribution of enriched concentrations of minerals.

Politico-Economics of Mineral Resources

Historically, various regions of the world have been noted for their deposits of economic minerals, and these regions have been subject to exploitation by one method or another since the discovery of their value — either by conquest, colonization, or foreign-owned industrial development. However, growing nationalism of the countries in these mineral-rich regions has caused uncertainty of future supply in the countries which have come to rely on them. Recently, the mineral-rich, lesser-developed nations have served notice in the form of expropriations, nationalizations, and embargoes, on the more developed nations that things are going to be different in the future. While the L.D.C.'s desperately need the development capital and technology which can be provided by the developed countries, they have generally decided that future resource development will be controlled by the host country. Under such control, the prospect is for increased tariffs, and for increased price control by the formation of cartels; both with the intent of maximizing the benefits gained by the host country.

In normal times, cartels have been used quite effectively to stabilize prices and thereby protect the profitability of production and thus production itself. A dangerous condition can arise, however, if tariffs and cartels are used to political advantage. Unfortunately, mineral resources have been, are being, and will continue to be used as the basis for political, economic, and military advantage of one nation over another.

Recent changes in the investment climate in mineral and mineral-fuel producing nations have had a profound effect on the international minerals industry and thus the availability and cost of mineral-derived raw materials. The future in this area is not clear. Restoration of the flow of mineral commodities from these countries is largely dependent upon at least two considerations: the confidence of investors in the political enterprise of the less-developed nations, and the inclination of these nations to develop their mineral endowment for export purposes.

Environmental Nature of Mineral Resources

In recent years, there has been an increasing concern for the degradation of the environment caused by the extraction of minerals from the ground and the processing of their products into manufactured goods. Governments, both local and national, are demanding more and more control of how their land is going to be used and what manufacturing processes may be conducted on that land. Increased population density and mobility, combined with rising incomes in the developed countries of the

world, have pushed to the forefront health and aesthetic issues. All minerals have been affected, from the locally used products of sand and gravel to the exportable products for distant industrial use. Development restrictions and processing requirements incurred for environmental reasons have decreased availability and increased costs of every mineral commodity in commerce.

Increased Demands

The world's demand for mineral-derived raw materials is increasing rapidly. This growth is the result of *both* increased population and increased consumption per capita. Continuing high population growth rates in many countries are a severe threat to the future availability of all raw materials. When these countries are the less-developed countries, the problem is doubly serious. In these countries, the per capita consumption will become much larger as their populace strive for equality with the developed countries (Fig. 1).

Contrary to popular belief, increases in consumption in the developed countries are, for the most part, due to increased population. The per capita use of some commodities has actually dropped in the U.S. (Fig. 2). However, the disparity in the per capita GNP and commodity consumption between developed countries is significantly smaller than that for the developing countries.

Huge amounts of capital will be required by these developing countries. The only source of this capital is the developed nations, who in turn require mineral products from the underdeveloped nations in return for its capital — a vicious cycle. Clearly, a resolution must be achieved if either group is to reach its goals.

Diminishing Availability of Energy

In any society, the production of raw materials requires a large proportion of the total energy consumed. Insofar as minerals and metals are concerned, the energy consumption per unit amount of mineral or metal produced will continue to increase as lower and lower grade ores are mined and processed. This trend reflects the greater quantities of rock mined per pound of metal as industry is forced to leaner ore bodies. Actually, in the recent past, energy has been substituted profitably for capital or labor in the production of mineral-derived raw materials. Agriculture also experienced a similar phenomenon. The impressive agriculture production in the U.S. has been achieved by the use of large amounts of fossil energy. Thus, in both mining and agriculture, technology has served as a vehicle by which energy can be substituted for human labor and capital investment in the production of primary raw materials.

Metal prices and availability are going to suffer severely unless energy-saving technology for metal extraction is developed. Mining of nonmetallic minerals will probably be less affected so long as ore grade remains high, but mineral prices must keep pace with energy costs if adequate quantities of all these materials are to continue to be available.

Since energy itself is derived mainly from mineral fuels (fossil fuels), its availability, until nonmineral sources can be developed, will also be largely dependent upon the solutions of the preceding problems. Further, unlike other materials derived from minerals, energy cannot be reused or recycled. Once used, it is distributed into the atmosphere in the form of heat and combustion products never to be recovered nor reused. Thus, energy is in itself the *ultimate raw material* and must be conserved tenaciously! Mineral fuels are the only truly exhaustible raw materials which man uses!

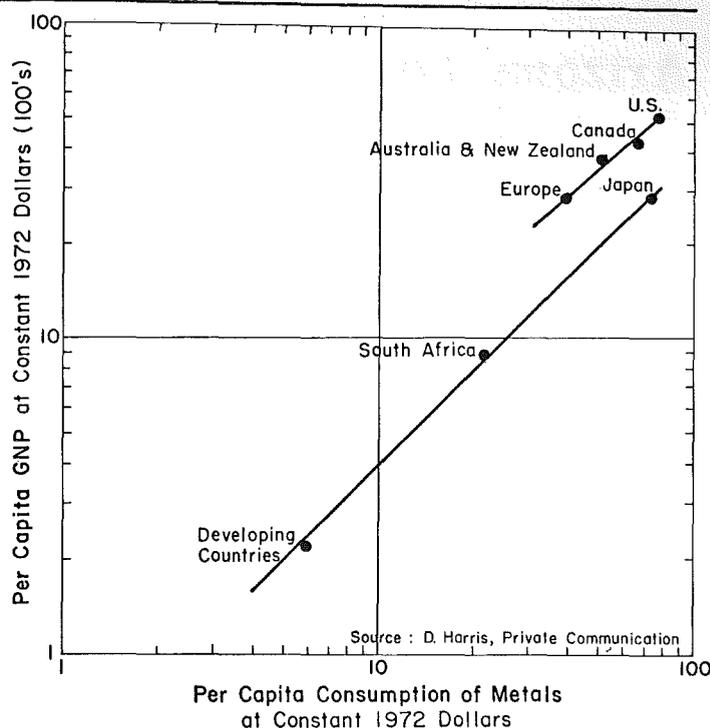


Figure 1
Per capita consumption of metals vs per capita gross national product, 1970. Metals (including raw steel, copper, lead, zinc, and aluminum) are aggregated at 1972 prices.

METAL	PER CAPITA CONSUMPTION (LBS)		GROWTH RATE (%)
	1951	1970	1951-1970
Iron	1342.8	1124.4	-.91
Chromium	4.0	5.08	1.25
Manganese	13.35	12.76	-.25
Nickel	1.35	1.96	2.0
Tungsten	.073	.080	.5
Aluminum	12.89	39.69	6.0
Copper	28.18	27.11	-.25
Lead	13.91	12.83	-.42
Magnesium	12.29	11.11	-.58
Zinc	13.78	13.21	-.25
Titanium	3.0	4.71	2.4

Figure 2
Per capita industrial demand, showing quantities and rates of growth, 1951-1970.

A Plan for the Future

In the face of the foregoing problems, the U.S. reacted in 1970 by the passage of a law — the National Materials Policy Act. The purpose of this legislation was to investigate and make recommendations as to the posture of the United States government with regard to a number of concerns:

1. national and international material requirements;
2. national and international population size and the enhancement of environmental quality;
3. recommended means of extraction, development, and use of materials in order to enhance environmental quality and conserve materials;
4. means of exploiting existing scientific knowledge in the supply, use, recovery, and disposal of materials;

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Arizona Turquoise

by
Robert T. O'Haire
Mineralogist

The use of turquoise by the South-western Indians dates back to at least 300 years B.C. Arizona has three areas of prehistoric turquoise mining.

The most extensive workings occur in the Mineral Park region (1 on the map) in Mohave County around Ithaca Peak and Turquoise Mountain, formerly called Aztec Peak. In the Courtland-Gleeson area (2) of Cochise County, it has been claimed that Indians turned over entire hillsides in their search for turquoise. The third major prehistoric area, Canyon Creek Ruin (3), is located in the Fort Apache Indian Reservation in Gila County, on the east side of Canyon Creek approximately 10 miles north of the Salt River.

Mineral Park

Of the prehistoric mining localities, only the Mineral Park area is presently a source of turquoise. Modern production in this area goes back to 1883, and it now accounts for the largest production in Arizona. Ithaca Peak and Turquoise Mountain are within Duval Corporation's open-pit copper mine, which is located approximately 15 miles northeast of Kingman. Much of the turquoise from Mineral Park is characterized by chalcopryite stringers that create a spider-web effect throughout the material. Generally, the turquoise occurs as seams, masses, and veins in altered, mineralized granitic rock.

Duval realized early in its mine development that mineral collecting and mining could coexist. Lease arrangements were made with L.W. Hardy of Kingman, giving him the right to retrieve the turquoise unearthed by their mining operations.

Turquoise at the Duval site runs the full range of quality from very porous, pale-colored material, commonly called "chalk," to high-grade gem material. Much of the material collected is chalky and requires special treatment in order to make it appealing and salable. However, as operations continue, turquoise is being encountered that is as good as there is these days. In 1973, Mineral Park produced 23,878 pounds of green chalk, 54,818 pounds of blue chalk, and 4,344 pounds of gem quality turquoise. Stabilized or treated chalk and gem quality turquoise are sold to established buyers.

Morenci

Arizona's largest open-pit copper

producer, the Morenci Mine (4) of Phelps Dodge Corporation, located in Greenlee County four miles northeast of Clifton, is also a major producer of excellent turquoise. The turquoise occurs as thin plates and nodules in close association with a diabase dike system that crosses the ore body in a northwest to southeast direction.

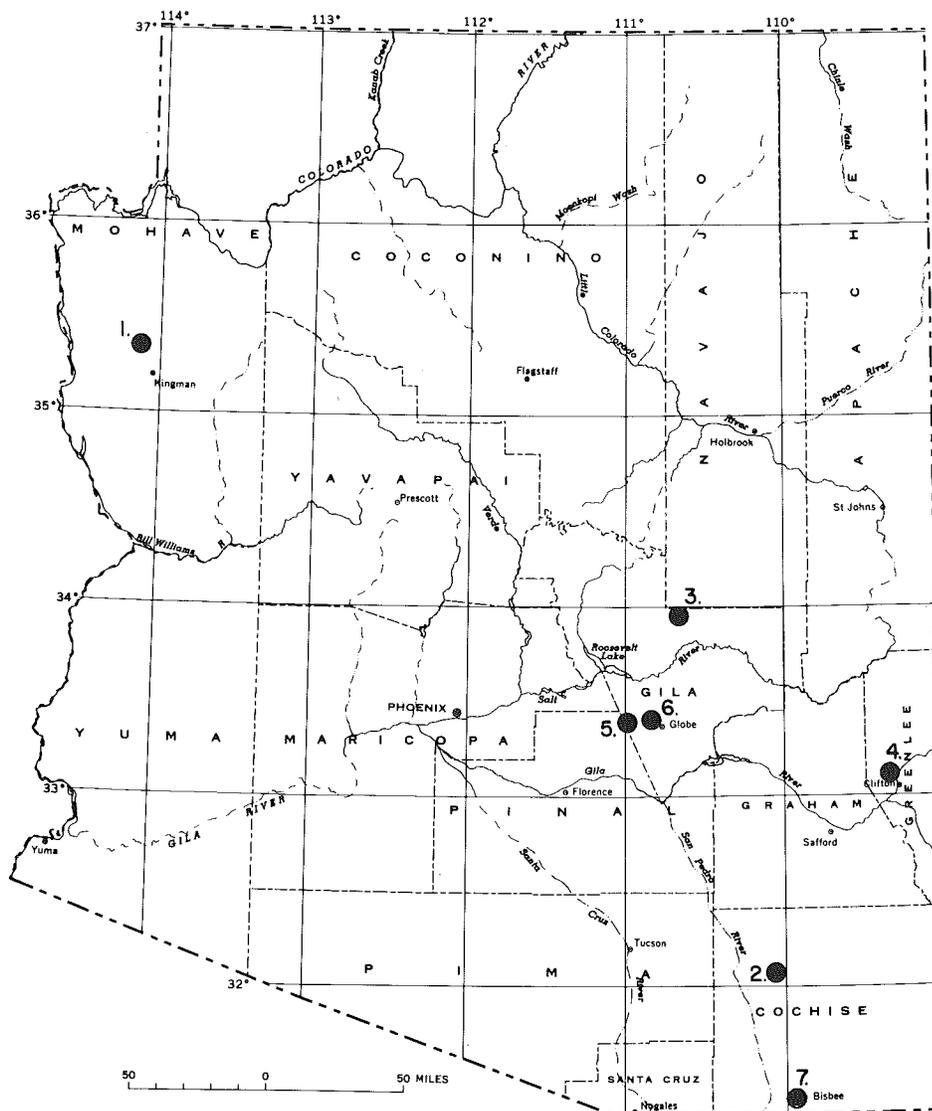
Much of Morenci's turquoise is very firm and shows good color. It often has bright pyrite inclusions which, to many individuals, enhances its beauty. Experts often use these pyrite inclusions as an aid

in identifying the original source. The concession to collect turquoise has been acquired by W.O. (Lucky) Brown of Gallup, New Mexico.

Globe-Miami

The Globe-Miami area, in Gila County, is a district noted for occurrence of turquoise. Turquoise has been produced from the oxidized zone of the formerly abandoned Castle Dome open-cut mine (5).

John Sinkankas, in *Gemstones of North America* (1959), states that veinlets of



EXPLANATION

Arizona Turquoise — Past and Present

- | | |
|----------------------|---------------------------------|
| 1. Mineral Park | 5. Castle Dome and Pinto Valley |
| 2. Courtland-Gleeson | 6. Copper Cities |
| 3. Canyon Creek Ruin | 7. Bisbee |
| 4. Morenci | |

(Number refers to locality mentioned in text)

turquoise occur up to ½-inch thick, forming plates of several inches across, while nodules or nuggets up to ½-inch thick occur in places associated with clay minerals and sericite. All qualities occur at the mine, from blue chalk to good hard blue. The copper mine closed December, 1953; however, the Castle Dome area was reactivated in May, 1972, when the Pinto Valley Mine (5) started its development. Pinto Valley, owned by Cities Service Company, is presently Arizona's second-largest producer of turquoise. This mine is located 8 miles west of Miami on U.S. Highway 60 and includes the Castle Dome workings. All qualities of turquoise occur, ranging from chalk to good, hard blue. Approximately 9,000 pounds of turquoise per month are collected by L.W. Hardy, the lessee.

The Copper Cities Mine (6), formerly called the Sleeping Beauty Mine, is owned by Cities Service Company and is located 3½ miles north of Miami. An estimated several hundred pounds of turquoise was found there in the early 1950s during the initial stripping operations. Some good material was mined from time to time, but in general the quality was more chalky than that from Castle Dome. Material at the Copper Cities deposit is iron-bearing and mostly greenish in color, whereas the Castle Dome material is almost exclusively turquoise of the blue variety.

Bisbee

Excellent turquoise has come from the Phelps Dodge mines at Bisbee (7), located in the southeastern corner of Arizona about six miles north of Mexico. Turquoise on the property occurs as minute stringers in massive pyrite on the 1,200-foot level of the Cole Shaft and also as masses of large size in the Lavender Open Pit.

Before Phelps Dodge closed its pit, the gem stone material was collected from a turquoise-bearing waste dump within the open cut. Since Phelps Dodge stopped its operation, its lessee, Bob Matthews, is collecting from both the pit and waste dumps. Matthews, who is the first and only individual franchised to collect turquoise in Bisbee, has been operating at the Phelps Dodge property for the past 4 years. By early 1974 he had produced approximately 2,000 pounds of good-to-excellent turquoise, as there is very little chalky material found on the property. Total production is not known.

The turquoise is cut and polished at the Bisbee Blue Gem Shop. It's then shipped to Navajo craftsmen or other Indian silversmiths to be made into jewelry. The finished jewelry is returned to the Bisbee Blue Turquoise Jewelry Store, located at the viewpoint to the

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RUMBLES AND RATTLES

Towards an Explanation

by
H. Wesley Peirce
Geologist

Since last Easter weekend, a rash of rumble and building-rattle incidents was reported by residents of the Tucson metropolitan area. Many phone calls were made to City, State, and Federal offices; the news media were active; and conjectures ranged from doom and gloom prophecy to facetious remarks ("it's Smokey the Bear stomping out a fire").

Some folks were amused and objectively curious while others were frightened and certain of a disaster to come. The attempt at resolving this cause of concern represented a community effort on the part of many citizen observers, industry and military representatives, news media personnel, various governmental employees, and scientific personnel related to the fields of geology, geophysics, and atmospheric science. Two things are certain: (1) there is a phenomenon to explain, and (2) there is no shortage of opinions about causes.

The principal manifestations noted by many observers included window and door rattles and distant outdoor rumbles. Human directional sensing of noise propagation tended to suggest a source to the west, and several observers noted that large windows and sliding glass doors with westerly exposures were especially noisy.

The uniqueness of these events seems to be in doubt. Some say that they have experienced this sort of thing for years but perhaps not with such frequency and intensity. The informal record available to us regarding this episode goes back to Good Friday, the 28th of March. In fact, two unrelated and separate observers independently have stated that the worst of the events experienced (thus far) occurred on Good Friday and that Easter Sunday was a bothersome day (further information concerning Easter week end is solicited). We have the continuous written record from April 1, 1975 for one susceptible family living in an uncompleted residence in the quieter countryside northwest of Tucson on the Tortolita Mountain piedmont slope. Through April 18 (noisy Friday!) the number of events recorded by them ranges from none on the week ends of April 5-6 and 12-13, to 12 on Friday the 18th. At least one event was recorded for each weekday except the 4th, when the family was not at home. Seven events were noted on the 8th, 11th, and 17th, and nine on the 15th. This family says that their experience with this phenomenon,

although perhaps not as intense or frequent, ranges over three years at this location — two in a trailer and one in the house.

Newspaper reports initiated during the week of April 7th drew community-wide attention. The number of observers markedly increased as interest was stimulated and a commonality of experience established.

Doug Shakel, a geologist in the Department of Geosciences, College of Earth Sciences, University of Arizona, expressed his and the Department's interest through the two principal local daily newspapers. A coupon was provided and citizens invited to share their observations. On Friday, April 18th, by Rose Samardzich of Earth Sciences, and Cherri Ralph, Irma Neighbors, Doug Shakel, and Dr. John Sumner (geophysicist) of Geosciences, over one hundred phone calls were received and information recorded. In addition, Doug has received more than 500 of the newspaper coupon reports, many with appended notes, opinions, and other information. One observer, living in Winkelman, a small town about fifty-five miles north and twelve miles east of Tucson, noted the afternoon events of the 18th recorded in Tucson, but not those of the morning.

There is much information to be digested, and it will be some time before it is all compiled and interpreted on its own merits as well as in conjunction with data derived elsewhere.

Seeking an explanation

In seeking an explanation for these rumbles and rattles, it seems necessary to begin with some variety of shock. In this regard there are two major categories: (1) shocks initiated within and transported through solid earth, and (2) shocks initiated within and transported through the atmosphere. Shocks of the first type can be further subdivided into man-caused events such as blasting at mines, and natural processes such as faulting (earthquakes). Atmospheric-related causes largely have been attributed to sound barrier penetration by aircraft (sonic boom) during certain atmospheric conditions.

John Minsch of the U.S. Magnetic and Seismological Observatory in Tucson, utilizing the seismographic record, ruled out earthquakes and underground blasting (*Tucson Daily Citizen*, 4/19/75). Chief Deputy State Mine Inspector Edward Chamberlain of Tucson also ruled out mining activity (*Arizona Daily Star*, 4/18/75). Dr. Sumner, acting both as an earth scientist and one who experienced the phenomenon in question, concluded

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The Mining Club

by Jay C. Dotson

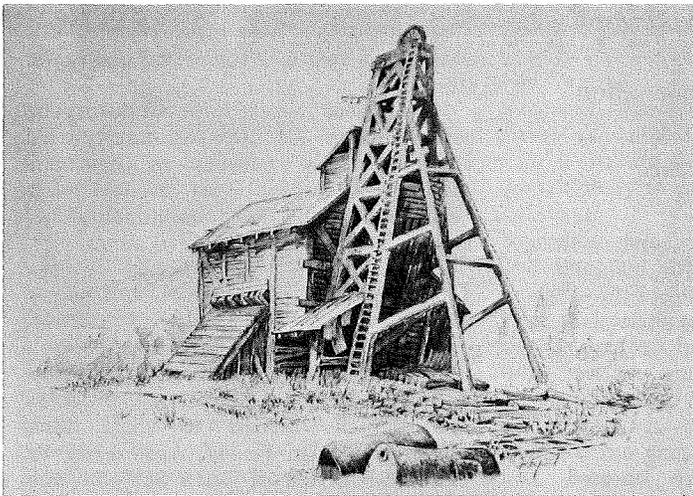
Mining and minerals exploration have long been important activities in the lives of the inhabitants of the Southwest. There has been a succession of peoples in Arizona looking for gold, silver, and other valuable minerals: Indians, Spanish conquistadors, Forty-niners, pioneer settlers, and the Johnnies-come-lately.

Over the years mining in Arizona, and especially in southern Arizona, has increased in importance until today Tucson is recognized as one of the largest and most active mining centers in the world.

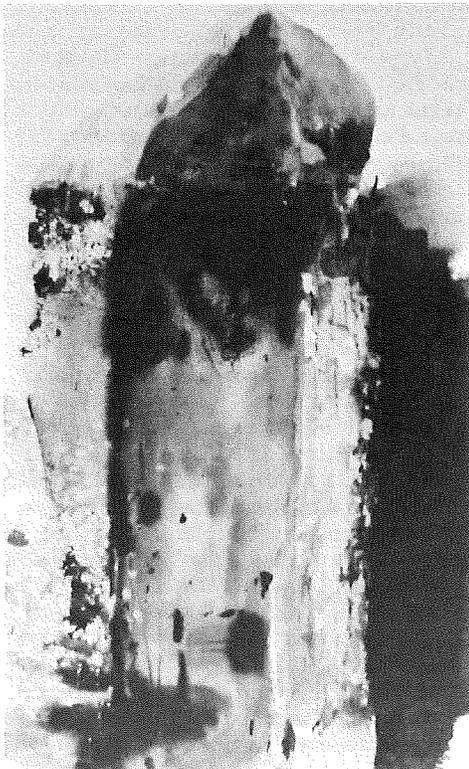
For many years engineers and geologists talked about a place for mining professionals to meet both socially and professionally, but it wasn't until February 1971 that the Mining Club of the Southwest came into existence. Since then, the club has strived for growth and increased recognition by the mining fraternity. The membership has reached almost 500, with members from all over the United States and several foreign countries. The club offers four categories of membership: resident, suburban, nonresident, and corporate.

The Mining Club of the Southwest enjoys reciprocal privileges with the Mining Clubs of London and New York and with the Engineers Club of Toronto.

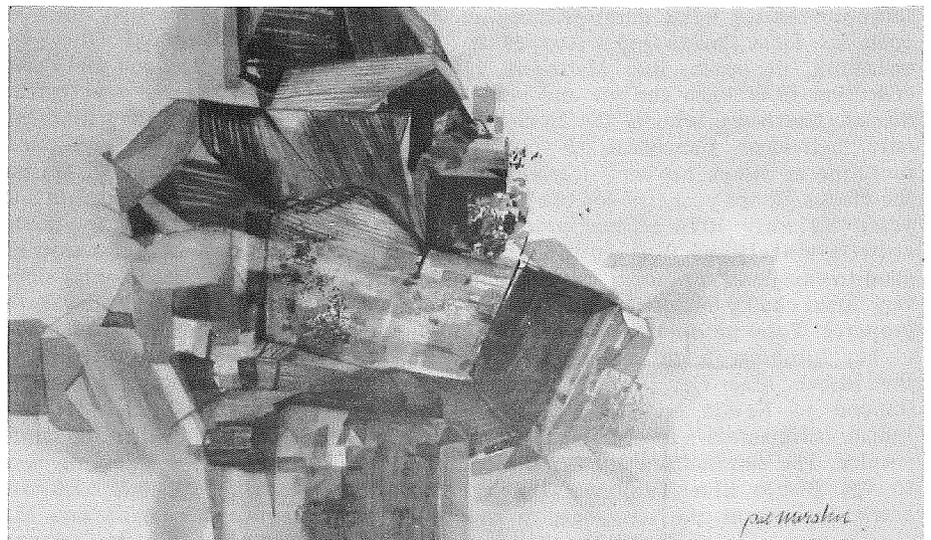
The club was formed to provide the benefits and services of a social club, including the recreation, pleasure, fellowship, and education of its members and the public, and for the advancement of science as applied to mining and related industries.



Top: Van Winkle Shaft, pen and ink; right, Red Mountain #1, watercolor, both by Ken Hatfield. Mr. Hatfield's drawings and paintings are exclusively of mining towns and scenes. A large selection of his work is currently being shown in the Copper Gallery.



Watercolors by Pat Marohn; Left: Citrine crystal; bottom: Pyrite. Unfortunately, black and white printing doesn't show the delicate shading of tones and colors in Mrs. Marohn's paintings; they should be seen in color. She prepared this series of paintings especially for a show at the Copper Gallery, using opals, lapis lazuli, and many different crystals as beginnings for these abstracts.



of the Southwest

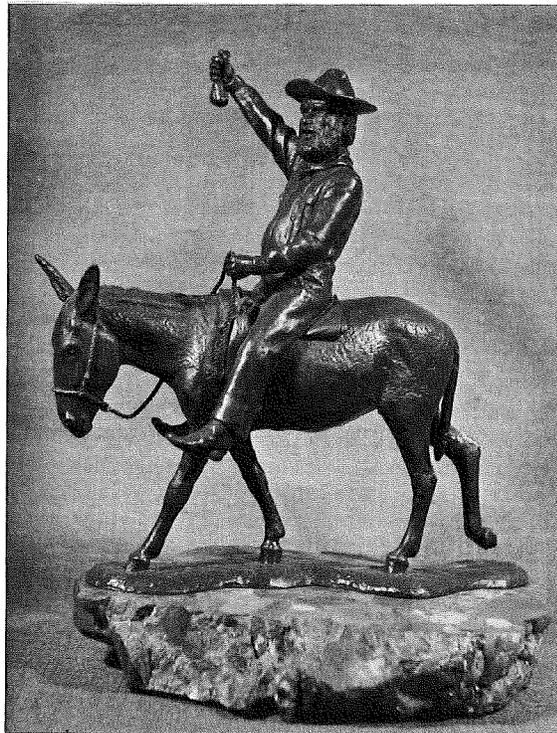
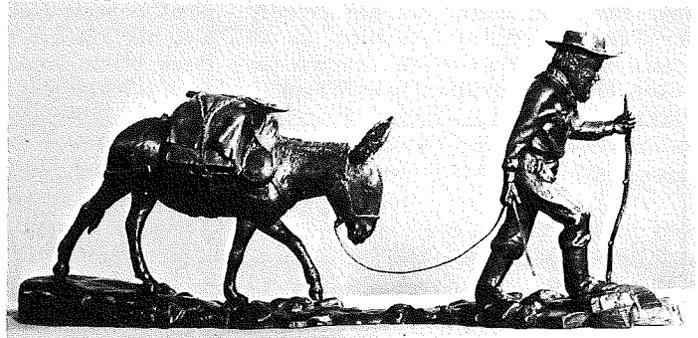
Some of the facilities and services available to members include a private lounge, a private board room for meetings and special group lunches, a private club luncheon room, and a small library. The club sponsors a gourmet dinner club, pool parties, distinguished speaker luncheons, a tennis competition, bimonthly beer busts, and the Copper Gallery of southwestern and mining arts and crafts.

The Copper Gallery features numerous artists and craftsmen, and whenever possible they're drawn from among the club membership or from the larger mining fraternity. Past exhibitors include Pan Eimon, wife of member Paul Eimon, the first club president and manager of exploration for Essex International, Inc.; Mary Heinrichs, mother of members Walt and Grover Heinrichs; Polly Bowditch, wife of member Sam Bowditch, retired geologist from ASARCO; John Beeder, mining geologist with Tenneco Oil Co.; George-Ann Tognoni, wife of consulting geological engineer Hal Tognoni; Tad Nicols, geologist and professional photographer; and Betty Herndon, wife of retired mill superintendent Thomas Herndon.

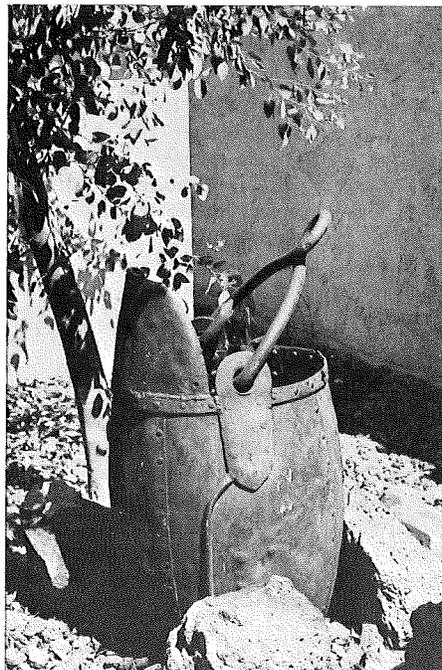
Our present exhibitor is Ken Hatfield, Senior Geologist with Kerr-McGee Corp. The subjects of Mr. Hatfield's pencil and ink sketches and water colors are almost entirely old mines and mining accoutrements. Mr. Hatfield's exhibit will run through mid-July. Starting in July the Copper Gallery will feature George-Ann Tognoni's outstanding works in bronze sculpture.

Visitors are welcome at the Mining Club of the Southwest. The club quarters are in the Sheraton Pueblo Inn, 350 South Freeway, Tucson, and are open 11:00 a.m. to 3:00 p.m. each weekday. Mrs. Ruth Kessler is the club manager and official hostess.

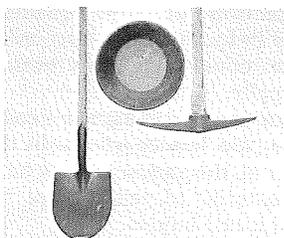
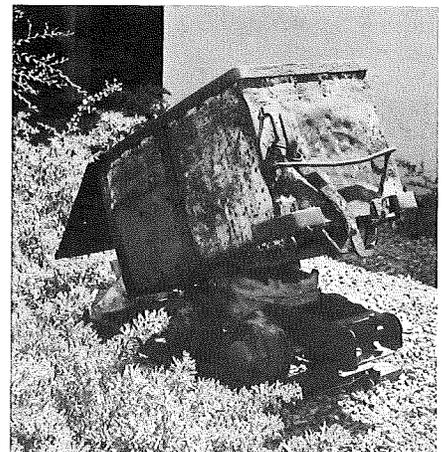
Jay Dotson is a Professor of Mining and Geological Engineering in the College of Mines, University of Arizona. He is also a member of the Board of the Mining Club of the Southwest, and has been managing the Copper Gallery.



Top: Eureka; left: To the Hills with Malapai; bronzes by George-Ann Tognoni. Mrs. Tognoni has always loved animals, and most of her sculptures include them. When she moved to the southwest, she began to sculpt cowboys with their horses, and the prospectors shown here. A showing of her sculptures begins mid-July at the Copper Gallery.



Below: some of the old mining equipment and antique tools decoratively used in the meeting rooms and outdoors entrance and patio. An old ore bucket and ore car are pictured here. The pick, shovel, and pan are hung in the reading room.



Rumbles Continued

that the solid earth was not directly involved and shifted attention to an atmospheric phenomenon known as "channeling," a condition in which sound

during this recent episode. On April 17th, plant manager Jack Stoker said that they had not blasted for a month but that three blasts would be set off on April 18th (*Citizen*, 4/17/75). A representative

buildings. This resulted in rattlings of things free enough to rattle. The rumblings heard out-of-doors are testimony to the idea that the shock waves were set up by a sound phenomenon. It seems, therefore, that the available evidence suggests that causes should be sought that were initiated above the ground surface.

The application of the seismographic record to this problem is vital in that it is an indispensable aid in evaluating possibilities. The State of Arizona has neither a seismologist nor a seismological research and detection program. The U.S. observatory in Tucson is being converted to a remote unit that will send signals to Albuquerque, New Mexico, and, therefore, will not be available for local applications. Arizona is a growing state and its leaders should become increasingly sensitive to the important contributions that an adequate seismological program can bring to understanding the nature of both the structure and the earth processes characteristic of Arizona.

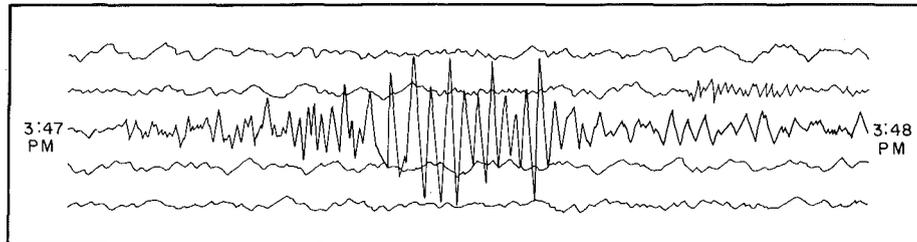


Fig. 3 Seismogram showing recorded blasting event.

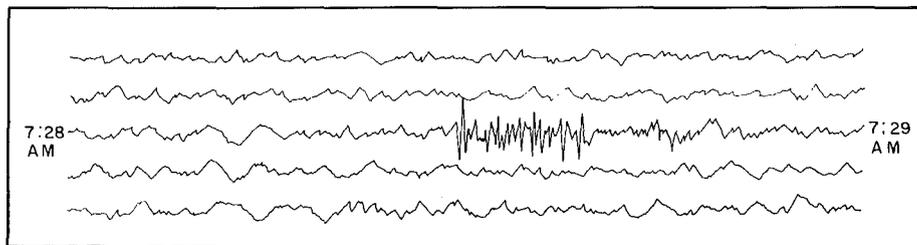


Fig. 4 Seismogram showing recorded rumble-rattle event.

can travel distances (*Star*, 4/18/75). Richard A. Wood, meteorologist with the National Weather Service, Tucson, related our shocks to atmospheric conditions that allowed transmission of sound waves created by sonic booms west of Tucson (*Star*, 4/24/75). These atmospheric conditions related to the position and speed of the jet stream, and to a temperature inversion, above the jet stream, capable of refracting a sound wave back to earth. Mr. Wood further suggested that our shocks were not new and that we were more conscious of them.

It is quite natural for us to search for causes among phenomena that are a part of our experience. As already suggested, it appears as though we must choose, basically, between blasting, internal earth forces, and sonic booms. In assigning causes there is an inherent potential for injustice. This can best be minimized by utilizing, objectively, as much relevant data as is possible. Too, there likely is an inherent tendency to disclaim in the cases where subjective fingers are pointed at possible human-related causes. However, it also would not be fair to invoke potentially dangerous earth forces where there is no scientific basis for doing so.

Mining activity is easy to point to because there are at least eight properties within 25 miles of Tucson that regularly engage in blasting. Some of the mines blast daily and have been doing so for years. The Arizona Portland Cement Co., which blasts irregularly at its quarry just northwest of the end of the Tucson Mountains, received many phone calls

of this company called us on the 18th before the blasts and also called afterward to give us the three blast times. We then asked Dr. Sumner if he would check with Mr. Minsch at the Seismological Observatory to see if and how these timed blast events recorded on the seismogram. He was able to obtain copies of the primary record and these have been examined.

In addition to the blasting at the cement plant quarry on the 18th, all of the larger copper mines around Tucson blasted between 3 and 4 p.m. on the same day. In our opinion all of these blasting events are evident on the seismogram (Fig. 3). It also is clear that the rumble-rattle events are recorded on the seismogram (Fig. 4). However, it is interesting to note that the respective seismogram records are greatly different. The blasts produce pronounced features whereas the rumble-rattle related record is minor in comparison.

Shakel made a plot of all the times reported for rattling events and it is significant to note that not one falls between 3 and 4 p.m. when all of the copper mine blasts took place. Too, not one overlaps any of the three blasts set off at the cement plant quarry.

Why is it that the blasts that were transmitted through the earth and left a more pronounced seismogram record were not sensed whereas the events that result in a slight record were? The answer seems to be that the shocks were atmospherically transmitted and therefore acted directly on the aboveground exterior surfaces of

Turquoise continued

Lavender Open Pit. The Store should not be confused with the Bisbee Blue Gem Shop mentioned previously. The Shop sells cut stones, predominantly to established buyers, but the demand for Bisbee material is great and the supply is small.

Summary

Although it is well known that more copper is produced from Arizona than any other state, it is not as well known that Arizona also might be the largest source of turquoise in the United States. Pinto Valley may become Arizona's largest producing area if the present production of approximately 9,000 pounds per month continues. At Mineral Park, more than 83,000 pounds of turquoise was produced in 1973. L.W. Hardy, holder of both the Pinto Valley and Mineral Park concessions, says that he believes that these two areas alone presently supply more turquoise than is produced in any other state.

Almost all of Arizona's copper production comes from large low-grade bulk deposits where the economics of mining demand fast handling of large quantities of material. This has enabled the collection of large quantities of turquoise in four of these large mines that otherwise could not have been mined economically.

Due to the present great demand for turquoise, the lessees who hold the right to collect at the various mines have little or no material to sell, except to their well-established buyers.

A Simple Test Chrysocolla or Turquoise?

by
Robert T. O'Haire
Mineralogist

Chrysocolla is mistakenly identified as turquoise more often than any other substance. A simple, 15-second test will help identify your sample correctly.

A drop of concentrated hydrochloric acid placed on your sample at room temperature will react immediately if the sample is chrysocolla. The acid will turn to a greenish-yellow color which can be more easily observed by blotting it with a white tissue. When the test is made on fair to excellent quality turquoise, no reaction will take place.

If the acid test is positive, meaning the acid turns greenish-yellow, the sample almost certainly isn't good turquoise and probably is chrysocolla. But not all minerals that give a positive reaction are chrysocolla. For example, azurite and malachite will change the acid's color (but they will effervesce also — a distinguishing factor to watch for). Not all the samples that react negatively are turquoise, though. Knowledge both of mineralogy and other test procedures is obviously very useful.

When they are in doubt, residents of Arizona who have collected samples from within Arizona are welcome to submit them for identification free of charge. Material submitted from out of state is also welcome. However, there is a charge of \$2.00 per sample (pre-payment required) for out-of-state material. Send raw material only; please do not send jewelry.

Enough money to cover return postage and handling must be enclosed with the sample if it's to be returned to the sender.

The commercial grade of hydrochloric acid (HCl), commonly called muriatic acid (32% HCl), can also be used for this test. This acid is available in many hardware stores and swimming pool supply houses. Be sure the muriatic acid you buy is not highly colored; a slightly yellow-colored acid is acceptable. The color can be checked by adding a drop to a white tissue.

Handle acid carefully and read the directions on the container.

Technology continued

5. means to enhance coordination and cooperation among federal departments and agencies;
6. the feasibility of establishing computer inventories of national and international materials requirements and supplies; and
7. which federal agency should be assigned responsibility concerning the policy.

Subsequent to the passage of this act, a committee composed of prestigious citizens was formed as the Natural Materials Policy Commission. The report of this committee, "Material Needs and the Environment Today and Tomorrow" was issued in June of 1973. The Commission recommended a five-point policy saying "... it should be the policy of the United States to:

1. provide adequate energy and materials to satisfy not only the basic needs of nutrition, shelter, and health, but a dynamic economy, without indulgence in waste;
2. rely on market forces as a price determinant of the mix of imports and domestic production in the field of materials, but at the same time decrease and prevent wherever necessary a dangerous or costly dependence on imports;
3. accomplish the foregoing objectives while protecting or enhancing the environment in which we live;
4. conserve our natural resources and environment by treating waste materials as resources and returning them either to use or, in a harmless condition, to the ecosystems;
5. institute coordinated resource policy planning which recognizes the interrelationships among materials, energy, and the environment."

Thus, for the first time, a policy was prescribed which linked materials, energy, and the natural environment. The National Research Council's report of the Committee on Mineral Resources and the Environment which was released on February 11 of this year placed additional emphasis on this prescription.

The Role of Technology

No amount of technology is going to cause nature to redistribute minerals on the face of the earth, nor is technology necessarily going to modify the political aspirations of sovereign nations. As technologists, however, we do have the capability of changing the particular resources upon which our raw materials are based. We can uncover new mineral deposits by improving our exploration techniques. We can learn how to extract materials from alternate mineral resources — petroleum from oil shales or tar sands; aluminum from clays or tungsten from brines, for example. We can alter the consumption pattern of our industry and of our people — not by deprivation, but by more efficient usage of the materials at our disposal. The environmental impact of production and consumption is another area in which we technologists can be effective. But, probably the most important area of all for us to influence is the *increased productivity of energy*. Energy, as it is now produced mainly from mineral fuels, can no longer be substituted for labor and capital. New technology must acknowledge energy for its *value as a raw material*.

If we view the whole area of materials production and consumption as a system, the areas of technological concern can be broken into three basic elements: *production, conservation, and environmental protection*.

Production

The basic question is: *How can we produce needed amounts of metals from ores of steadily decreasing grade while concurrently producing less environmental damage and consuming less energy than in the past?* Obviously this is the area which should be of primary concern to chemical engineers and extractive metallurgists. The traditional methods by which minerals are currently processed and metals extracted are not good enough to fulfill today's requirements. Technology must be

developed by many countries which will utilize their low-grade domestic mineral resources in order to offset dependency on foreign mineral supplies. Technology must be developed to more effectively use the energy required to mine ores and process them to metals and other minerals.

Conservation

The basic question here is: *How can we satisfy our material needs while at the same time consume less of the world's mineral and energy resources?* The answer to this question has three components — *recycling, substitution, and efficient design.*

While the recycling problem today is largely one of economics, the technology of recycling metals and other materials is far from complete. The problem of separating minor amounts of copper from iron in order that the iron can be returned to the steelmaking process and the problem of separating iron from aluminum alloy are just two of the problems.

The substitution of plentiful metals and other materials for scarce metals and materials will also offer new challenges to the technologist. In the past, only in time of war have we had to make a concentrated effort to alleviate shortages by substitution. Normally the forces of the marketplace have controlled the flow and the choice of materials. Now, conservation measures may cause us to again turn our technologists to the consideration of alternatives.

In the actual application of materials to various uses, engineers in general will have an important responsibility. Machinery and even household appliances must be designed for optimum performance in the face of material shortages, for reliability throughout their service life, and for ease of recycling of constituent ingredients. Thus, the designer, working with the chemical engineer, the metallurgical engineer, and the mechanical engineer, will be attempting to utilize metals and other materials which are readily available, to cause substitute metals and materials to fulfill functional requirements, and to improve product *durability, maintainability, repairability, and recyclability.*

Environmental Protection

Finally, the technologist, in all of his activities, will be called upon to be a watchdog of the environment. In the U.S., the National Environmental Policy Act of 1970 (NEPA) was enacted because:

"The Congress, recognizing the profound impact of man's activities on the interrelations of all components of the natural environment . . . (wished) to create conditions under which man and nature can exist in productive harmony and fulfill the social, economic, and other requirements of present and future generations of Americans."

Thus, NEPA is already a part of the U.S. national materials policy and the responsibility of all technologists of this country to implement.

Conclusion

Our ability to respond to this world-wide problem largely depends on the *programs* that can be established, the professional *skills* that can be mustered, and the degree of international *cooperation* which can be achieved. The world energy and materials shortages have grown out of a number of causes. The solution of these problems will require efforts on a number of fronts:

— an improvement in the productivity of energy

a decreased rate of usage of raw materials
 an improved recycling technology
 an improved supply technology
 an improved knowledge of the true extent of the world's resources
 a modification of the resources normally used for those mineral commodities which are in short supply
 a readjustment of the foreign policy of many nations in order to achieve stabilized conditions of resource development and international trade
 and, probably an increase in the price of many raw materials to more correctly reflect their cost and utility to a social-conscious society.

We, as technologists, have an important role to play in the world today. These problems will be difficult to resolve, but *they must be resolved* if the world's society is to continue to progress.

Ultimately, technology must be the future of raw material supply, for the true wealth of any society must be measured not just by that society's mineral endowment, but by the use to which that society puts the available raw materials in the fulfillment of the needs of its people.

A Dialogue with Dr. Boyd

Dr. James Boyd, President of Materials Associates, has served as Executive Director of the National Commission on Materials Policy, Director of the U.S. Bureau of Mines, President and Chairman of Copper Range Co., Vice President of Kennecott Copper Corp., and Dean of the Colorado School of Mines.

Q. What do you feel about America's wastefulness?

A. We're a tremendously wasteful people. We can extend our resources by turning wastes into a resource. The thing that will bring about the recycling of urban waste will be primarily the competition between the availability of landfill areas with the cost of disposing of those wastes in other ways, such as recovering those resources the wastes contain. This is all within our grasp. In fact, over 10 percent of the available, viable urban wastes are now under contract to be treated by industry. The government has given some help on this. For instance, the U.S. Bureau of Mines has developed a system that uses normal metallurgical practices, and has built pilot plants of the systems that can recover materials from urban wastes, put them back into the materials cycle, and probably do it economically.

Q. What about the final point of the National Materials Policy Commission's report — the environment?

A. The country should realize that everything you do in the materials cycle affects the environment. Everything you do in industry, using these materials, depends upon energy. Each of these things has an effect on the other. You cannot establish policy unless you take clearly into consideration the fact that the environment, the materials supply, and the energy supply are intimately related. They *have* to be handled together; but we are violating this concept at the present time.

Nobody is really paying much attention to materials since Rogers Morton has gone over to the Commerce Department. We are going to be in real trouble unless we recognize this.

Q. Are we running out of resources?

A. I made a calculation that if we could mine, and our technology improved over the years, we wouldn't have to go down more than a kilometer into the earth's crust (using the nodules on the sea floor and so forth), and we'd probably have enough materials in the crust of the earth to handle the growth of the human race as it presently is growing and improving in its technological use of materials for 14,000,000 years. Now, if we can't solve our balance between population and resources in 14,000,000 years we won't be around very long. This is a silly example, but it proves in a way that although the earth is a finite body, the potential resources are so enormous to do what we need to do that in our equations we can put them down almost to infinity.

Q. Will one of our main limitations be shortage of capital?

A. A good point. This is what you should talk to your congressman about. What is capital? In terms of an individual, it's purely savings. In terms of a company, it's the profit. The terms are the same. The ability to earn above your needs and wants is capital. We proved during the last war we could improve our productivity and our savings enormously in time of emergency. Our ability in this country to generate capital is extremely large. The ability of undeveloped countries to generate capital is virtually zero. They can't even get enough money to subsist. What we need to do in the body politic, then, is to encourage the creation of capital by doing the same things we do to encourage production of materials or energy. We have enormous resources available to us — if we can make our people understand that this is what is needed. We have to work a little.

Q. Working more means profits — and isn't "profits" a dirty word?

A. Well, we've got to make it an essential word in order to keep our quality of life being further distributed to people who don't yet have it. Most of us can do without a little of this so-called "quality of life."

Q. Doesn't part of that responsibility fall back to the White House and Congress? You're asking a lot of the individual citizen to be farsighted enough to see that he should put his savings into the longterm picture from the materials and energy supply standpoint instead of something else.

A. Absolutely. But now, is it possible for a democratic political system to carry out anticipatory legislation? If it isn't, then we have a hopeless situation. I don't know the answer to this question. If we're imaginative enough we should be able to make our congressmen realize we're not going to vote for them unless they strengthen our economy. We have got to come back to the grassroots.

Q. Do you think that technology can be expanded in an unlimited way?

A. To put a limit on technology is a very difficult thing to do. You can assume there's an enormous, almost unlimited horizon for technology. When that's balanced against the financial resources, the willingness to work, we might find some constrictions.

Q. How do we get a handle on estimating how fast technology is expanding in relation to today's problems?

A. I think technology is probably expanding too fast for the social structures. But the question is: is technology causing the problems, or do the problems cause the need for technology; I don't know the answer to that.

Q. Why has the percentage of copper that's recycled stayed at 30 percent for the past 30 or 40 years?

A. I don't know of any real waste of copper. I suspect most of copper is going into use; we're improving the capital base of this country. The copper's in communications and transportation systems and is still in use. There *is* a little waste in urban landfill.

Q. I want to bring up the possibility that you can't predict really new technologies. You can only show a rate of change of existing technologies.

A. You can predict with some certainty that new technologies will develop. The *timing* is impossible to predict. I'll even stick my neck out and predict with some certainty that we'll be using the hydrogen atom in the fusion process for generating energy. It might be 2 or 3 generations from now — it'll come along when we need it.

Q. While on the National Materials Policy Commission, did it ever look at the social problems caused in part by the technological advances made during the last few years?

A. We had endless debate about this, but I don't think we ever came to a conclusion. Our directions were pretty clear: it was a Materials Policy Commission. We did have people on the staff who would constantly pull us over to the social side.

Q. Don't you think one could get into trouble making policy relating to one aspect of our existence without taking into consideration the impact it has on the other aspects?

A. We do this every day. Everything we do is in a cell by itself. One of the principal recommendations of the Commission was that there be a central coordinating body.

Q. Is this possible?

A. Last year Congress set up a Supplies and Shortages Commission. They appointed immediately the senators and congressmen to that commission, and Mr. Nixon appointed members of his administration, but there were also to be 5 public members. They picked 5 economists. Then Hugh Scott and Mike Mansfield said, "look, we want somebody who knows something about materials; the National Materials Policy Commission says we're faced with these particular problems, and we should have some coordinating body that can give Congress some forewarning of these shortages." With that, they tried to find someone who had no conflicts of interest, but who knew something about the materials industry. There isn't any such person. That's where it's stuck right now. I got word from Washington recently that they are reopening the question, though. There had been no shortages the last five or six months, so it'd gone clear out of their minds. They are beginning to realize now, however, that they could be faced with shortages again.

Q. What's OTA?

A. This is a new concept in political science. For years the scientific and engineering communities have been trying to get Congress to assess their problems technologically. About two or three years ago the Office of Technology Assessment was formed in the Congress. It's a body of Congress like the General

Accounting Office or Library of Congress. They set up a Technology Assessment Board consisting of, I think, 6 senators and 6 congressmen. It's completely bipartisan. The chairmanship changes each session of Congress from the Senate to the House and back again. They're there to take requests from congressional committees to assess technologically what the impact will be of legislation they're considering. If they had had this office when they wrote the Pure Air Act or the Pure Water Act, we might have had a different kind of legislation. Congress is beginning to ask these questions — in fact, they're snowing the Board a bit. The Board works through a series of advisory committees; there's a materials advisory panel — I'm chairman of that.

What Congress is trying to do is set up a mechanism whereby legislation can have the impacts on the other disciplines, the economy, and the social structure all taken into consideration.

Q. When is the dependency on imported materials too great?

A. When the other countries cut you off. No, really, this is a lot of nonsense. The United States has never been independent of the

rest of the world for resources, *ever*. We are still one of the richest nations in resources in the world. We've gotten excited about the Arabs and their oil, but they have no other resources to speak of — except sand, if they can make that a resource.

Even in wartime, with the stockpiles we had, we were always dependent upon trading with the enemy. We would go around through Portugal or China or someplace, but we had to have certain resources.

Q. It seems to me that government is probably the most inefficient way to control anything, so I count on the marketplace for short-term solutions. But can we count on the marketplace to develop the long-term solutions to our problems?

A. No, you can't entirely depend on the marketplace. There must be a certain amount of government planning. Someone in government must be looking down the pipe, as the Forest Service and Bureau of Mines have always done. And you have to have the devices to nudge the marketplace in a given direction, to equate risk into the economic formula. To do this, you have to have some government planning.

Arizona Bureau of Mines Publications Update

New reference source

Bulletin 190, Bibliography of the Geology and Mineral Resources of Arizona 1965-1970, by John S. Vuich and Jan C. Wilt, is now available from the Arizona Bureau of Mines. This bulletin, a supplement to ABM Bulletin 173, presents a comprehensive listing of the literature on the geology and mineral resources of Arizona released between January 1965 and December 1970.

Containing 155 pages of bibliographic references and indexing, Bulletin 190's 6-year span of coverage contains nearly one-half the quantity of listings found in Bulletin 173, which covered the previous 117 years.

Bulletin 190 costs \$2.00. If ordered by mail, 20¢ should be included for handling and postage.

"Mineral and Water Resources" reprinted

Mineral and Water Resources of Arizona, Bulletin 180, has been reprinted and is now available for purchase. Originally published in 1969, Bulletin 180 is a joint effort of the U.S. Geological Survey, the U.S. Bureau of Reclamation, and the Arizona Bureau of Mines. The bulletin contains 638 pages, and the cost is \$4.50 (\$4.95 if ordered by mail).

Fuel resource bulletin reprinted

Coal, Oil, Natural Gas, Helium, and Uranium in Arizona, Bulletin 182, has been reprinted. The bulletin, which includes a packet of 19 separate maps, was originally printed by 1970, authored by H. Wesley Peirce, Stanton B. Keith

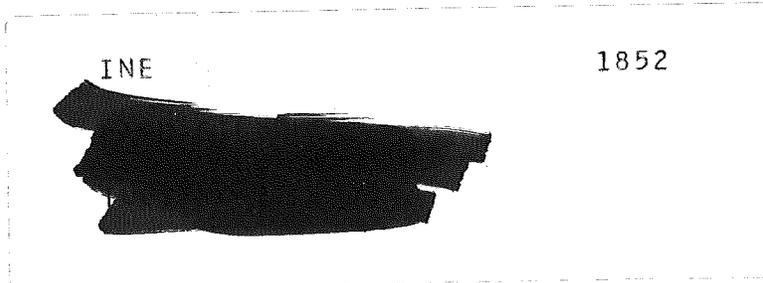
and Jan C. Wilt. It costs \$4.50 (\$4.95 by mail).

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