

Minerals for the Future

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Since we became an industrial commonwealth, with the colossal appetite for raw materials inherent in such a way of life, the more farsighted among us have been haunted by the realization that minerals do not grow, at least over periods short enough to relate to the rate of depletion.

A moment's reflection on how all groups in our national life pin their hopes on the concept of an ever-expanding economy, will make one realize how widespread the consternation would be if it should become apparent that limited mineral supplies forebode a shrinking economy.

For more than a generation, uneasiness about depletion of minerals has caused numerous studies, largely under government auspices, directed at management of our national affairs to avoid waking up someday to discover that the raw-material base for our burgeoning economy has been eroded away.

Most of these studies have come up with ominous estimates of limited supplies which have stirred minor areas of public opinion, but the simple fact is that virtually nothing has been done in the way of altering our course. Because the older estimates have been proved to be unrealistic, a considerable group in the mineral industry scoffs at such studies.

In addition to national considerations, certain even more farseeing and less nationalistic citizens have viewed the problem on a world basis. If the rest of the world should otherwise be able to fulfill even partly its dream of industrialization and better living for all, and the world's population grows to anything approaching the fantastic numbers that experts on population trends predict, these students of mineral problems wonder how the minerals can be provided to satisfy such staggering requirements. Will mineral supplies be the bottleneck to expansion of industrialization, and if so, is it likely that a scramble for the remainder will renew jungle law among nations and the devil take the hindmost?

The realization that mineral depletion is inexorable has led some conservationists to the viewpoint that we should set aside a substantial portion of our known mineral reserve for posterity. Despite the warnings given in the afore-mentioned studies, little attention has been paid to this viewpoint. The consequences of such a course would be genuinely painful, and in the present decade the bogie of encroaching Communism would be utilized as a sufficient excuse to postpone the day of reckoning.

However, if the viewpoint is valid, and if some mineral reserves are as small as even 3 times the amounts estimated, the impact of depletion may not be a problem for remote generations. Conceivably, unless our pattern of use is quite elastic, depletion might start to curb full-employment expansionism in our children's time.

My own belief is that the means will be available to posterity to satisfy raw-material requirements for continued economic expansion and cultural progress. Nevertheless, because many think that mineral scarcities are as close to us as to our children, it behooves us to take an analytic look. The practical aspects of the problem can be treated under the following five headings.

1) *What can we expect from scientific prospecting as a means of enlarging the total available amount of economic minerals?*

Despite extensive geologic study and research by both college-trained and experience-trained men, it is still true that most of the mineral deposits in production today were found in or near outcrops by simple prospecting or by lucky accidents. Petroleum is an exception, and the finding of coal seams or other persistent sedimentary beds far from outcrops may be considered another. In the metalliferous field, the hope that geologic knowledge can be extrapolated to find hidden deposits has not yet borne fruit to an important extent. Also, except for petroleum, geophysical science has not yet brought home rewards commensurate with the efforts expended.

This situation would be all right if we still had large virgin areas to reward simple prospecting, but we do not. Most laymen would be astonished at the extent to which areas they regard as virgin wilderness have been examined many

years ago. Most geologists agree that the age of discovery by simple prospecting is drawing to a close, and that we have been lucky in the way that known productive deposits have continued to pay off.

However, despite these forbidding observations, it is my own opinion that we are on the verge of an era of discoveries by scientific prospecting. Geophysical and geochemical prospecting will bring most of the earlier successes, probably enough to take care of the needs of at least the rest of the 20th century. What geologic science may do from then on, either alone or in combination with some other science, is difficult to predict, but it is certainly apparent that geology will play a useful part in the application of geophysical and geochemical methods. Scientific prospecting can be applied to extensive areas that are potentially mineral bearing but are covered with soil, alluvium, or glacial drift as well as to concealed deposits in proved areas.

This optimism is based partly on successes in the oil industry, and partly on results that have been obtained in recent years in the metalliferous field.

2) *What can we expect from more efficient extraction and processing?*

Our generation has benefited immensely from the efforts of an army of technical men who have continuously strived—successfully—to get more from deposits, to process lower grade or more refractory material, or to make utilization more efficient. These gains have been so continuous that many of us have been inclined to take them for granted.

That they will continue cannot be doubted, and in some cases the results will no doubt be as startling as the production of magnesium from sea water—a limitless source. For example, it requires only ordinary imagination to visualize in an atomic age the extraction of iron, magnesium, silicon, aluminum, soda, lime, and potash from such limitless sources as the common rocks if necessary. On the other hand, it can hardly be foreseen that technology will make such elements as copper, lead, zinc, nickel, chromium, manganese, titanium, tungsten, cobalt, tin, or the rare metals commercially extractable from such rocks. These conclusions bring us sharply up against the question: "Does a progressive civilization have to have the second group if it has access to limitless supplies the first?"

3) *What can we do about reclamation of minerals and metals from wastes of various sorts?*

Every adult person has been shocked in his time by the destructive aspects of an expanding, free economy, the devastation of the forests, erosion of the soil, pollution of water and air, and the approaching exhaustion of our finest min-

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eral deposits. Yet we can regrow forests if we save the soil, we can purify water, and we can rebuild soil—or even grow plants without it. We can also reclaim mineral wastes previously tossed aside or left behind.

How many of us are equally shocked at the reckless waste of metals and minerals that goes on about us, or the quantities of phosphorus, potash, and nitrogen that we run into our polluted streams? Shocked or not, we do little about it. Faced with an outpouring of nature's gifts, economic incentives have been lacking to systematize the reclamation of more than a few items. Our government has so little regard for raw-material waste that it can bring itself to sink battleships for target practice or abandon thousands of tons of equipment and supplies at distant places. Our fellow-citizens have so little concern over fuel depletion that they can devote 150 horsepower to hauling their individual persons around! And the losses through easily preventable corrosion confront us wherever we go.

However, if and when we become inclined to curb wastes, the potentialities are simply enormous. Our phosphorus supply, for example, can probably be extended tenfold by conservational measures.

4) *How much can we afford to pay for mineral supplies?*

Probably the least generally understood aspect of mineral economics is the profound effect of price on supply and demand. For example, manganese ore has been considered a potentially rare enough material to be included in our national stockpile and to call for special measures to improve the supply. This material currently sells for about 4¢ per pound. Suppose it were raised to \$1.

At such a price the world's commercial reserves would be multiplied tenfold. Mining people could afford to look much farther afield and deeper. Smaller deposits of good grade would become workable, and enormous tonnages of low-grade material would be commercially exploitable. Users would be much less exacting on specifications and would undertake research toward using less. We know that they could reclaim three-fourths of what they now waste, and their bright young men could probably learn to eliminate its principal use, in steel-making. By all these reactions, the manganese supply could be made to go at least 100 times as far as it does under present conditions, and in addition it could be made nonessential.

Can we afford \$1 per pound for manganese ore? At this price the national consumption would probably be below 3 pounds per capita per year—an annual cost per citizen of \$3. Very few of us would ever know the difference.

Lead is another example. We currently use about 15 pounds per capita per year of new lead, which in pig form costs 15¢ per pound. It is used principally in storage batteries, gasoline, cable sheathing, acid vessels, construction, paints, glass, and weights. In all of these uses, except storage batteries, there are ready substitutes. There are substitute materials for storage batteries also, but those developed to date involve materials that are scarcer than lead. The lead in storage batteries is now 85-percent reclaimed. At \$1 per pound, probably all the uses except storage batteries would largely disappear, and the lead in these would be 98-percent reclaimed. Available supplies would expand enormously. One cannot foresee depletion of lead supplies under such conditions in less than 1000 years, and the cost to the average citizen would be under \$5 per year. This represents about a half-day's extra work per year to an employed citizenry that is now trying to decide whether it wants to work more than 30 hours per week! Moreover, at 98-percent recovery, the consumer would be using only 2¢ worth out of the dollar cost and returning the rest. His net cost, after allowing for collection and purification, would be under 10¢ per pound. Beyond this we have possibilities of substitution. Furthermore, the public can well afford to pay, not \$1 per pound, but \$20 per pound for the lead it absolutely needs. Think how far such a price would extend the supply.

On the other hand, it should be realized that no metals, even the most expensive or durable ones, are 100-percent reclaimed. High prices and serious efforts to conserve wastes will help tremendously, but they will never achieve complete reclamation.

The question of ability to pay has another interesting aspect. Today and in the past, almost everything we have built we expect to pay out in 25 years or less. This means that a single generation shoulders the cost, even though the article may last longer, in some cases for many generations. As a result, each generation enjoys a very large gift of buildings, public works, equipment, tools, materials, and other bequests from its predecessors, for which it could afford to pay its share if higher prices were necessary for the raw materials.

5) *What can we do to substitute abundant minerals and metals for scarcer ones?*

We have already touched on the feasibility, in an atomic age, of utilizing the abundant elements of the common rocks, whenever such measures become necessary. With iron, aluminum, magnesium, and silicon available in limitless supply from such sources, can it be said that we absolutely need any other metals for construction, tools, and durable goods? We

can say with certainty that the metals like lead, zinc, copper, tin, and the ferro-alloys will last for hundreds of years for their most essential uses, but if they finally come to an end, there is no basis for the contention that they cannot be eliminated altogether in favor of the metals of the common rocks or ceramic materials.

As for the minerals necessary for agriculture, lime and potash are recoverable from common rocks, and known phosphorus reserves are sufficient for thousands of years, and for tens of thousands if they are conserved.

In the areas and times more clearly perceptible, it is perfectly evident that our technology has an immense capacity to find satisfactory substitutes for scarce materials. The process goes on constantly; there is no reason to anticipate its end.

Also, it is not beyond the bounds of possibility that man may learn to synthesize the elements at prices he can afford to pay for their most essential uses.

Before one adopts a more pessimistic attitude, it should be realized that neither the joy of living nor the progress of culture are dependent on multistory buildings, 60,000-ton ships, rockets, automobiles, airplanes, or radio.

To summarize the outlook for metal and mineral supplies, there seems to be no reason why we need fear that the growth of either industry, culture, or well-being need be stifled because of depletion. Reserves of the scarcer minerals can be greatly extended at costs that can easily be borne, and in the final analysis they are not necessary to the progress of civilization in any real sense. In fact, there is some basis for the idea that cultural development might proceed faster if we were less surrounded by material wealth, since it frequently seems to be our master instead of our servant.

The harsh statements made about waste in the foregoing paragraphs and the conclusion that posterity will not be in jeopardy for mineral resources may appear to be in conflict. Should we take special action to prevent waste or should we carry on along our present course of conserving only where it pays?

To acknowledge that the survival of posterity is not fundamentally dependent in our self-denial does not mean that our successors are not handicapped by our wastefulness. Probably they will be, even though they can continue to enjoy material well-being by added effort. It would seem then, to be fair play to exercise, through educational measures rather than compulsions, a certain restraint in despoiling the earth of its treasures. Moreover, speaking strictly in our own behalf, all human experience indicates that curbing of our appetites is good for our own characters.