OUR STRATEGIC MINERALS RESOURCES

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As GRADUATES OF THE California Institute of Technology where we received our principal training in physical sciences and engineering, all of us are vitally concerned with sources of supply and the application of materials with which me must work or which we plan to use in future scientific developments. In normal times, the problems of raw material supply, especially in the field with which I am associated, are sufficiently complex to tax all of our ingenuity. Today, these problems are even more complicated. The advent of an emergency program, requiring substantial shifts in the nation's industrial economy, invariably is characterized initially by serious shortages of materials. These shortages can only be handled, at least in the early stages, by stringent controls.

For the first two years of World War II, we also encountered such conditions of scarcity. Special control mechanisms had to be established under the War Production Board. As time passed and more satisfactory methods of control were established, productive capacity began to satisfy expanding military programs. Raw materials ceased to be the main guiding influence and our productive capacity was limited more by manpower than by the materials themselves. In fact, by the end of the war we had sufficient stocks of mineral raw materials to carry us over the difficult reconversion period and still leave substantial quantities for transfer to the national stockpile. This experience shows that by use of foresight it should be possible to provide sufficient quantities of raw materials to supply our ever-changing and shifting economy.

The impact of a military program

It may seem strange to you that an industrial economy which has been operating at full capacity, as ours has been for the past two years, should have its raw material resources strained by conversion to a military program. Upon analysis, however, the reasons for current difficulties become fairly obvious.

The vast machinery of production, which is the foundation of our industrial economy, is always in delicate balance with the supply of raw materials. The economic laws of supply and demand tend to gear productive capacity from the raw materials stage to the final product in equally close balance. However, increased production of war materials markedly shifts that balance, and accelerated military programs require larger amounts of critical materials in proportion to the manpower required to process them. Furthermore, military equipment is used under much more exacting conditions and requires larger quantities of critical materials.

The most dramatic examples are steel, aluminum, copper, and especially the ferro-alloys. Increased aircraft production, ammunition manufacturing, and other military programs draw heavily upon aluminum, far in excess of normal peace-time requirements. The ammunition and communications programs of the military make equally tremendous demands upon our available copper supplies. Furthermore, the expansion and creation of additional productive facilities for all metals and chemicals draws heavily upon these and other scarce raw materials.

Steel is a case in point: the military program seriously disrupts the gigantic industry by making heavier demands on alloy steels and certain semi-fabricated shapes, such as plate. Special requirements for steels to resist high temperatures for increased jet engine programs and for high speed cutting tools make unbelievable demands upon production of such critical materials as cobalt, columbium, tungsten, and chrome. Normally, there would be a relatively small demand for these materials in the peacetime economy. Productive capacity under a peacetime competitive enterprise system without artificial stimulants is obviously not sufficient to meet this rapidly increasing emergency requirement.

Since new mines cannot be created or developed at a speed comparable to that of a manufacturing plant, new domestic raw material supplies cannot be made available

An address given before the Fourteenth Annual Seminar of the California Institute of Technology Alumni Association, April 14, 1951 in less than two to five years. Nor is it possible to obtain a sudden expansion of domestic stocks of metals and other minerals from foreign sources, especially when foreign users are likewise in the midst of an expanding economy.

All that can be done is to curtail consumption by less essential users in order to divert materials to the military program. This can result in serious disruption of fabricating industries which depend upon these materials for their existence. Thus, the diversion of cobalt, for example, from normal channels to the military can compel radical engineering design changes in the radio and television industries.

Adaptability of engineering

Scientists and designing engineers exert a profound influence upon the application of raw materials. Consider again metal requirements for high temperature resistant parts of the jet engine or specialized atomic energy equipment. In most cases, the designing engineers and scientists predicated their plans upon materials available at the time, with little thought directed toward the possibility of meeting requirements of a vastly expanded program. The lack of such knowledge must eventually result in design changes.

Columbium is an outstanding example. If the original jet engine designs were left unchanged, the requirements for columbium would exceed in a single year all the world's known ore reserves of this metal. When designing engineers were apprised of this condition, they were able to reduce the quantities of columbium for jet engines to bring requirements into balance with available supply.

Unfortunately, many substitute materials, such as nickel, chromium, cobalt, etc., are also in this critical class. However, resources of these materials can be defined within limits and in many cases the problem of supply can be solved eventually by increased raw material production or through expanded metallurgical research into methods of obtaining greater recovery from known ores.

As soon as producers, or those responsible for production, are sufficiently informed to plan for future expansion, it is possible to anticipate that requirements will be met. Unfortunately, these most critical and scarce materials are subject to rising prices, and the problems of supply raise serious questions of economic stability and international relations.

To state the matter simply—and this will perhaps over-simplify it—we know that we can artificially stimulate increased production and supplies of some metals and minerals by price incentives of various sorts such as premiums or bonuses, higher ceiling prices, special tax relief or increased import traffic. Thus, domestic ores which are not now commercial because of excessive distances from market, or because of poor grade or lack of amenability to standard methods of benefication would be brought to market. However, such sources are not too dependable and would give added impetus to the inflationary spiral. Further, the use of tariffs as a measure of domestic protection—take the case of copper, for example—would be offensive to certain friendly foreign nations on whom we are now dependent for substantial quantities of metals and minerals.

In extreme cases, however, drastic action is called for. Tungsten is a case in point. Since the beginning of World War II, and earlier, we have geared our domestic manufacturing industry to the use of high speed cutting tools which are dependent upon tungsten alloys for their cutting edges. The sudden increased demands for tungsten for military uses—armor piercing shells, electronic equipment, armorplate, and a thousand other special uses—coupled with suddenly increased demands for this metal for machine tools has created a currently critical shortage of the metal. Limitations on the uses of this metal have been ordered by the Government in order to restrict its availability to the most essential uses.

Think for a moment what it would mean if the machine tool industry were to be deprived of tungsten, and the industry were required to go to other and inferior material for the manufacture of high speed cutting tools. I have been told that such a step would reduce the efficiency of industrial production in some lines by as much as 90 per cent. This would mean the necessity of doubling the working forces or time of manufacture, or reducing the output of some materials by half, thereby multiplying the costs of the manufactured items.

Thus, the lack of a metal like tungsten, the total annual value of which has amounted to less than $500,000, would have an inflationary effect tremendously in excess of its intrinsic value. In this extreme case, therefore, a price increase for the raw material or other incentive would in effect be deflationary, rather than inflationary. This illustration with tungsten indicates, I believe, the serious economic as well as engineering problems that shortages of critical and strategic minerals create.

Supply and demand

We are dependent upon economic laws of supply and demand. Serious increases in the demand for scarce materials are reflected by proportionate increases in price, and the necessity of tapping lower-grade sources can further force increases out of all proportion to normal peacetime values. Except for molybdenum, this country has never been self-sufficient in critical ferroalloy metals and minerals.

These problems cannot be solved in a short time, but this does not necessarily mean that we must lose our military potential by being forced to reduce production. The dilemma leaves us with a difficult alternative: In order to have an ample supply of scarce commodities, we must curtail unnecessary or nonessential use and redraft our plans to permit use of more abundant materials. Thus, careful planning is called for on the part of scientists and designing engineers. All of our native American inguenity will be required to keep the vast industrial mechanism we now possess in good working order.

Because we have always thought that our natural resources of raw materials were limitless, as a nation we have never seriously considered the possibility of scarcity, nor have we ever before in peacetime been obliged to ration our resources to counteract continually increasing rates of consumption. As our technology advances, and as scientific discoveries provide a more livable world, our population is bound to increase. With this increase, the demands for raw materials can reach astronomical proportions. Consequently, we must devote ever greater attention to the discovery, production, development and use of all our basic raw materials.

Within the United States we have skimmed off the cream of our higher-grade mineral deposits—those orebodies that were easily found. The price of these raw materials must be high enough to absorb the costs of search and discovery as well as extraction and refining. Increased efforts must be made to improve the techniques of extractive metallurgy in proportion to efforts directed toward improved methods in physical metallurgy.

A technologic challenge

To me, one of the most significant advances is that exemplified by the new metal, titanium, which I reported on in *Engineering and Science* several years ago (May, 1948). Recognizing the inherent possibilities of this metal, the United States Bureau of Mines obtained funds for the production of experimental quantities and for physical research on titanium products. Aside from the funds we ourselves have obtained for this purpose, the Armed Forces have transferred additional money to the Bureau primarily for physical metallurgy and for research in the application of titanium metal.

Although the raw materials from which titanium is extracted are almost limitless on the North American continent, present methods for obtaining titanium from its ore are costly and power-consuming. Our efforts with respect to this metal have been largely concentrated upon its use and applications. We have virtually neglected research in improved methods for extracting the metal from its ores. Demands for titanium which have developed over the past two or three years are now far in excess of our existing production capacity.

In an effort to solve this problem, the Defense Minerals Administration, under the Defense Production Act, is assisting at least two large companies to expand production of titanium sponge by utilizing the present known extractive processes. However, those now engaged in the production of titanium are concerned about investments in these plants; more efficient processing methods can render these installations obsolete almost overnight.

What the current mobilization program has done in effect is to plunge us into avenues which have not yet been fully opened, explored and developed technologically. Given time and opportunity for concentrated effort, there is no doubt but that the engineers and scientists of industry and Government and those in our colleges could work out more economical and speedier extractive methods, develop the proper methods of processing the metal, learn the characteristics and properties of innumerable alloys and adapt them to the great variety of manufacturing methods and needs. Here is a whole new field of great promise which challenges the technologists of the nation. I have no doubt that we will successfully meet that challenge, but the times call for intensified effort and greater speed.

Stockpiling program

It is not possible to discuss strategic mineral resources without some reference to the stockpiling program.

For many years there had been a few voices crying in the wilderness in the attempt to establish a stockpiling doctrine. Material shortages during World War I were not sufficiently acute to launch the nation into a substantial stockpiling program. It was not until a few months before World War II that the necessity for stockpiling was fully recognized and money was set aside for the accumulation of raw material stocks in this country to protect us in the event of a cut in foreign sources.

The shortages that developed, however, in World War II did lend substantial impetus to the program. Toward the end of the war, Public Law 520 was passed by the 79th Congress and this action launched the nation on a real program of stockpiling. Unfortunately, the effectiveness of the program was soon to be diminished.

The military authorities who were in charge of the program, although subconsciously realizing the necessity of it, lowered their sights in the fear that money directed to stockpiling would be diverted from the design and production of military end products. It was not until the sinister impact of Communist imperialism made itself felt across the breadth of the United States that we as a nation became properly alive to the need for having in our hands sufficient quantities of strategic raw materials to carry us over danger periods. By that time, however, the need for military production was acute and the consequent disruption of the national economy, which I have mentioned before, became evident.

Under these conditions, the task of stockpiling became much more difficult. Fortunately, the stockpile accumulation has progressed to a point where we are in a much safer position than was the case in 1941, although by no means far enough along for us to relax the procurement pressure for a minute.

In a situation like this, there is a tendency for one group to blame another for defects or deficiencies in such a program. There may be, however, some comfort in realizing that public pressure under our democratic system has been responsible for the degree of success of the program thus far. We are not all activated by logic or foresight, for it was the desire to cut down on Government spending, balance the budget, and economize generally that resulted in the decline in stockpile accumulation at the very time when we should have been pushing a policy of aggressive procurement.

Defense Production Act

The question is, what do we do now? Until the passage of the Defense Production Act last September, the only means for expanding production of critical raw materials above current industrial levels was through the use of stockpile procurement to encourage the opening and development of new raw material sources.

With insufficient funds available, the program did not get very far and stockpiling accumulations were derived largely from existing world surpluses, due largely to the low state of the industrial recovery in Western Europe and other industrial areas.

The operations of the European Recovery Program, with consequent increased industrial production, have made demands upon world supplies of raw materials approaching those of the pre-war period and far above the demands of the United States when it was contracting in the world markets for stockpile accumulations. There remains then only the solution to the problem of increasing existing capacity.

The Defense Production Act gives the President wide latitude in bringing into production new sources of critical raw material supply, and the President in turn has placed this responsibility upon the Secretary of the Interior and his agency, the Defense Minerals Administration. That agency in turn is requested to help create new industries. Naturally, everybody expects the agency to do the job overnight.

The evident solution to many of the problems involved in this program requires the use of economic tools that are entirely new in peacetime, or even during a period of partial mobilization in this country. In order to entice private capital (the Defense Production Act requires the work to be done through private enterprise and with private capital), incentives must be created to encourage individuals or corporations into a field which is notoriously speculative. Since this must be done during a time of high taxes and a shortage of manpower and materials, real incentives are required.

Because this policy necessitates committing the Government for substantial sums of money over long periods of time, programs must be developed with care and executed with finesse in order that the strength of the Government may be available to producers without subjecting them to the evils of bureaucratic control. I for one believe that the entrepreneur approach is necessary to the discovery and development of new mineral resources and this approach cannot be achieved under the shadow of exacting bureaucratic control.

The principal financial instrument for stimulating mining ventures is the assurance of a market for the ore over a sufficient period to permit amortization of investment. There must be reasonable assurance to the investor that some opportunity exists for the recovery of invested capital. To provide this assurance for the innumerable small operations in the mining industry as well as the large ones imposes a tremendous administrative burden on any Federal agency. The Defense Minerals Administration is handling the larger projects on an individual basis through direct negotiation, while developing general programs to assist the smaller units of the minerals industry without the necessity for detailed negotiations with Federal authorities.

It may be difficult for the average engineer to appreciate the enormousness of the task in establishing such a program and having it approved in our vast Government mechanism. First of all, we must have sufficient ingenuity to think up a plan that is nearly foolproof.

Last month we may have achieved something toward this objective in the tungsten program that was adopted, by establishing a ceiling price for the metal sufficiently high over a five-year period ($65) to permit production from high-cost domestic operations. At the same time a floor was set under that price by having the Government guarantee to purchase any tungsten concentrates which could not be sold on the market at $63 during the same period.

Since there will probably be no bonanza discoveries of tungsten in this country, and the demand is so greatly in excess of the present supply, this form of program for this particular material presents no serious economic hazard of an inflationary nature. However, with the bulk commodities, such as copper, lead, and zinc, iron ore, etc., the economic problems become much more difficult and the means used to stimulate tungsten production would obviously be undesirable with this group of commodities.

A national problem

I sincerely hope that I have made clear to my fellow alumni that those of us who are working in this field must be more alert than we have been in the past to the problems of supply. A handful of Government employees cannot solve the supply problem for metals and minerals. This can only be achieved through intelligent action by a well-informed public cognizant of the situation and ingenious enough to provide the solution through their own initiative. I am certain that there are very few in active research, either in the colleges, industry or in the consuming field, who cannot help.