WORLD MINERALS--METALS

29 September 1947

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CAPTAIN WORTHINGTON: Gentlemen, continuing our studies on materials, we hear today from the Chief of the Metal Economic Division, Bureau of Mines, Mr. Charles W. Merrill, Mr. Merrill.

MR. MERRILL: Captain Worthington, Gentlemen: The subject I have been given, "World Minerals--Metals," is such a broad one that I could start off in almost any direction. In order to narrow it to some extent, I will try to develop two points: First, the importance of metals to industry, civilization and defense; and, second, the strategic possibilities of metals due to their unequal distribution over the surface of the earth.

Some of the ages of development of man have been named after the metals. One of the earliest ages was probably the Bronze Age when metals first became available. Some have traced the rise of civilizations by the ability of groups to have metals at their command.

With the use of iron it became possible to arm defenders or to undertake aggressions so that metal-using groups were able to increase their power over their neighbors. As this use of metals went forward, the possibilities for the development of industry became greater and greater. We might say our own period is largely characterized by the use of metals, and the use of metals in the art of war, of course, dominates the present development of war.

The two characteristics of our time are both based on minerals--minerals for power in the form of petroleum and coal, and minerals for metals for the machines that can convert the power that we have into fabrication and for carrying on all sorts of activities, such as transportation and other useful or what we consider useful activities. Under present conditions, of course, the use of metals dominates the whole art of defense. If you were to strip an army of its metals, I suppose the first catastrophe would be taking the brass off the officers, but more serious would be removing Ordnance from the troops themselves.

Now, the availability of metals to nations can be the result of several conditions. The most satisfactory is to have mines within your own terrain which are defendable and which are sufficiently productive so that you not only supply all your needs but best of all yield some exportable surplus which permits of expansion of mine use in times of emergency such as in war.

But nations have not found it either possible or necessary to be self-sufficient in all metals. In the United States, we are more fortunate

than any other single contiguous nation, and we even rival the British Empire, which under its flag, produces much of what it needs.

If, however, a nation is short of some of its essential metals, there are several courses open to it. The commonest, of course, is importation. From a defense standpoint, imports have the objectionable feature that the trade routes through which they are channeled to the factories must be defended, and the defense of them is sometimes difficult or impossible. Even if it is relatively easy, it means that the force detailed for the defense is not available for other purposes.

Another method of assuring the availability of metals in times of emergency is stockpiling. This has the advantage that you have the materials at the most convenient points, often in a state of refinement, which makes them even more available than were the materials in the mines of your own country.

The accumulation of stock piles is, however, a very expensive process, and one that no country has carried out to a point where it is satisfactory, although stock piles have been accumulated by various countries in anticipation of an emergency. To a very, very small extent there were some government owned stock piles in the United States before the war that was just ended, and of course we do now have a stockpiling program.

Another possibility in providing metals for emergencies is to develop substitutes which would be available within the country and would be substitutable for those materials which are in short supply. There are some objections to this. First of all, of course, if a substitute were as good as the thing it was substituting for, it wouldn't be a substitute. Under the definitation of substitute, it is assumed to be inferior.

In the second place, if you take up substitutes at a time of emergency, you ask your industrial machine--including your machinery and the workers--to adapt themselves to methods which are new to them and which tend to decrease their productivity at the very time when it should be increased. However, substitution is a very, very important factor and was used with great success in Germany, and in the United States there were many substitutes used during the last war.

Last of the important possibilities is the development of low-grade noncommercial deposits. That has been put forward in the United States and offers considerable possibilities in some fields. One difficulty is that usually a low-grade deposit is noncommercial because it is highly absorbent of labor. Usually in war periods manpower is one of the critical materials, we might say, and the allocation of an extra large section of it to working materials that have a very low yield is objectionable.

Frequently, in order to avoid this issue, they use large scale machinery, which is, you might say, the American way. You then have the problem of providing the machinery, because if before that time there was no machinery used for that purpose--the needs were supplied by imports, let us say, or consumption was smaller--you have no way to develop quickly powerful excavators, shovels, and so on, to operate mines, working huge tonnages of rock in order to get very small returns of metal.

Another factor to consider in the supply of metals is the facilities for their reduction. Virtually no metals are ready for use as they occur in the crust of the earth. Usually the ore can be beneficiated by grinding it and eliminating some part of the rock which has little or nothing in it, making a concentrate. Or there are methods in which the useful minerals can be dissolved and precipitated away from the worthless rock that is with them. Frequently after the concentrate is made, you still don't have metal, but a compound such as sulphide or oxide which must be reduced.

So the second stage then would be smelting and the facilities must be available for that activity. The United States is particularly well blessed with a balanced mining and smelting industry, but there are many countries which either do a great deal more mining than smelting or vice versa. For, example in South America a very large part of the ore produced leaves the country either as ore or as concentrates to be reduced elsewhere.

The other extreme would be countries like Belgian, with a nearly dead metal mining industry but with large smelters that have come to depend on the imports of foreign ores or concentrates.

Following smelting, the next stage would be refining. Most smelters turn out a product that is not very widely usable and the material must be given the further process of refining.

Following refining, there usually is a first breaking down process into the larger shapes before fabrication. By that I include such activities as rolling, drawing wire, extruding soft metals like aluminum or lead--casting, forging. Then the last process, of course, is fabrication, which so frequently depends on imported shapes. Fabrication is rather beyond the problem I am trying to cover now.

The second major point that I will try to elucidate is the strategic possibilities of metal resources which is a function of their uneven distribution. In almost all strategic considerations, you must have some unevenness of your distribution about which to fit your plans. If one could imagine a battle being fought on a perfectly flat plain, with no water courses on it, I presume that if there were nothing but infantry

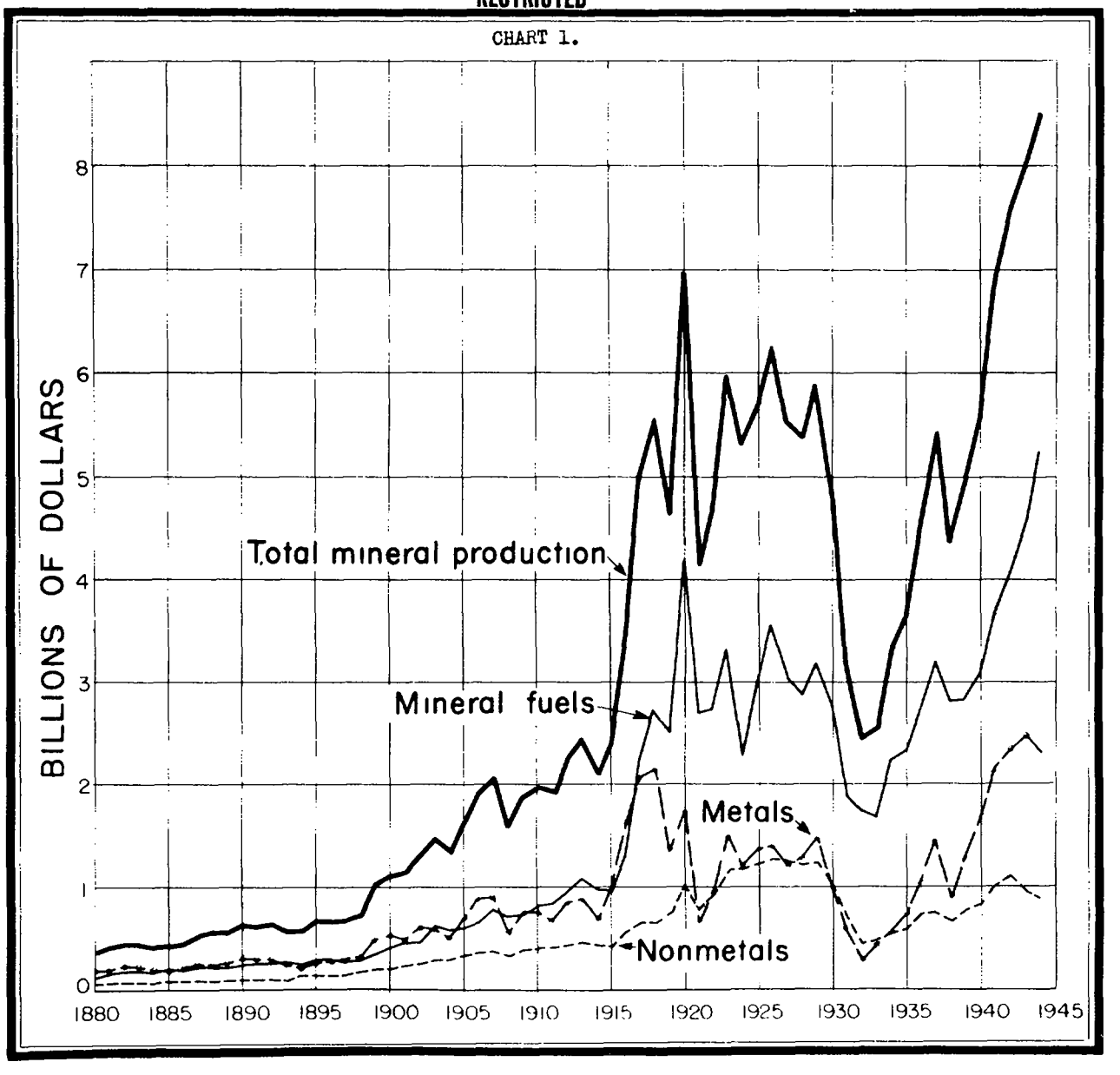
in there, it would just go to slaughter. The larger army finally would have somebody left. But if you have hills, rivers, swamps, mountains, shorelands, and so on to protect your flanks, you have the possibility of making plans, by which, if they mature more successfully than the plans of your enemy, you are able to accomplish extraordinary results with what statistically would appear to be inferior forces.

Now that same principal applies to mineral deposits. If you can arrange the implementing of your defense forces with mines which you can defend, or stock pile, and if you have arrangements for the facilities, such as the smelters, the refineries, and the other manufacturing processes, to utilize these various materials, you can have a tremendous advantage, postive advantage over those that are contesting against you. Similarly, if you can find ways to strike at the essential metal sources of those that are contesting with you, you can eliminate their strategic advantages.

In World War II there were some startling conditions of that kind created. For example, in connection with facilities when the Germans moved through the Low Countries and into northern France--the area in which so much of the smelting, particularly of zinc had been carried on—they were denied to the allied forces. In the United States there was tremendous demand for the use of facilities which were found to be more or less of the proper capacity for home consumption; it was a very serious problem to reduce the plentiful ores of zinc into usable form. Undoubtedly, that was very carefully calculated by the German General Staff in its strategic plans.

There are numbers of possibilities of improving your strategic position by the development of allies mines or in arranging for the defense of the routes by which foreign sources can be moved into your areas of manufacture, or by the development of mines within your own area, perhaps by favored treatment or subsidy, a method, which, by the way, the Germans used to a great extent in subsidizing the Hermann Goering Steel Works. These works were entirely uneconomic from a commercial angle, but very useful because they were centrally located from the standpoint of the defense position in Germany.

The following chart gives the course of mineral production in the United States from 1860 to 1944. It illustrates the tremendous rise of minerals in the United States as the country was transforming itself from a basically agrarian society into one in which the minerals were dominant and in which manufacturing based on them could develop.



Trends in value of mineral production in the United States, 1880-1944

In the earlier period, up until about 1915, you will note that the lines representing metals and mineral figures are almost parallel. The tremendous rise of the mineral figures from that time on, with the more or less leveling off of the metals illustrates two points: (1) the tremendous development of the petroleum industry for powering our automobile transportation, and (2) (perhaps more significant from the standpoint of this audience) there was a slowing down of flush production of metals. The age of discovery was coming to a close.

Of course, the metals show a big jump in 1940. This, as indicated by the chart, is in dollars and so to a considerable extent the fluctuation in value affects the curves, but the broad outlines of the thing, I think, are clear as to the points that I just brought out.

The second chart shows the self-sufficiency of the United States in the production from known reserves. This is a complete list of minerals, but we can pick out the metals from among them.

On the left, the quantity of reserves against production is shown--the number of years that known reserves could support production. On the right is the number of years that the known reserves could support the consumption. They are both at a 1935-1944 rate of production and consumption, that being a period which would include a considerable period of what we might call normal peacetime and a period of our highest capacity in war.

Now at the top of the list we have an unlimited source of supply of magnesium. Magnesium being made from sea water, there is no limit to that. As a matter of fact, as fast as one pumps out sea water and takes magnesium out of it, I presume, it is enriched from the rivers, carrying magnesium, as it is leached out of the earth.

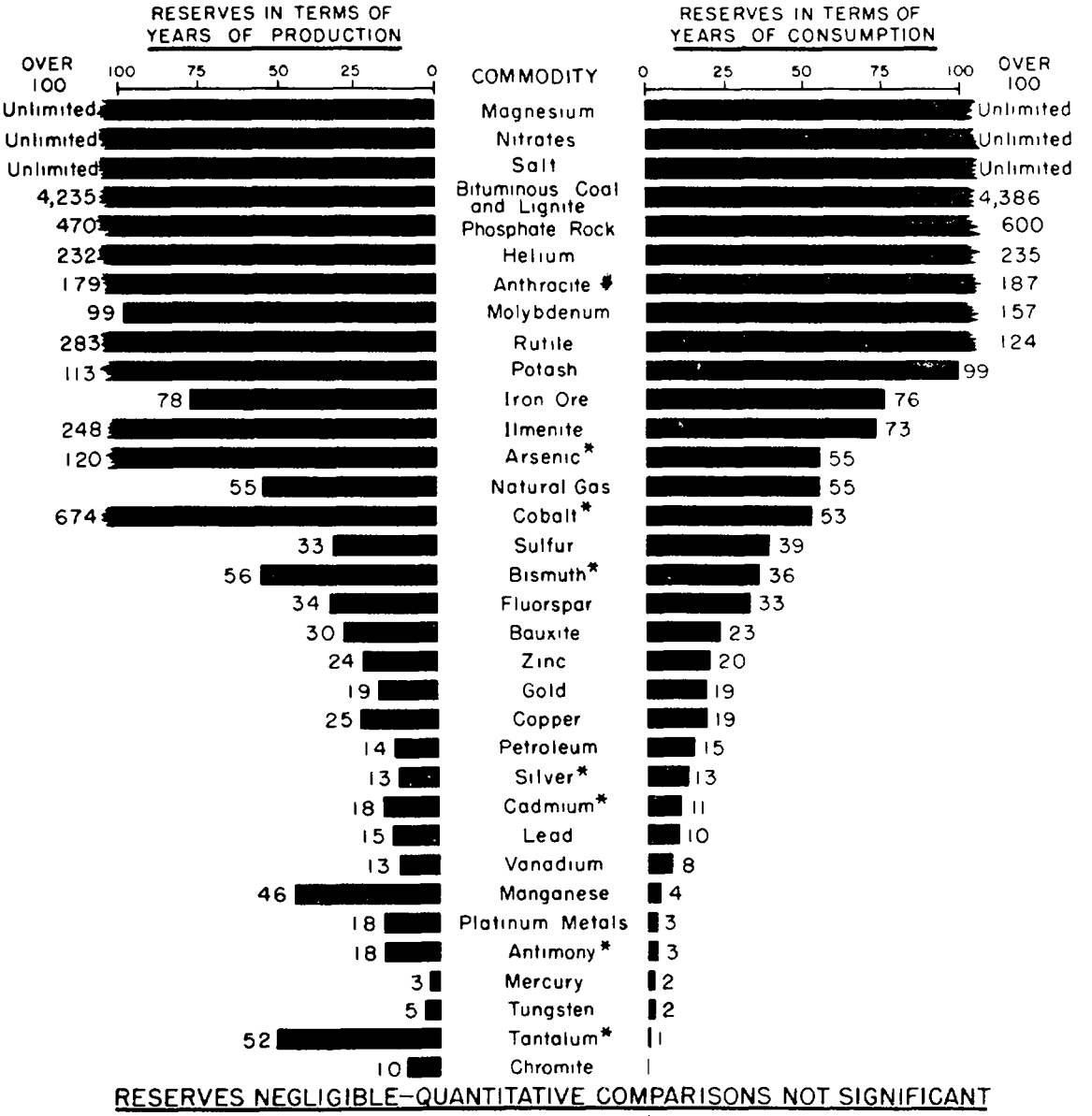
Next on the list is molybdenum which is produced largely at Climax, Colorado, although 25 to 30 percent is produced as a byproduct of some of the large copper mines in some of the other Western States. In this we have a 99-year supply at the rate of production during that period and a 157-year supply at the rate of consumption. The reason that the supply is longer for consumption is that we have a large export which we have to supply out of our production--or which we do supply. Molybdenum would be in that happy state where we have a large exportable surplus so that no matter what the emergency was, we would undoubtedly have the capacity to meet it.

For iron ore the figures are 73 years and 76 years. I don't know that there is much need of reading them down until we pick one farther down--take zinc, for instance, 24--and 20-year supply. That is beginning to get short enough so that it would cause some concern. It must

CHART 2.

ESTIMATED "COMMERCIAL" RESERVES AS OF 1944, IN KNOWN DEPOSITS, COMPARED WITH 1935-44 ANNUAL RATES OF PRODUCTION & CONSUMPTION

Figures indicate only order of magnitude of estimated reserves They do not imply that production at rates indicated could be maintained for the full period shown Estimates do not include allowance for future discoveries



RESERVES NEGLIGIBLE—QUANTITATIVE COMPARISONS NOT SIGNIFICANT

Mica (Strategic)
Asbestos (Long Fiber)
Graphite (Flake)
Nickel*
Tin
Diamonds (Industrial)
Quartz Crystal

*Obtained chiefly as by-products Output dependent on rate of production of associated metals

not be assumed, however, that these figures illustrate the ultimate return. There are still discoveries. There are the possibilities of finding methods by which lower grade ore can be worked. Prices could rise and make possible the operation at present cost of areas now too low grade to be economic, and there are other possibilities.

Of course, in cautious mine development a company does not go out of its way to determine its entire possible reserves, but merely carries enough reserves, if it can, to allow for careful planning, with facilities for their reduction, so that while some of those figures seem very short, we might say that all of them indicate a minimum period for which the material could be supplied.

There is one other factor to take into consideration on that, and that is, if there were no further discoveries and no change in the economic balance, no subsidies, it would not be possible in most instances to exhaust the supply in the period of time indicated. A mine does not lend itself to to be worked out according to a schedule that somebody would determine. It has a characteristic exhaustion rate of its own; particularly if it is a vein, only the edge of it can be attacked. Even if the United States wanted all the content of a vein in one particular year, it might have to be satisfied with a maximum rate of exploitation that would take 50 years before the materials would be removed a mile or so deep.

The third chart illustrates the self-sufficiency of the United States with repect to a number of the important minerals. Speaking of the metals only, we find that the top of the list is molybdenum. The upper figure gives the ratio of production to consumption during peacetime; the lower, during a wartime period. It will be seen that there is an exportable surplus of molybdenum even in wartime--27 percent excess in wartime; 194 peacetime.

But the drop down the list is not very far before we begin to find a deficiency in wartime. Copper shows it, and even in peacetime the surplus of copper is small. The principal reason for this deficiency is not the lack of mineral blessings, but the tremendous development of American industry. In many of the metals, the United States consumption is half of the world's, despite the fact that we occupy only about five percent of the land surface and have only about seven percent of the world's population.

Down towards the end of the list, of course, we find some of the metals, of which there is a complete lack, whether it is under war conditions or peace, as with tin. You find another interesting reversal in the case of chromite, where the peacetime production to consumption shows a blank bar, but in wartime, due to subsidies and special stimulation, we find we do better.

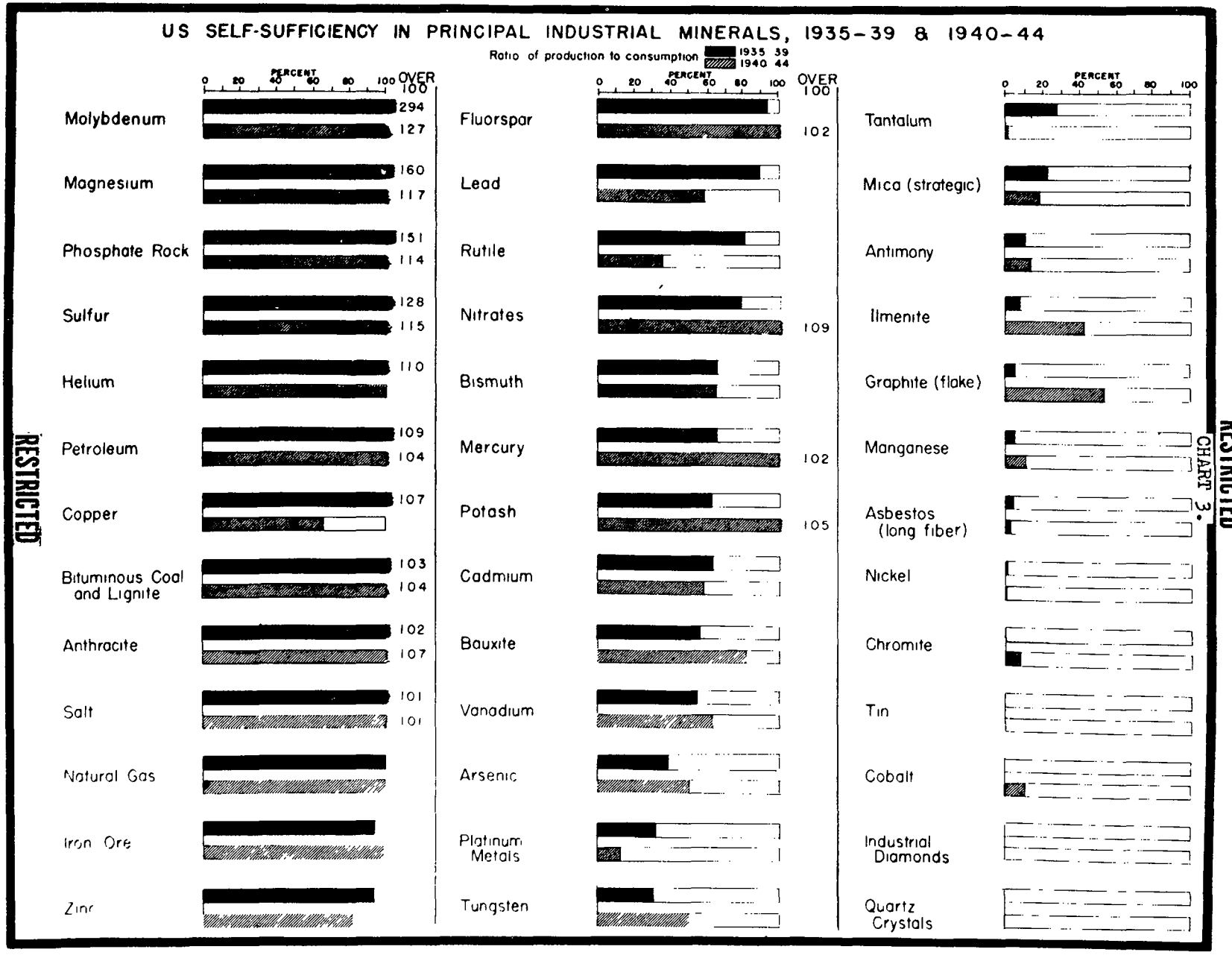


CHART 3.

RESTRICTED

On the fourth chart the various minerals have been classified in several groupings with respect to the United States self-sufficiency.

I thought that in closing I might take two or three principal minerals and discuss them specifically against the general pattern that I tried to outline here. Take the mineral copper, for example, which is one of the most important of the metals both in peace and in war, our domestic resources are great enough to give us a slightly exportable surplus under peacetime conditions, but during the war we had a considerable deficiency. At the present time we are not able to produce as much as we need to supply the deficiency accumulated during the war and to fill the so-called pipe line that was drained dry.

We are in a very good position to import copper. United States investment capital has gone out and is extremely active in the development and the management of foreign mines. If the trade routes could be kept open, we would have an excellent source from abroad.

Fortunately, there are large resources in Canada; also great resources in Chile; some in Mexico. The trade routes from all of those would be expected to be among the ones to defend more easily.

With respect to the stockpiling of copper, it is included on the strategic list, but the objective is not made known. The progress in obtaining it is not reported specifically so far. Because of the ruling in Stockpiling Act that reconversion must not be interfered with, there has been virtually no progress made.

As to substitutes for copper, there are some considerable possibilities, particularly if the present pattern of prices persists. Aluminum is substitutable for copper for a number of uses, which include some of the electrical uses. If aluminum stays at 15 cents and copper at 21.5 cents--which more or less reverses the two to one ratio of price that was the commonplace of the thirties--aluminum will undoubtedly make considerable advancement in the formerly exclusive copper market.

As to the development of low-grade ores as a source of copper, if the present deposits are worked out, I believe that there are considerable possibilities. There has been a discovery of a very low-grade ore in Arizona made within the last two or three years. It is the only first-class discovery in almost twenty-five years in copper, but this ore is very low-grade. In fact, I think it is uneconomic, although this is not definitely known, by the prices existing in the thirties, but under present prices the owners are pressing forward to develop the ore. This is a deposit large enough to supply all the needs of the country for two or three years, which is a considerable contribution for a discovery developed within that period.

CHART 4.

U S MINERAL POSITION—ACTUAL, IMPENDING, AND POTENTIAL

Based on known "commercial" reserves, outlook for noteworthy discovery, and the possibility that known submarginal resources can be made available by technologic progress and improved economic conditions

RELATIVE SELF-SUFFICIENCY

ACTUAL AND IMPENDING

(Based on present technologic and economic conditions and on known "commercial" reserves)

A VIRTUAL SELF-SUFFICIENCY ASSURED FOR A LONG TIME

- Bituminous coal and lignite
- Anthracite
- Natural gas
- Magnesium
- Molybdenum
- Fluorspar (metallurgical)
- Helium
- Magnesite
- Nitrates
- Phosphate rock
- Potash
- Salt
- Sulfur

B COMPLETE OR VIRTUAL DEPENDENCE ON FOREIGN SOURCES

1 Small or remote expectation of improving position through discovery

- Chromite
- Ferro-grade manganese
- Nickel•
- Platinum metals
- Tin
- Industrial diamonds
- Quartz crystal
- Asbestos (spinning quality)

2 Good expectation of improving position through discovery

- Cobalt•
- Graphite (flake)

C PARTIAL DEPENDENCE ON FOREIGN SOURCES, ACTUAL OR IMPENDING

1 Good expectation of improving position through discovery

- Petroleum
- Arsenic•
- Bismuth•
- Cadmium•
- Copper
- Iron ore
- Lead
- Mercury
- Tantalum•
- Tungsten
- Zinc
- Fluorspar (acid-grade)

2 Little hope of improving position through discovery

- Antimony•
- Vanadium
- High-grade bauxite
- Strategic mica

• *Domestic production chiefly byproduct*

POTENTIAL

(If technologic and economic changes permit use of known submarginal resources)

A VIRTUAL SELF-SUFFICIENCY

- Bituminous coal and lignite
- Anthracite
- Natural gas
- Petroleum
- Aluminum ores
- Copper
- Iron ore
- Magnesium
- Manganese
- Molybdenum
- Titanium
- Vanadium
- Fluorspar (all grades)
- Graphite (flake)
- Helium
- Magnesite
- Nitrates
- Phosphate rock
- Potash
- Salt
- Sulfur

B COMPLETE OR VIRTUAL DEPENDENCE ON FOREIGN SOURCES

- Platinum metals
- Tin
- Industrial diamonds
- Quartz crystal
- Asbestos (spinning quality)

C PARTIAL DEPENDENCE ON FOREIGN SOURCES

- Antimony
- Arsenic
- Bismuth
- Cadmium
- Cobalt
- Chromite
- Lead
- Mercury
- Nickel
- Tantalum
- Tungsten
- Zinc
- Strategic mica

Now in the facilities for handling copper, the United States is very well supplied with smelters and refineries, and with the various mills for rolling, drawing, casting and forging. As a matter of fact the United States has done a good deal of the smelting, refining, and primary rolling of copper for the world. Until recently, most of the copper came to the United States in a rather low state of preparation for use from South America, and some even came from Africa to the United States.

There is a very strong tendency, however, on the part of all countries to round out their industrial machines, so that there will be a tendency for the United States to become less and less dominant in the reduction of copper.

As to the maldistribution or the unequal distribution of copper as a factor in world strategy, the United States position is excellent. We have enough for peace and almost enough for war. There is no potential enemy of the United States that would have within its borders enough copper to sustain a war effort anywhere near the one that could be sustained within the United States. Almost half the production of copper before the war was in the United States. Now it is somewhere near a third.

Very large foreign deposits are in Chile, which is hardly a world threat, and in Central Africa, the Belgian Congo, and Rhodesia, in which an industrial war would not be likely to be launched. There are other copper deposits scattered through Europe, but they are of minor extent compared to what is available in the United States.

Undoubtedly some of the imperialistic expeditions of the countries of Europe have been based on a desire to improve their position in copper. It helped round out the British Empire to have control of Rhodesia, and undoubtedly Belgian obtains a great deal of power by its control of the Belgian Congo.

I might take up one more very quickly before the questions, taking another type of commodity that is just the opposite of copper with respect to the United States--tin. The domestic production of tin at all time would probably supply the United States for a week, so you might say, we are without tin. When war broke out, we had virtually no facilities for the reduction of tin concentrates, so we found ourselves without any tin and without any government-owned stockpiles of tin, and without any smelters by which we could handle ores or concentrates which we might be able to rake up somewhere for reduction into usable tin.

The last was remedied during the war by the Government building a plant in Texas which it has had to run under very unsatisfactory conditions, because the intake of ore doesn't blend well. The operators have

to accept lower-grade varieties which are refined at a cost considerably in excess of what competitors smelt for abroad.

In an instance of that kind, it would appear that the only safe defense move would be extensive stockpiling, and with such attention as could be given to the keeping open of trade routes or the maintaining of friendships with such areas as Bolivia--the great producer of tin in the Western Hemisphere--and the other great area in the Far East, the Dutch East Indies and Malaya. As a matter of fact, these Far East deposits were so completely indefensible against attack by Japan that they were unavailable to us within a few months of Japan's entry in the war. Tin was a splendid example of just how the conquest of territory outside this country can make it difficult for us to wage war.

We did foresee the war coming. There were great encouragements given to industrial companies to over buy on tin, some of our allies had tin available to them, and we had smelters available to us in Great Britain. So we squeaked through better than we might have.

The control of tin by other countries has been an extremely important part of their imperial programs. The English, of course, are finding the Malaya area in peacetime one of their principal sources of dollar credit because the United States consumes about half the tin of the world. The British can mine a great deal, smelt it, and deliver it to the United States for dollars.

I think I have exhausted my time, so I will close with that statement.

CAPTAIN WORTHINGTON: Ready for questions.

Questions: You mentioned that the Bureau of Mines was doing a certain amount of stockpiling of minerals and metals. Could you give us some idea as to how this is done, who does the planning of the type and quantities, who pays for it--I presume the Government--but does private industry have a part in the planned stockpiling? Just give us an idea of the procedure.

MR. MERRILL: In the first place I was a little bit careless in my use of words when I said "we." When I was speaking of "we", I was speaking of the Government, not the Bureau of Mines. The Bureau of Mines has no direct part in stockpiling. The stock pile program is under two Laws. One is Public 520; the original Stockpiling Act, Public 117 of 1939.

First, the Munitions Board (formerly the Army and Navy Munitions Board) is set up for the planning. The Board has set up two types of committees. One of them is made up of representatives of various government agencies which give advice. The Interior Department is represented; Agriculture because of the Rubber Plan, and Commerce because of the Trade

angle, and so on. Then there is another set of committees known as Industry Advisory Committee made up of representatives of private industry.

These advisory committees are made up of some ten to twenty men each for each group of committees. There is one known as the Nonferrous Group in which about ten metals are included; the Iron and Steel Committee, which takes up only iron and steel problems, and so on. I think there are about fifteen committees. The thing is enormously complicated. There is a document gotten out by the Army and Navy Munitions Board which outlines the full hierarchy of authority. I guess that there must be 500 representatives listed in it. I have a sort of a worm's eye view, being on two or three of the interagency committees and I have to see them and the Industry Advisory Committees in operation.

Now, the Board, with the advice of this interagency committee and the advice of the Industry Advisory Committees, finally set out objectives to be gained. The thing is implemented by appropriations from time to time by Congress. At present, I think, that $275,000,000 has been made available for cash purchases and contracts beyond the fiscal year.

These funds are allocated to the various programs, and the actual purchasing is done by the Treasury Department. That department has a special organization which is purchasing for stockpiling, and it wants everybody interested to submit plans for supply. It puts out invitations to bid. It makes special, almost across-the-table contracts for supply, particularly for those commodities which are hard to supply on specification, and where it has to have special concessions for extra good grade, and one thing or another of that kind.

I believe some progress in accumulating bauxite is being made. In one of the laws it states that when any material belonging to the Government is declared surplus, it automatically is available to the Army and Navy Munitions Board for stockpiling. I guess the mercury objective may be very nearly met because there were huge quantities of mercury in the United States for the new mercury battery which was going to be used in a big way in the South Pacific, and which was only invented in 1944 or 1945. That mercury was in the hands of the Government which had no use for it, hence the mercury moved into the stock pile.

QUESTION. Would you pursue that a little further? Is there such conflict between the Government and private industry?

MR. MERRILL: The law provides for that. It states that the Government cannot purchase until material is declared to be in such surplus that purchases will not hinder reconversion. I think it is the CPA--I guess it is not in existence any longer--or some successor to it that makes such determination.

Incidentally, the things that are most needed in the stock pile are almost by definition the things that are in short supply, so we have a stock pile that is overloaded in materials that were more or less borderline strategics in World War II and devoid of some of the materials that are most seriously needed. If we are given a period of peace of ten or twenty years, and if Congress can keep up its interest in defense sufficiently to supply something in the neighborhood of two billion dollars to accumulate this stock pile over that period, why, you can expect a very logical and fully accumulated stock pile, but it is a very, very difficult problem, as I see it, both politically and economically. If there is a hazard of early war, it is a very difficult thing of timing.

QUESTION: You spoke of having adequate magnesium supplies from sea water. Could you expand a little on research and development and the possibilities of obtaining any metals from sea water besides magnesium?

MR. MERRILL: There is no important metal that could be hoped to be gotten from sea water except magnesium. The other metals are such things as calcium, and particularly sodium, which are not very widely used for anything at all and are available in enormous quantity from other sources. Sea water, of course, has been put forth as a source of gold and other things for a long time, but there is not much of anything metallic in sea water but salines, and of these only magnesium is used in very large quantity.

MR. MESSELMAN: What plans are there in existence to meet the shortage of high-grade iron ore when the deposit in the Masabi Range peters out?

MR. MERRILL: There are several plans. There are major reserves, of course, in the Lake Superior area where they have developed what they call taconite. The high-grade ore there is encased in rocks which run twenty to thirty percent iron. The iron oxide in taconite is very intimately mixed with silica, but by fine grinding it has been found possible to separate the two. After they are separated, some method has to be found for agglomerating them to prevent their being blown out of the furnace when they are smelted. The problem is more economic than it is technical, though it might be that some extraordinary technical trick would be hit upon that would cut down the cost greatly and make it suddenly economic.

It is my guess that what will happen is that as a result of the slowly applied pressure of higher and higher prices due to shortages of high-grade supplies, other possible sources will be considered competitively and we will have the possibility of importing high grades from abroad, or possibly let some of our iron and steel industry leave the country and import some foreign iron and steel. That doesn't sound very likely to me, however.

Perhaps we will develop sources in Canada where some very large discoveries have been made. We might move the steel industry to points where they could take advantage of deposits which are now too far from the great centers. Our steel industry is largely an interior industry, which from a defense standpoint is excellent, but from the standpoint of access to world supplies is very bad.

There are two possibilities there: Either we could increase the facilities on the Atlantic or Pacific seaboard or we could dig the St. Lawrence seaway and give easy access to world ships into the Great Lakes area, where, by the way, the better coals are available for coking. So far as markets are concerned, they would be rather evenly distributed.

QUESTION: I noted from one of your charts that the supply of bauxite will last about twenty-three years at the 1935-1944 rate. Some other sources give it even less than that. Can you tell us anything that is being done to improve the aluminum supply?

MR. MERRILL: Well, one reason that figure is rather large in the chart is because of certain grades that are included which will be very difficult to use without great expense. They have a high silica content which makes excellent abrasives but they are not very good for metal. However, the chart does not get down to such details as what would be the most commercial way of utilizing what we have.

Now, the possibility of sources of aluminum in the United States have been very carefully studied. The bauxite possibilities are probably pretty well delineated. There are two other important possibilities, which are noncommercial. At least they never have been commercial. One is alunite, which is a mineral found in desert areas in Utah and which has been a sort of a perennial invitation to promoters and perhaps to more serious scientists; and then there is the possibility of making aluminum from clay.

You can go out in any backyard and get ten to twenty percent ore with a shovel. The trouble with backyard material is that it is not commercial.

There are other possibilities. There are apparently tremendous bauxite resources abroad. In the Caribbean area there have been large quantities developed and the Guianas have a large supply left; there are also large but unmeasured deposits in Brazil; also some of the Japanese Mandated Islands, which we now control, appear to have a great deal of undeveloped bauxite. There is some in the Dutch East Indies. As soon as world trade gets on an even keel we can ship material all over the world for hardly any cost. Almost any Bauxite that is at tidewater could be within a dollar or two a ton of being competitive with what is being used. One of the problems, of course, is the return haul for ships bringing this bulky material to the United States.

Then in Europe there are very large bauxite resources, but the trouble there is that it is a little different type, and our reduction plants can't handle it without extensive changes. It is what is known as the monohydrate type, on which the industry was first developed in France. The word "bauxite" comes from the name of the town of Baux in southern France where bauxite is of this other type. Whether or not we would want to convert to use it, I don't know. The problem is largely a commercial problem. If we are willing to pay a little bit more for the stuff, we have a great many ways to solve it.

There is one other serious problem in the bauxite business. That is that one of the main constituents of aluminum is power, and power gets more expensive as you get nearer industrial centers. It becomes cheaper where it is going to waste in waterfalls at the fringe of industrial civilization. The more likely pattern of development—if the areas were defensible--would be to put the large reduction works in such places as Northern Canada perhaps, or along the coast of Norway, or in the Amazon Valley where there is a tremendous waste of hydroelectric resources and where people would be glad to get just a few mills, as against plants in the United States where the power can be much more advantageously sold for machine operation which requires a large population for the machine tending.

CAPTAIN WORTHINGTON: We are very much indebted to you, Mr. Merrill, for giving us the value of your extensive knowledge of the subject. Thank you very much.

(13 October 1947--450)S/MnG