NONFERROUS AND LIGHT METALS RESOURCES OF THE WORLD

1 October 1953

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DR. CLEM: Gentlemen, this morning we advance one step further in our study of natural resources by examining the situation on relative to nonferrous and light metal materials. While no one of the metals which ordinarily fall in this category is used in the same large quantity as steel, yet, taken as a group, they represent an important and integral element of our everyday economy, and, furthermore, they stand high on the list of those materials which we regard as essential to our national defense and that of the free world.

To discuss this subject for us this morning, we have with us a gentleman who, as a geologist, an author, and editor, and a minerals consultant to both private industry and the Government, has had an extensive and varied career in the minerals field. At the present time he is serving as Manager of the Information and Analysis Department of the Battelle Memorial Institute, Columbus, Ohio.

It is a pleasure to present to you Dr. Richard J. Lund, who will speak to you on the subject, "Nonferrous and Light Metals Resources of the World."

DR. LUND: Mr. Clem, gentlemen of the Industrial College: It is a great privilege, I assure you, to be here to participate in this important program. I have heard much of the work of the college here from my good friends Elmer Pehrson and Dr. Leith, under whom it was my privilege to study a good many years ago at the University of Wisconsin and who, I think, has participated frequently in the discussions here on the subject of minerals.

The subject of our talk this morning is exceedingly broad in scope. Even within 40 minutes we are going to have a chance to hit only the high spots, leaving the opportunity to go into a little more detail on certain subjects in the question period thereafter and in the discussion period this afternoon.

I shall start by giving a quick view of the geography of some dozen of the important nonferrous metals by means of slides which will show you the world pattern so far as production is concerned. I am going to include in the nonferrous metals nickel, tungsten, molybdenum, and chromium. I will give one slide on manganese. Except for manganese, these others assume more and more importance in the nonferrous field because of their use and importance in the so-called superalloys where they frequently are not used with iron.

As we go through the slides, I will try to give you a few of the highlights of recent and planned capacity boosts and any important changes in the production pattern as shown on the maps; a brief review then of the reserve picture by main geographical areas; a brief discussion on the free world situation versus the Soviet bloc situation; and finally end up with a few brief comments on the implications regarding United States policy.

First, with respect to the geographical distribution of these nonferrous metals. Many of you may recognize these slides. The information on them was taken from the "Atlas of the World's Resources," Vol 2, by Van Royen, Bowles, and Pehrson in collaboration with the Bureau of Mines, published by Prentice-Hall in 1952. These slides give the picture, representing averages of several years and those years are not all the same. Some of them go back into the thirties and early forties. Most of them are for the early forties, and I will try to give you any important changes that have taken place since then. Actually, the pattern hasn't changed much since those earlier years. The capacities have been increased in those areas that have been important generally in the past, with some exceptions.

So with that introduction, let us go, please, to the first slide, showing the world mine production of copper. (Slides were not reproduced; "Atlas of the World's Resources," Vol 2, is available in ICAF Library.)

Slide 1--we see, of course, that the whole picture is dominated by the United States, Canada, Chile, and South Africa. Those three regions of North America, South America, and the southern part of Africa--the Belgian Congo and Rhodesia--are the big areas in the world copper picture. That hasn't changed much since the slide was prepared. It represents the average for 1937, 1941, and 1945.

The 1951 mine output, world total, amounted to just under 3 million short tons of copper. The United States produced in 1951 about one-third of that--32 percent; Chile was next with 14 percent; Northern Rhodesia, 12 percent; the USSR, about 10 percent; and Canada, 9 percent.

The expansions planned for copper, either under way or presently planned for the future, total just under 900,000 tons--the figure is 865,000 tons for the actual areas that I have covered. That amounts to about a 30-percent increase over the output in 1951. Out of that 865,000 the United States expansions will give an increase of some 320,000 tons. Our own production was just about a million tons, so it represents about a 32-percent increase in our own capacity to produce.

The important developments are briefly the San Manuel in Arizona; Greater Butte in Montana; Lavender Pit in Arizona; White Pine in Michigan; Gerington in Nevada; those being the important ones in this country.

Canada will increase its capacity by some 54,000 tons by 1955, with important developments in the Gaspe Peninsula, in Quebec, and at Lynn Lake. South America will add to its capacity by some 350,000 tons, 250,000 of which are pretty definite; the other 100,000 tons are somewhat doubtful. The Chuquicamata copper development down in Chile is the big new development in that area where they are planning this big increase to take into account the change in the ore body from the oxide type near the surface to the sulphide type lower down. This, of course, involves a different type of beneficiation. That is just under way at the present time and will extend their reserves tremendously.

In Africa the northern Rhodesian developments will amount to some 130,000 tons additional and Australia has a small amount, some 10,000 tons.

Slide 2--the second slide simply shows you the pattern of world smelter production of copper, and you see there is not much difference from the mine output pattern. Most of the copper is smelted pretty close to where it is mined. The refining picture would be somewhat different, but we are only going into the mining and smelter picture.

Slide 3--turning now to lead, we see again that the North American continent dominates the picture, with Australia also being important. Western Europe has some importance, along with the USSR, but North America and Australia are the two big elements in lead, South America not being nearly so important as it was in the case of copper.

The total 1951 world mine output was about 1,847,000 short tons, of which the United States produced 21 percent; Australia, 14 percent; Mexico, 13 percent; and Canada, 9 percent. So we have an awful lot of lead right on our own continent of North America. Major expansions are in Southeast Missouri, Quebec, and New Brunswick, and the Tsumeb production in Southwest Africa will increase the importance of Southwest Africa in the world lead picture in the future.

Turning briefly to the world smelter picture for lead, there is very little difference between the pattern for mine and smelter production.

Slide 4--now going quickly to zinc we see the same general pattern, lead and zinc being associated together geologically. The same general picture shows up on the world map--North America, Australia, and Germany. The total world mine output in 1951 was about 2.5 million tons, considerably more than lead, but a little less than copper, which was 2.9 million tons.

The United States produced 27 percent in 1951; Canada, 14 percent; Australia, 9 percent; and Mexico, 8 percent. Expansions are

largely involved in smelter modernization programs and in new electrolytic refining capacities going up in various parts of the world. Considerable mine expansion is going on in Pennsylvania, Washington, Virginia, and Tennessee in this country; New Brunswick in Canada; and at Tsumeb again in Southwest Africa. The smelter picture again is quite similar, with probably a little more difference than in the case of lead. We see a little less smelter capacity in Australia. There is a lot of movement of concentrates from Australia to European smelters and from the South African producing countries to Europe and the United States. The Mexican picture, you see, is important. The capacity is much less for smelters than for mines, this material generally coming to the United States for smelting.

Slide 5--our next material is aluminum. We start out, so far as raw materials are concerned, with bauxite. We see a great preponderance of capacity in the United States and in the northern part of South America, British Guiana, and Surinam. This, of course, is a bit out of date now--1938, 1942, and 1945 were the years covered by the chart. In western Europe, Yugoslavia, France, Italy, and Hungary are the important producers. Hungary is the biggest in Europe. Indonesia is also an important source. Since then, perhaps the most important development is the Jamaican reserve of a little different type of bauxite, high in iron, low in silica which requires a somewhat different type of processing. There is a tremendous reserve being developed in the island of Jamaica. An aluminum plant just completed there will serve to supply the Alcan needs at the Kitimat, B. C. reduction plant now being constructed in Canada.

There is also a very sizable amount of high-grade reserves in the Gold Coast of Africa. The British have announced plans to exploit this and to reduce the ore to metal by using sizable hydroelectric resources there.

The total world production of bauxite in 1951 was about 10.6 million tons, the estimated aluminum content being about one-fourth of that or a little over 2.5 million.

Going to the picture of the metal itself, we see again quite a different pattern from that represented by bauxite, a great preponderance of the smelter production or the reduction capacity of the world being on the North American continent, the United States and Canada, with western Europe the other principal producer.

Of the total production of metal in 1951 of just under 2 million tons--all of these tons I am giving you are short tons, incidentally--the United States produced 43 percent; Canada, 23 percent; and the USSR, about 11 percent. That meant that roughly two-thirds of the world output of aluminum in 1951 was represented by the United States and

Canada. Since then certainly our own expansion has been much more rapid than that in other parts of the world, so that our percentage of world production has gone well up since 1951.

In expansions the United States had a goal of 1,544,000 tons by 1955. This goal was boosted about a year ago to about 1.7 million tons, but this third round involving an increase of some 200,000 tons has been somewhat stymied and we are not too sure just how much of that goal is going to be reached. This whole program, just assuming the 1955 goal of 1.5 million tons, will mean doubling the capacity in the period 1950-1955.

In Canada, you have all certainly read about the tremendous development at Kitimat in British Columbia. The ultimate goal is some 500,000 tons of metal. That will ultimately better than double the Canadian production.

I have mentioned the development of Jamaican reserves of bauxite. Actually, a plant has gone up and I think is now in operation on the island of Jamaica to convert the bauxite into alumina for shipment to the plant of the Alcan company at Kitimat.

I mentioned the Gold Coast development where the British are seriously considering an African plant and the building of power facilities there to make use of the bauxite in that area, with an estimated capacity on the order of 200,000 tons per year. That may take a lot of time to come, however.

Slide 6--going now quickly to tin, which is still considered to be such an important metal strategically--shows the world mine production pattern for 1929, 1936, and 1938, which, you see, centers predominantly in southeastern Asia, Malaya being the largest by all odds; China and Indonesia being second; Indo-China being very small; Bolivia, the Belgian Congo, and Nigeria.

By and large the same pattern still holds. There was a great interruption in the supplies during World War II, but since then output from southeastern Asia has bounced back. During the last five years or so, world production of tin (1948-1952 inclusive) has exceeded actual world consumption (not including stockpiling, of course) by some 28 percent. Most of the balance has gone into the stockpile.

The 1951 mine output of tin was 185,000 tons. Malaya produced about 35 percent; Bolivia, 20 percent; and Indonesia, 19 percent. Among those three countries you have about 75 percent of the total world supply of tin.

Slide 7--this next slide shows smelter output. It shows a very different pattern. The Malaya smelter output dominates the entire picture and western Europe being about the balance, with a small output in Indonesia and Australia. This is not up to date. It does not show the capacity of our Texas City tin smelter in the United States which would amount to a very substantial sized column on this slide, with a capacity--depending on what type of concentrate is used--of up to 70 or 80 thousand tons, almost half the world output. The normal production at Texas City, utilizing lower-grade Bolivian ores, is 30 or 40 thousand tons a year.

Actually, right now, the main problem in tin is one of excess capacity rather than excess demand, and the prices, as you probably have noted, have broken badly since decontrol.

Total United States stocks in April 1953 were 214.000 tons of which the trade estimates the government stockpile is around 180,000 tons. This figure of 214,000 tons represents about five times the United States 1952 consumption of primary tin, so this is really a huge stockpile of tin that is in the United States.

Slide 8--going quickly now to some of the other nonferrous metals, the nickel picture is dominated almost entirely by Canada. World output was 190,000 tons in 1952, Canada producing about 80 percent; USSR, some 14 percent; and New Caledonia, 6 percent. We have heard a lot about expansions. Nickel has been perhaps one of the shortest and most critical metals in the past several years. International Nickel has gone ahead with a sizable increase in its capacity; Nicaro has been reopened in Cuba; Sherritt Gordon at Lynn Lake; the Hanna operation in Oregon; the Falconbridge development in Canada. All these expansions will tend to push up nickel production and capacity in the next few years by something of the order of 50 percent.

Going on now to a few of the others that are sometimes considered in the ferrous field, tungsten is pretty well scattered all over the world. China has been the dominant part of the tungsten picture in the past but is now part of the Soviet bloc. You can see the importance of Korea in the recent tungsten picture, and it remains so. Equally important are the United States and Bolivia.

World production was about 17,000 tons in 1952, with China, 36 percent; United States, 13 percent; Portugal, 9; Bolivia, 7; and Korea 6.

Slide 9--molybdenum production is dominated by the United States where over half of our capacity is located at the important ore body at Climax, Colorado. Recently I think somewhat more than half of our output for current needs has come as a byproduct largely of copper mining operations. Important expansion is going on in the Climax mine in Colorado. That will boost the capacity substantially in the next few years.

Slide 10--chromite is pretty well scattered, but the USSR was the predominant producer in the years 1939, 1942, and 1945; South Africa, next; Turkey, very important; Yugoslavia; the Philippines in the refractory chromite field was very important; and Cuba was very important at that time. There is not too much change in that picture, except for the important increases in the South African supplies, Turkey, and the Philippines to take into account the loss of our supply source since the USSR cut us off several years ago.

Just a brief word on manganese. You see the importance of Russia in that picture; India; the Gold Coast of South Africa; Brazil, a smaller amount. Here again we have been doing without Russian supplies, made up for in recent years by larger supplies from India, the Union of South Africa, the Transvaal, and the Gold Coast. Important developments under way in Brazil will supply large amounts in the future. There Bethlehem Steel Company has been developing the Amapa deposit in the northern part of Brazil, and United States Steel has just recently concluded negotiations to develop a deposit in Central Brazil. This involves a very long trip down a river in barges.

I think we will skip some of the others and just consider now--since you are especially interested in the light metals field--the magnesium picture, for which I have no slide. This is very much a coming metal in the light metals field. World production in 1952 amounted to 166,000 tons, with the United States producing almost two-thirds of that--63.5 percent. The USSR is estimated to be in second place, but we don't know too much about this, except that a couple of magnesium plants in Germany have probably been moved over to Russia and are probably producing magnesium over there to the extent of maybe a quarter of this output in 1952, perhaps to the extent of 30 or 40 thousand tons. A small production comes from Canada and Great Britain.

The United States output has been pushed up from something on the order of 16,000 tons in 1950--short tons again--to 105,000 tons in 1952, mainly through the reopening of government plants, many of which are high-cost operations. Many of these have since been closed down again. So the 1953 output may be less than the 1952.

Titanium is a very important metal in the light metals' field which is coming along a little slower than, I guess, everybody hopes. The important raw material is the mineral ilmenite. While world production of titanium concentrates was just under a million tons in 1951, the titanium content was just under 300,000 tons. The United States share of that in 1950--I don't have the breakdown in 1951--was a little over 50 percent; India, 27 percent; and Norway, 13 percent.

We don't have time to trace the development of the titanium picture in the United States, where we saw our self-sufficiency really develop during World War II from complete dependence, virtually, on India in the past to practically self-sufficiency through the development of New York deposits, Florida deposits, and later, just recently, the Allard Lake deposit in Canada.

For the metal itself, the United States has a goal of some 25,000 tons of metal to be produced in 1956. The estimated output in 1953 is going to reach only about 2,500 tons. This means that between 1953 and 1956, if we are going to reach that goal, we will have to expand by a factor of 10. The three principal producers are DuPont, Titanium Metals Corporation of America, and with Cramet (the Crane Company) coming into the picture with plans to produce something of the order of 6,000 tons a year in a plant that hasn't definitely been located yet. There has been a small production in Japan, from which imports have been coming into the United States.

The United Kingdom has just recently announced plans for Imperial Chemicals Industries to build a new plant to produce 1,500 tons of sponge per year.

I think we will have to skip the cobalt picture, which is dominated by the Belgian Congo, French Morocco, and Northern Rhodesia, with a few developments in this country that will help the situation.

Now I will give a quick review of the world reserve picture for the metals that we have considered. Incidentally, these slides are taken from a paper by Elmer Pehrson, presented to the United Nations Scientific Conference, considering the utilization of resources for 1949, published in 1952. This is the only comprehensive summary I have seen of the world reserve picture. A lot of careful thought went into the preparation of the figures.

Manganese, you see, is estimated at about a 250-year supply at the 1948 rate of consumption; chromite, 47 years; tungsten, 125 years; copper, much less, 45 years; lead, 33; zinc, 39; tin, 38 (the last four being remarkably close together) bauxite, much higher, you see, 200 years at 1947 consumption. That won't be that much because of increased consumption since then, although the Jamaican discovery of some several hundred million tons of high-grade bauxite might have put it up above that figure.

That pretty well covers the metals that we are considering.

The next slide represents a comparison of recent production rates and estimated reserves by hemispheres, in different parts of the world. We just don't have time to consider these in detail.

If you want to cover this in more detail, I refer you to Mr. Pehrson's article in this publication put out by the United Nations. I think this, so far as the reserve picture is concerned, matches up fairly reasonably with the picture of production which we will see in just a few minutes that will compare the Soviet bloc with the free world, and the reserves will not be too far out of line with the production.

Now for a quick comparison of the position of the different parts of the world. These were taken from a paper that was presented by Evan Just at the American Institute of Mining and Metallurgical Engineers in St. Louis in 1951, published in the June 1951 issue of the Engineering and Mining Journal. It is an excellent comparison of the mineral potential of different parts of the world and an analysis of what happens if various areas are lost.

As we see in the case of chromite, it is dominated by the western European fringe and Southern Africa, and by middle western Europe. The Soviet sphere accounts for about 20 percent.

Cobalt, we haven't considered, but South Africa is the important element in that picture.

Columbite and columbium-tantalum are dominated by Southern Africa.

Copper and lead are dominated by the Western Hemisphere.

Manganese, Russia is about half the picture, and the rest is scattered.

Mercury, western Europe accounts for about three-fourths of the world total.

North America accounts for the great bulk of molybdenum and nickel.

Tin, of course, comes from the Far East.

Tungsten, rather scattered, but with the Soviet bloc (now including China) is predominating.

Zinc, North America with better than half, and the rest rather scattered.

The next slide shows these areas geographically on a map and with just very broad conclusions. Areas 1 and 3, the western European fringe and North Africa (3 being the Middle East--which is important only in the petroleum picture which is not a part of our discussion this morning) could give the Soviet approximate equality; 1, 2, and 3 could give it definitely the advantage, 2 being the South African area,

where very important parts of our supplies of manganese, chromite, tantalum, cobalt, and columbium originate. Area 2, as we see, has what we need the most. That is South Africa.

Now just a few concluding words about the implications of this situation with respect to United States policy. Of course, that means that in considering our vast requirements picture for an all-out mobilization effort, we must increase supplies both domestic and foreign. This program has been underway and quite effectively so as you see from the plans that are being prepared for expansions in aluminum, copper, and nickel that will substantially increase the output in the next few years. In some cases perhaps they won't meet completely all-out effort requirements and this has to be taken care of by the stockpiling program.

An element in the stockpiling picture (which is vitally important) is estimating what areas can be counted on in the future, and laying plans to make sure that those areas are available. We can't be sure with the long sea hauls that substantial losses will not be encountered in the future. We can't be sure that some of those areas might not be lost or that damage may result in lessening the output of those areas.

One element on the other side of the picture--in figuring requirements--that I haven't seen taken into account is a factor of reduced production capacity due to damage from bombs suffered by our own industries. In any all-out future war we are bound to suffer extensive damage of this sort, but I can see that it would be virtually impossible to factor such effects into our requirements picture.

That will conclude the formal talk but I will be glad to answer your questions.

QUESTION: Most of us are vitally concerned with the role that titanium will play, particularly in technological progress. Could you describe very briefly the problem in extracting this apparent plentiful material and what you think the possibilities are of our getting the quantities we would like to have? The requirements you gave us, I understand are compiled, it seems to me, on what we might be able to get. I think if we could get what we wanted, we would have the industrial revolution all over again today. I think every one working on a drafting board would like to design everything out of titanium if we could get it. I understood previously that it would take something like a miracle, a completely different method of extraction. I am not familiar with the problem.

DR. LUND: I think you are dead right so far as the potentialities of this metal are concerned and the tremendous interest of design engineers in the use of it, but at a price. Perhaps some of these requirements figures that we see right now, we can probably use. Maybe

we can use that much at present prices, which go up, as you probably know, in terms of sheet and other fabricated forms to 15 or 20 dollars per pound. The problem there is--even though we have tremendous supplies of this mineral ilmenite throughout the world--one of producing the pure metal, and the metal must be very pure to obtain the necessary properties. Extremely small quantities of oxygen, nitrogen, and hydrogen in this metal will embrittle and destroy the necessary ductility for working it so that very special techniques are required, not only of the processes that involve melting, but in handling the molten metal because the metal picks up oxygen at elevated temperatures. Unless you keep oxygen gases away from it, it will take on oxygen. It absorbs oxygen just like that (snapping fingers), and the oxygen will penetrate into the metal, embrittle it, and destroy its usefulness.

In refining the metal you have to start out with pretty pure substance to begin with, not just the compound ilmenite or mineral alone, which is a iron-titanium combination. The titanium must now be recovered either by using pure oxide or, as they do now, titanium tetrachloride, and change that to pure metallic form, accomplished by the straight Kroll process or by a modification of it. In this reduction you have to keep oxygen away from the titanium by a vacuum. Melting operations also involve special techniques, requiring refractories that will not combine with titanium metal and destroy its usefulness. They have to adopt all sorts of tricks to accomplish these ends.

One other factor that makes it expensive now is that the only process we know of that is successful is a batch process. No continuous process is yet available that has been commercially proved. Its affinity for gases and other materials requires that they cut out carbon crucibles to melt it because it picks up carbon so fast you will get too much and it will embrittle it. Now they use water-cooled copper.

QUESTION: Getting back to the line of the first question, we have read from previous studies, and have taken from your talk this morning, that the exploration of new sources is not highly regarded, at least not too well considered. Is it a fact that the world offers no room for further exploration of new sources of all these metals? I see nothing brought in from New Zealand, New Guinea, Borneo, Madagascar, and a lot of places that would at least offer some possibility.

DR. LUND: If I gave that impression--perhaps I did by inference--this morning, I didn't mean to do so. Certainly there will be lots of discoveries made in the future. We have seen evidences of that just recently with the new lead and zinc discoveries up in the Gaspé Peninsula and copper deposits in Quebec and New Brunswick. I dealt with the titanium deposits at Allard Lake, Canada; iron discoveries down in Venezuela; Brazilian iron deposits have long been known but the development of the Venezuelan iron deposits certainly is a recent discovery.

No, the potentials for further discoveries are certainly important, either in the areas that have not yet been sufficiently explored or in others. There is a lot of area yet up on the Canadian shield that hasn't been adequately explored. Moreover, we will certainly see improvements made in geophysical instruments, and techniques for finding these ores will certainly be improved in the future, making it possible to locate more definitely, to start with, areas that merit the costs of drilling.

So I don't want to minimize the importance of this, but there has been a lot of agreement that the best places to find these additional new deposits will generally be in the same general areas where the most important production has been in the past. That is not going to hold true, however, 100 percent, that's for sure.

QUESTION: Doctor Lund, I understand that there is a United States tariff on bauxite now. In view of the fact that we are more or less dependent upon foreign sources for bauxite and also the obvious advantage of our conserving our own domestic resources, it seems to me such a tariff would be unfavorable. Would you care to comment on that?

DR. LUND: Personally, I am inclined to agree with you. We have only limited supplies of bauxite in this country, particularly high-grade bauxite. We are beginning to use more and more of our lower-grade bauxite containing higher amounts of silica. The Hurricane Creek plant of Reynolds Mining Corporation is operating on such material, and I think the Mobile Plant of the Aluminum Company of America is equipped to handle it.

I feel myself that certainly it would be sensible, in those cases where we require a very substantial percentage of the material from foreign sources, to question the advisability of a tariff, although, again, you must develop and maintain some system whereby the production that we now have is not going to be curtailed, is not going to be killed by such a tariff policy.

I don't know what the answer is. There is a big fight on now--not on bauxite, but on lead and zinc--in which lots of plans are being considered. One that has a lot of industry backing is a sliding scale tariff which goes up and down according to what the price is. Just what the answer is, I don't know, but I do think that you cannot just wipe tariffs out and thereby greatly cripple domestic industries. In many cases you are going to seriously hurt domestic mining industries, if you simply wipe out these tariffs completely, because by and large in many cases foreign producers can produce metal much more cheaply.

For example the copper deposits--the ore itself in the ground--of Rhodesia and the Belgian Congo will average around 4 percent of

copper; our own mill feed is closer to 1 percent of copper. New developments such as San Manuel and Greater Butte will produce copper substantially under 1 percent, less than 20 pounds of copper per ton of ore.

These are all parts of this question, and I don't think there is any flat broad answer can be given that takes into account the important variables.

QUESTION: This is a little bit away from the metals discussion, but in processing uranium ore, it is my impression that great quantities, of the material processed have a small return in uranium. Is there any possibility of byproducts in that material? If so, would you comment on them?

DR. LUND: I am not familiar with too many of the details, but my comment would be this. Where you are considering the extremely low-grade uranium that is being recovered, the uranium itself is in the nature of a byproduct of other materials. You see the very important development of uranium from the South African gold fields, where uranium itself is an important byproduct, and the uranium in the phosphate deposits of Florida where it certainly could not be recovered of itself without these other products coming along.

Now so far as the uranium deposits themselves are concerned, the deposits of the Colorado Plateau region are perhaps good illustrations of this point, although even there, I think most of those deposits will contain a substantial amount of vanadium. I don't know what is being done with it, whether it is accumulating or not. I suspect it is, but I think most of the deposits of the Colorado Plateau--and they are becoming very important in the picture--have vanadium and of course some radium, along with it but very, very little of the latter.

So far as deposits that depend on uranium alone are concerned, I just don't think, unless there are some byproducts that will help pay the way, they can go too far down into the extremely low grade and do it economically. They may have to be tapped eventually, depending on how badly we need them.

QUESTION: Doctor, is there any indication from the purchases by the Soviet Union of these metals as to what its people are considering the most critical metal category there and if they are stockpiling these metals at all?

Dr. LUND: I am afraid I can't answer that. I haven't made too detailed a study of just what their imports are. Generally speaking, in the nonferrous field I think they are not too well off in copper,

lead, and zinc. I read the other day of a hydroelectric development that is just being completed and that should improve their situation with respect to the refining of copper, for instance. They have the power now to increase their capacity. Tin--they have plenty of, certainly. So far as aluminum is concerned, they are getting much of their high-grade bauxite from Hungary. So far as aluminum from their own resources is concerned, I think they are utilizing low-grade material that we would consider quite uneconomic in this country. Whether the production of alumina is from syenites, anorthosites, or clay--whatever it may be--I think they are not gearing their total production to the use of as high-grade bauxite as we are. I don't know about nickel. They may well be short in nickel. The Petsamo deposit, taken over from Finland, is relatively small. They are well off in chromite and manganese. I would be surprised if they don't have molybdenum.

Broadly speaking, so far as the Soviet Union is concerned, with the variety of geology, with the tremendous area available, I am inclined to give it a tremendous potential so far as mineral production is concerned. It may take quite a while to develop it, however.

QUESTION: We have noticed that the United States has shortages of certain metals. In your opinion which of these shortages are the most critical to us in case we would go to war and what are we doing concerning the stockpiling of these critical items?

DR. LUND: This is a little tough. Nickel, certainly, is one of the most vital; also cobalt and columbium. The superalloy field has added quite a different picture, and here we have seen one of the worst shortages we ran into in the earlier stages of the Korean period--the shortage in cobalt. We have just been completing a study for an outside organization on the long-range picture for both nickel and cobalt, and we find that the engine people are now designing pretty largely away from cobalt, so the cobalt picture is easing. As a matter of fact, a number of people in the industry, with whom we have talked, feel that they are going to have a selling job to do for cobalt in the next few years. This doesn't explain the picture for an emergency period.

On the other hand here is a picture where there is a metal--cobalt--that has extremely interesting properties so far as high-temperature applications are concerned, and yet its use is not known. If engines or parts of engines are designed to its use, you are not sure but that you are going to need a lot more than is going to be available. They are building stockpiles, but even these stocks plus available production have scared these people off and now they are designing in nickel instead of cobalt.

Nickel is perhaps as good an illustration as we have. Certainly stockpiles are being built up, but I don't know the detailed figures on objectives and percentages yet attained. But International Nickel has contracted for 2 million pounds a month, 24 million pounds a year, for five years. There is a lot of other additional nickel production coming in, a lot of which will go in the stockpile--Falconbridge, Fredericktown, Hanna, all of these involve Government guarantees on the output from these operations. We have seen that plans are underway to boost total capacity by over 50 percent. This may still not be enough to satisfy emergency requirements, even with the stockpile thrown in.

QUESTION: We have been led to understand that manganese is a very important item and we have quite a shortage of it.

DR. LUND: It is a very important item and one that has certainly had a tremendous amount of study because of its vital importance in steel. You have reference now to the overall manganese picture rather than electrolytic manganese, I assume. I think the work that has been done has pretty well proved what we can do with our own lower-grade domestic manganese deposits. There are still some angles to be studied, however, including one now underway on what we can do with Maine deposits. A lot of work has also been done in determining what we can do in recovering manganese from blast furnace slags. A major amount of manganese that goes into steel goes right on through. It doesn't come out in finished steel. Therefore, there is a lot of manganese that is left in the slag that goes out on the dumps. Work has been proceeding on the utilization of the manganese in these slags--at a price, of course, but price in an emergency isn't the controlling matter.

We also see manganese developments down in Venezuela and Brazil. This doesn't mean we can definitely count on these areas, but South America is a lot closer to us than India. The African stuff is probably about the same distance, but strategically we may be able to count a little more on Venezuela and Brazil, we hope, than on Africa.

QUESTION: Doctor, you showed us a slide which was prepared, I think, by Mr. Pehrson and which showed the situation with respect to world reserve supplies. I was quite shocked as I looked at that--I think I read the figure correctly--to see several items, of which lead and zinc were two, which we were going to run out of in about 30 years. Did I understand that correctly--in our lifetime there won't be any automobile batteries?

DR. LUND: Those figures showed the number of years represented by pretty well-indicated or proved reserve figures at the then prevailing rate of consumption. Mr. Pehrson will be the first one, I am sure, to

admit that there is going to be a lot more zinc, lead, copper, and other metals discovered. These figures on reserves were the best he could find. We know only too well, whether we are dealing with iron ore, copper, or what, that the mining companies probably have a pretty good idea that there is a lot more ore there than is shown on their books as proved reserved. Many states tax these companies the minute reserves are indicated in the ground. They slap on ad valorem tax, and as a result they just don't publicize how much metal they have in the ground until they have to.

I will remember that 30 years ago everybody was terribly worried because we had only 8 or 10 years' proved oil reserves. Just think of the billions of barrels we've produced since the, and our proved reserves are much, much higher now than they were then. The same thing is going to be true with these metals. But eventually we are going to go to lower and lower grade materials and substitutes.

Definitely substitution is going to be a factor in future copper consumption. Aluminum is certainly going to be important as a substitute for copper in the electrical field. All you have to do is go through a wire mill, such as the Kaiser plant at Newark, as I did a couple of years ago, to see what aluminum is doing to copper in the electrical field.

You may be familiar with plans of electric utilities to virtually double their output of kilowatt-hours in the next 10 years, continuing their expansion rate of the past few decades. They just can't see where the plans to increase copper output are going to meet their increased requirements, and they have been going more and more into aluminum. You have seen aluminum sockets in light bulbs, and it has gone over into the wiring of motors, even smaller motors. Long-distance transmission has already shifted entirely to aluminum and shorter distance transmission in city distribution systems is now going to aluminum in sizable amounts.

QUESTION: Doctor, molybdenum has a very excellent potential at high-temperature applications if they can prevent oxidation. Do you have anything to report on the progress in that direction?

DR. LUND: A lot of work has been done in this field. Molybdenum is another one of the metals that takes on oxygen at elevated temperatures and becomes embrittled. Ceramic coatings seem to have a lot of promise in correcting this. I can't tell you any up-to-the-minute details of just what particular coatings look like the best bet, but certainly there is probably reason to expect that somebody is going to come up with some coatings that will permit molybdenum to stand the desired high temperatures. And, of course, designers are all very anxious to keep increasing the temperatures at which jet engines are

operating today. They would like to go up another 50, 100, or 200 degrees higher than the 1650-degree operating temperatures of present engines. Molybdenum looks promising and ceramics or a combination of ceramics and metals look interesting. Again there are serious problems of brittle properties with the probability that they may have to redesign rather substantially the nature of these equipment items and perhaps the engine itself in order to make use of it.

DR. CLEM: Dr. Lund, I believe our time is just about run out. I think you are going to favor us by remaining this afternoon for group discussions. Gentlemen, you will have an opportunity then to continue your questioning.

Dr. Lund, I thank you for a very thorough coverage and stimulating discussion of the nonferrous and light metals' materials.

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