# MATERIALS FOR THE PRODUCTION OF STEEL

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Dr. Donald M. Fraser, Chief Geologist, Bethlehem Steel Company, was born in Ordway, Colorado, 1 June 1903. He received his B.A. and M.A. degrees from the University of Oregon and his Ph.D. degree from Columbia University, after which he joined the faculty of the Department of Geology, Lehigh University. For many years he was a consulting geologist, specializing in iron and steel materials. He has been with the Bethlehem Steel Company since 1941. During recent years, he has visited prospective raw material properties in various parts of the United States, Canada, South America, Mexico, Europe, and West Africa. He is a member of the Geological Society of America, Mineralogical Society of America, American Institute of Mining and Metallurgical Engineers, American Iron and Steel Institute, and Sigma Xi.

# MATERIALS FOR THE PRODUCTION OF STEEL

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COLONEL O'NEIL: This morning we have our first lecture relating to natural resources--"Materials for the Production of Steel." Steel is essential to our peacetime economy, and is also essential to our wartime economy, so much so that you might say we have a tendency to question it. In our studies of mobilization, steel will become a recurring consideration in production priorities, allocation, and economic potential.

Our speaker this morning is the Chief Geologist of the Bethlehem Steel Company. You have read his biography and know his outstanding qualifications. He has lectured at the Industrial College on several previous occasions.

It is again a pleasure to welcome back to this platform and to introduce to you, Dr. Donald M. Fraser.

DR. FRASER: Colonel O'Neil, General Niblo, members of the Industrial College: The subject as I see it this morning is the raw materials for the steel industry, with emphasis on the three basic raw materials plus a further survey of the alloying metals.

There are many other materials used in the steel industry, but, with the exception of scrap, the various topics I will take up are those dealing with the naturally occurring minerals from which the metals are derived. This use of the term "raw materials" has a certain psychological, I suppose, background for me. I came from the West, and raw always has something to do with crude, uncouth, and so forth.

The various metals that I will try to give you some information on are not, all the metals, but are the three basic materials used in gross tonnage--iron ore, coal, and limestone, together with scrap. In addition we will try to cover manganese, nickel, chrome, cobalt, tungsten, and molybdenum, with a few remarks about columbium and tantalum. I think most of them are in there.

The steel industry in 1953 used 137 million tons of iron ore and about 100 million tons of coal. It produced approximately 70 million tons of coke and 38 million tons of limestone of various grades. These things, combined with about 60 million tons of scrap, produced close to 112 million tons of steel castings and ingots. These statistics are not given because I think you ought to remember them. I don't remember them most of the time. They are given because they set the background for the volumes of material used in the steel industry.

The steel capacity at the present time--that is, the capacity of the steel furnaces and mills--is about 124 million tons. About 82 million tons of pig iron capacity is available.

The iron production of the United States, or the iron mining of the United States, in 1953 was 120 million tons of domestic ore. The remainder of the 137 million tons that were used came from foreign sources or from stocks already available. The Lake Superior district produced 80 percent of that 120 million tons, of which the State of Minnesota alone produced about 68 percent. The Northeastern States produced 5 percent, the Southeastern States, 6.5 percent, and the Western States about 7.5 percent.

If we analyze these districts one by one as a future source, we find that the Lake Superior district has a considerable reserve, well in excess of a billion tons of ore from present open-pit mines and underground mines or those which could be developed rather easily. By easily, I mean without the necessity of further exploration; that is, the reserves are known. In addition there are several billions of tons of taconite. In looking through any of the trade journals, if you have seen the recent stories in the last few years on the development of taconite, you realize that it is going to be a very important source of iron ore in the future.

Taconite is a rock composed of hematite or magnetite with silica, so the entire volume of material must be ground to a very fine mesh, usually around 200, must be separated and, since it is so fine, cannot be used in the blast furnace as is, but must be agglomerated into something that is suitable for a blast furnace. The difficulty with sources of iron of that type is that it takes a lot of time to build a plant that can treat that material. It's totally different from putting a shovel into a pit such as Mahoning.

In addition to the development of that source in the Lake Superior district, the Northeastern States--New York, Pennyslvania, and

New Jersey--produce only about 5 percent of the iron ore. This is from underground mines and the ores have to be beneficiated. That would be a bottleneck as far as a rapid increase in production would be concerned.

In the Southeastern States, Alabama is outstanding and is a source of the better type of iron ore of that district. The mines are both open-pit and underground, and in the latter it is difficult to increase production on short notice. The Western States--Utah, Wyoming, and California--plus Alaska, may eventually produce more than they are producing at the present time, which is 7.5 percent of the total; but they cannot be considered as big resource states--or, in the case of Alaska, territory.

Now let us turn to the foreign deposits. There are varied iron and manganese mines that are important. Some of the districts and deposits have been discovered within the last few years and are now being developed.

In the vicinity of the Labrador-Quebec development, 350 miles of railroad was recently built in this new iron district. The production will be eventually at the rate of 10 million tons per year. The area was a very forbidding one in which to work. The country in the winter time is very cold. Even though the snowfall is not great in many places, perma-frost exists. The exploration of this area involved considerable flying as well as ground work, and this is the type of country in which the ore zone was first recognized. Following the recognition of the ore zone from the air, geologic studies were made and later a number of geologists and mining engineers with equipment went into the district and, by geophysical methods and drilling, uncovered considerable quantities of ore.

Canada therefore will be a producer in the future of a considerable tonnage of iron ore. The other districts in Canada, Steep Rock Lake and other mines in the Algoma area, will give fair tonnage; but the Labrador-Quebec district is one of the big sources of iron ore for the future of the United States.

Cuba is the next district I am going to discuss. Cuba has what is known as lateritic deposits. They are blanket deposits like residual soils. Close to 2 billion tons exist in Cuba. The ore has not been suitable for the furnaces as a source of iron due to the fact that it contains about 1 percent nickel, about 2.25 percent chrome, and .1 to .15 of 1 percent cobalt.

These three metals should be removed from the ore to make it suitable for the furnaces.

This problem has been given to some of the finest research organizations during the past 30 years, and millions of dollars have been spent on the research work, without, at the present time, a satisfactory operating plan that will recover the various metals. When I speak of nickel, I will mention this again.

The hills of Cuba are covered with iron ore. It is this type of country which will be developed. It has been mined in the past, but only relatively small tonnages, because of the presence of alloying metals.

Considerable tonnage of iron ore exists in the areas on the north coast of Cuba. One plant was put in during the war for the recovery of nickel, which was mined near Mayari on the north coast of Cuba. Iron is lost in the process through the contamination of the iron materials, although nickel and cobalt are recovered.

Cuba is a source of considerable metallic value for the future. Mexico, another country in the Western Hemisphere, can produce some iron ore, but the deposits are not so large that much can be shipped to the United States. They are used chiefly for domestic production.

For 30 years geologists have been searching in Pennyslvania for further deposits of iron ore. Until a few years before the advent of the airborne magnetometer this area had been examined, but not as completely as it has been examined since the adaptation of the magnetometer to the air. The whole of that country was flown over and an iron ore deposit was found and is being developed at the present time.

There are deposits of iron ore in Venezuela that have been developed, and there are others that will be developed, that are sources of considerable ore. Some of the ore is high grade. Prospectors or geologists will be looking for it in that country, following the findings of ore on the surface. It will involve drilling in order to determine the tonnage available.

This will give you a mental picture of a hill in Venezuela to which I previously referred. The hill is composed almost entirely of iron ore. There are a few patches of waste material mixed in with the iron, but essentially it is an iron mountain. It contains close to one-half billion tons of iron. A railroad has been built in there. The ore started coming out of that deposit last fall. This is a district lying about 190 miles south of the Orinoco River, about 200 miles in from the coast of Venezuela.

Brazil has a very large reserve tonnage of iron ore. It is one of the largest in the Western Hemisphere. A small tonnage has been produced and shipped in recent years, but it is not coming out as fast as it would if transportation were available to the iron ore deposits. There is a railroad into the district, but the facilities are pretty well taken up with present traffic, and it does not allow for increased production of iron ore.

The hills in Brazil have enormous beds of iron ore, and the total tonnage in the area amounts to several billion tons. In many of the developments, with roads, railroads, construction for power, and so forth, iron ore has been uncovered. The iron ore beds are not difficult to find, although it is not always possible to determine tonnage from a surface observation. One iron mountain of high-grade ore, is running 68 percent iron. Some of it is used in Brazilian furnaces at the present time. It is a very spectacular occurrence of iron ore.

The Caue peak deposit is being worked at the present time and ore is coming into the United States.

The ore is worked down from the top where there is a complete mountain of iron ore.

Casa de Pedra is one of the better iron ore deposits worked in Brazil, north of Rio. The ore is furnished to Brazilian furnaces.

We will move on to some of the other deposits of iron ore. I have not said anything about the deposits of iron in the Eastern Hemisphere. A great deal of work has been done by United States companies, as well as the Government, in the Eastern Hemisphere in an attempt to locate sources not only of iron ore but of other metals. We recognize they would not be available during wartime, and the reason this work is done by the companies is that it is a source of iron ore under normal conditions to conserve the deposits within the United States and the Western Hemisphere.

The deposits in Africa, in Liberia and Serra Leone, now are sources of iron ore, some of which comes to the United States. North Africa also ships iron ore to the United States. The tonnage is not large. We also get 2 or 3 million tons of iron ore from Sweden and scattered shipments from other places.

The problems connected with supplying iron ore to the furnaces in the United States are largely transportation. The economy of developing an iron ore property is usually the thing that determines whether it does go into development or is considered a reserve for the future.

In addition you know that I mentioned two or three places where technological advance is necessary to have some of these sources become useful. This improved technology in the case of taconites will improve the economy. The satisfactory treatment of lateritic deposits, which are widespread throughout the world is of special interest to us.

Coal is one of the other big tonnage raw materials. We have in this country tremendous quantities of good coal, coking coal. It is used not only as coke, however, but also as a source of energy and fuel, so not all the coal used is coking coal. The sources are, of course, through some of the Northern Mississippi States--Illinois, Indiana, Ohio--Pennsylvania, West Virginia, Virginia, Kentucky, and Alabama, and in the West--Wyoming, Oklahoma, and Colorado.

As I told you before, about 100 million tons of coal are used in the steel industry, or were in 1953. It won't be that great this year.

The problems are largely those of treating coals to improve their quality, such as lowering the ash content and the sulphur content and obtaining the proper mixture of high- and low-volatile coals. We recognize it is an important raw material that is available within this country and in large quantities, so it is largely an engineering problem.

The limestone situation is somewhat the same. It is used as a flux in various forms, various types. It is usually produced as close as possible to the steel plant, because the transportation charge is one of the big charges in the total cost of the limestone being fed to the furnaces. In 1953 some 38 million tons were used, which includes several types of flux stone. The stone used, depending on the plant, will vary in its composition. The usual stone will run higher in calcium carbonite than in magnesium carbonite. Low silica limestone is desired. The silica should be less than 1 percent although sometimes it is higher. The sulphur content is watched carefully, because sulphur from the limestone will get into the pig, producing bad effects.

The main problem in the case of limestone is to find a source close to the plant so that you have a low cost of production and can keep your price down in the steel plants.

The subject of scrap is a very complicated one. I have been asked embarrassing questions on previous occasions on the subject of scrap. I don't know a great deal about it. Each time I talk I have to get information from some of our people buying scrap. In 1953 we used about 60 million tons. About half of that was home scrap--that produced in the steel plants themselves. About half was purchased. Purchased scrap varies considerably in price, depending on demand.

I suppose there are other factors, of people partially cornering the market, problems of shipping, and whether some scrap can be brought in from foreign ports. I frankly am not very well informed on the subject of scrap.

We turn to some of the alloying metals, the first of which is manganese. Manganese occurs in a number of mineral forms, most of them oxides such as pyrolusite, psilomelane and manganite, the carbonate rhodochrosite, and rhodonite--a silicate. Those minerals are for the most part the ones from which manganese is produced.

The United States in 1953 imported about 3.5 million tons of manganese, whereas the mine shipments within the United States were only 162,000. We consumed 2.25 million tons.

The sources at the present time are India, Union of South Africa, the Gold Coast, Cuba, the Belgian Congo, Brazil, Mexico, and in the United States there are very large reserves of low-grade ore; they are found in Maine, Arkansas, South Dakota, Arizona, Nevada, and Minnesota.

The deposits in the Eastern Hemisphere are large. Russia has tremendous manganese deposits, from which it shipped to the United States for a number of years but finally cut off the shipments. A few shipments have come in recently but they are a very small tonnage. India has tremendous quantities of manganese. It is very difficult to see how we can obtain manganese from India in case of emergency. The additional sources in the Eastern Hemisphere are the Union of South Africa and the Gold Coast.

Cuba has produced a fair amount of manganese in the past. At present the production is down and the deposits are small.

In South America, Brazil has two fairly well-known big deposits of manganese. There is one plateau-like mountain of dominantly iron ore; it is about 1,100 feet high. The upper part of the mountain is composed of iron ore interlayered with silica. In one place there is a bed of manganese about 10 to 15 feet thick. It contains 30 to 40 million tons of manganese, a sizable deposit.

It has one disadvantage of quality--it contains 4 percent of alkalies. It also has a poor location. It is in the center of South America, and there is a 1,700-mile haul down rivers to get to the coast. It is considered as a source for the future. These problems are being studied at the present time by one of the American companies.

A few years ago one of the local prospectors went down through the northern part of Brazil, at one point he found some heavy rocks along the shore. The country for the most part is heavily forested and the vegetation comes to the river bank. He needed something to ballast his boat--the river was rough--so he stopped and took a couple of chunks down the river and then at his destination tossed those chunks out. Later, when a company was doing some exploring, he brought this heavy material and showed it to one or two people because he thought it might contain iron. It contained 48 percent manganese.

A railroad is being constructed and the deposit has been drilled. The area of the ore bodies was covered with forests making it very difficult to do prospecting. Flying was done over the area and photographs made which aided in engineering work. Over some of the ore the trees were cleared and later the ore body was sluiced down by hydraulic pressure. This mass is manganese, probably the best manganese deposit in the Western Hemisphere. There have been over 11 million tons of high-grade shipping ore proved, and there will be possibly close to that treated later by beneficiation. Shipping will be on the Amazon River from west of Macapá, up the river to a place called Santa Ana. This is one of the important places in the world from which manganese will be coming within two years. That may relieve some of the dependence on the Eastern Hemisphere.

In addition as we move north, we come to the Central American countries and Mexico. Central America has a number of small, scattered, manganese deposits. There's nothing of any great importance and no large production from this area.

There is an area in Mexico which is a new find of manganese made within the last few years. The modern approach to the development of this, however, is within the last few months. It is in the area southwest of Guadalajara and has to be truck-hauled to the railroad and taken to the west coast or the Gulf Coast and shipped by boat.

The district was originally worked by pick and shovel. A series of small adits were put in. Transportation--2,000 burros hauling manganese down from this mine. The mine is, 1,400 feet above the valley below. At the present time a road has been put into this district and a new mill is being put in. It is an important discovery which has not been completely explored as yet. It looks as if it may contain several million tons. The ore can be brought into the United States to plants entirely by rail if necessary.

Regarding the future reserve sources of manganese, it will be coming from the Amapa deposit in Brazil in the near future, and from the big mountain in central Brazil in the more distant future. Further technological advance in ways to beneficiate the ore will make possible the production of an increasing tonnage of manganese in Mexico and maybe even production from the very large low-grade deposits within the United States.

Let us turn to chromium. It is of course, as most of these metals are, alloyed with iron to produce high-strength high-temperature alloy steels. Chromium in the form of brick is also used in refractories quite extensively in the basic treatment of steel. At the present time, of the metallurgical chrome which is used in the alloy, 40 percent comes from Turkey; 38 percent of the total comes from South Africa and Southern Egypt combined. Seventy-seven percent of refractory chrome comes from the Philippines and a small amount from Cuba. New Caledonia produces some chrome, also the United States, but it is a relatively small production.

The world production in 1953 was 4 million tons. The United States imports 2.5 million tons. The United States production is 60,000 tons. The Western Hemisphere produces 140,000 tons. The United States consumed 1.3 million tons, considerable quantities, of course, going into the stockpile. That shows our dependence on outside sources.

In Montana, California, Oregon, and Alaska there are some chrome deposits. Some of those were put into production during the war and the tonnage could be increased. Also there is some chrome in Cuba. The Cuban sources of refractory chrome are fair. They are not being worked very extensively at the present time beacuse of the price of chrome. Cuba is a source of refractory chrome and of some metallurgical chrome. The metallurgical chrome in Montana could be increased in production. The United States and the rest of the Western Hemisphere could produce a sizable percentage if need be.

Nickel, another one of the ferroalloys used in making high-strength high-temperature steels and stainless steel, has received tremendous attention within the last few years. At the present time, in 1953--most of these figures I am giving you are for 1953--the United States consumed 212 million pounds of nickel. The steel industry used about 80 million pounds of that and the other was used, not by the primary producers of steel, but by the producers of alloys in other plants.

Canada produced about 80 to 90 percent of the total Western Hemisphere production of 390 million pounds of nickel, so Canada is a big producer and has a big reserve of nickel.

There has been a great deal of research work done in an effort to produce nickel from the Cuban lateritic ore previously mentioned. That also goes for cobalt, which I will mention in a moment.

At the present time we hope that one of these processes that have been studied very carefully for some years will come to pass and be satisfactory in producing nickel and will also result in the production from the lateritic ores, iron ore, nickel, cobalt, chromium, aluminum, and possibly manganese. The ore contains only small percentages of some of these, but since it is going to be a chemical treatment, the economy may depend on recovery of all the metals contained in it. If that does work out, then the biggest economic deposits of nickel in the world will be in the lateritic deposits of the Cuban type.

They are found not only in Cuba but in the East Indies, India, the Philippines, and in West Africa.

The United States produced less than 1 percent of the requirements. A new deposit is being worked at Riddle, Oregon. Canada is putting new mines into production under GSA urging and cooperation. I saw in the paper this morning that a new mine discovered a few years ago at Lynn Lake is producing a nickel concentrate and all excess concentrate is being sent to International Nickel Company to be processed under the GSA grant.

Cobalt, again, is used as an alloying metal in producing high-temperature high-strength steel. Most of it at the present time comes from the Belgian Congo. We have a consumption in the United States of about 9 million pounds, and the Western Hemisphere produces about 3 million pounds. We rely on the Belgian Congo as the source of a big percentage of cobalt.

Regarding the future situation, cobalt is present in some ores in the United States--in Missouri, Idaho, and Pennsylvania. The Missouri and Idaho deposits are being studied at the present time. The Pennsylvania deposit has been worked for many years. At the Cornwall Iron Mine in eastern Pennsylvania, near Lebanon, the iron ore contains a small percentage, of cobalt which is recovered. The tonnage produced in the United States can be increased if other States go into production. In addition we will get cobalt from the lateritic ores. They are a very important future source of this metal.

Molybdenum is produced in abundance in the United States at Climax, Colorado, where the United States production is 57 million pounds. Consumption was 31 million pounds in 1953. There is a very satisfactory situation regarding molybdenum. Climax has a reserve tonnage of something over 200 million tons of ore with a yearly production of about 6 million tons, from which is recovered 50 to 60 million pounds of molybdenum.

Tungsten is used as an alloy for the production of high-strength high-temperature steels. Its present sources are Korea, Bolivia, Spain, Portugal, Canada, Mexico, and Brazil. We also produce considerable tungsten in Idaho and Nevado, and the tonnage can be increased so that we will be more self-sufficient than we are at the present time.

In some of these cases, it is wise to import as much as possible during peacetime, during normal times, and to keep in mind that we want our deposits at home in shape to work in an emergency if necessary.

Columbium has been more important in recent times and is again used in high-strength high-temperature steel and electronics. Sources are Nigeria and the Belgian Congo which, together, produce 80 percent. There is a possible source in Arkansas, associated with titanium and bauxite deposits.

The United States consumption is 1 million pounds per year and the production is only a few thousand pounds. In this case we should attempt to develop the local deposits and try to find further sources in the Western Hemisphere.

These remarks are brief, and I may have read off too many statistics. The fact that I read them shows that I do not remember tonnage figures. However, they give a setting, showing the relative production in the world and in the Western Hemisphere, and what is consumed in the United States.

My feeling, after looking over some reports, is that you are going to get a summary of some reports on available raw materials later on. It seems to me that we do have the possibility of increasing the production of a number of these strategic materials in the United States. Certainly in the steel industry we are well aware of what is needed and recognize that it is necessary, not only from the point of view of our national interests, but from steel companies' economic demands, that we keep awake and try to increase the production of some of these metals.

I thank you.

COLONEL O'NEIL: Dr. Fraser is ready for your questions.

QUESTION: Canada has had a very extensive diamond drilling operation in certain parts for the last two or three years. What have been the indications of revealing any large bodies of these ferroalloys in that area? Do you know?

DR. FRASER: Well, one of the discoveries within the last few years from one of their diamond drilling programs was this Lynn Lake deposit that has proved to be a fairly important source of nickel. That's one. It is true that there has been a very active period in the last few years in Canada on iron ore. This was the result of two things--the Labrador-Quebec development and also Steep Rock Lake. Both of these showed the prospectors, who are very abundant and very active in Canada, that iron ore was a means of making money as well as gold, silver, and the base metals were. This created tremendous activity.

Now, the deposits they found, particularly these last two big mineral deposits--you might say districts, rather than ore bodies--were not primarily ferroalloys; they were copper, lead, and zinc. There was one called Geko to which a railroad is being built, and one in New Brunswick, both of which contain copper, lead, and zinc.

QUESTION: The reports we are reading, the Paley and the Malone reports, seem to be at odds as to our have or have-not in terms of metals. Would you care to comment on our availability of reserves of the various types of reserves?

DR. FRASER: Well, sure I will comment. If you are supposed to be an authority on something you don't dare to comment. If you don't know anything about it you can make a comment. We have talked quite a little bit about these reports and I think my own personal feeling, which, of course, may not at all represent the opinion of my associates in Bethlehem Steel, is that there is much about the Paley report that is very stimulating. I think on the long-range picture I would agree with it; but I believe that in terms of the immediate future the Malone report, which is where the Western Hemisphere sources are emphasized, is possibly closer to the truth.

I am not sure that there is a very great divergence of opinion. I am not hemming and hawing on this thing. I do know that in any long-range planning we have to realize the increase in demand for these raw materials is going to be extreme and we don't see any possibility of supplying that demand at the present time. But, for the next few years, if we get busy, within two or three years we can produce much more of many of these metals than we are producing at the present time.

I can't say which one is right and which is wrong, but I say what my own opinion will be. For example, take the matter of tungsten--there are numerous deposits of tungsten in the Western States. Some of this tonnage could be increased, but you have this problem: Who is going to put those mines in shape to produce three, four, or five times, as much as is needed at the present time. The average operator of a small company can't afford to do it, and the economic situation dictates that the company that has to report to stockholders can't very well do it either. So Government aid in many cases has been of very valuable assistance in developing small deposits.

QUESTION: Do you think we can place any real dependence on sources of supply of raw materials not in the Western Hemisphere in an all-out war?

DR. FRASER: That certainly gets into a field about which practically everybody here knows more than I do. I would say from what we have seen in the case of World War II that we should not place dependence upon a source in the Eastern Hemisphere for any material that is used in any quantity. It is possible that one plane load of something would be suitable or a satisfactorily important contribution. That is a different thing. But I believe that we should attempt to develop all our future needs within the Western Hemisphere.

I was talking with Mr. Guild. Some of you know him. We were in Cuba together in 1941-42, and we saw the shipping that was sunk around Cuba in a very few weeks. You could hardly go into any port city that you would not find remnants of the crews. I have the feeling that we would be very remiss to depend on any material that has to be brought in, in any sizable quantities from the Eastern Hemisphere.

QUESTION: Is there any research being given to going down deep in the earth to see what we can get in the way of the minerals we need?

DR. FRASER: That is a very interesting subject. When we say deep in the earth, of course it is a relative thing. I mentioned a place in eastern Pennsylvania where I said that some of the area has been covered during the past 30 years by ground work. With the advent of the airborne magnetometer it was possible to cover a larger area where the ore body was found. The closest it comes to the surface is 1,500 feet; the deepest is 3,000 feet. That is not deep as a mine goes. It shows that with the new geophysical techniques it is possible to get aid in finding ore bodies that are not visible--even though predictable, we will say--from geological studies.

When we get into depths of over two miles we are immediately confronted with problems which at the present time are very serious.

In most cases they are water problems, or weak rock or extreme pressure, or heat problems, and so forth. Although oil wells go down several miles--some holes are over 20,000 feet--mines, by and large, are less than 10,000 feet. Iron mines, for the most part, are less than 5,000 feet. If you can get ore in sufficient quantities to pay for the mining, you can go after it; and technical advances in the future will aid in finding deeper ores.

Coming back to the Pennsylvania iron mine again, although the field has been covered several times, each time more carefully, with a different idea, we hope we might pick up some deeper ore body. That's just for iron. Of course, some of the other metals companies who are primarily concerned with tungsten or other metals are probably doing the same thing.

You increase the problems theoretically probably in the ratio of the cube of the depths.

QUESTION: Doctor, what would be our most critical metal shortages for steel production in the event of war?

DR. FRASER: Well, there I have to answer on the basis largely of what I have read. Also, I have talked to some of the people who should know more than I do about it. It seems that with nickel, in spite of the big source in Canada and the present increased production, which has had such a tremendous rise, it is one of the most important metals, if not the most important metal, at the present time. But since we do have the Canadian source, and the possibility of the Cuban source, and since the concentrate of either nickel metal or nickel oxide could be flown into the United States from Cuba, in the event of war, it would not be as strategic as tungsten, which is now produced and shipped to us in very large quantities.

If the Cuban source could not be protected, that is, for water shipping, chromite might be very important. Then there is the Philippine source. Seventy-five percent of refractory chrome comes from the Philippines. The Cuban source could be increased, but that could not be in terms of many thousands of tons. It is not something that you might normally think of flying in as you would nickel metal, which is measured in terms of pounds.

There may be some others I am overlooking, but it seems to me that, if we can solve this lateritic problem in Cuba, we are going to answer the needs for nickel, cobalt, and chrome. We will have so much we probably won't know what to do with it. That would be a pleasant situation.

I can't answer that very well.

QUESTION: Dr. Fraser, you have discussed only a few metals this morning, and there are undoubtedly a great many that have possibilities. How extensively are the steel companies researching on other types of alloying materials?

DR. FRASER: I know that they have tried a number of different metals and combinations. One of the phases of this problem that I might have discussed is the substitution of some other metal, say, for nickel, for molybdenum, or for tungsten. We find that in several cases it is possible to substitute one for the other, maybe not getting quite the qualities that you wish, but coming close enough to them so that they are acceptable.

Now, as regards other metals, I would say that there has been a great deal of research work done. In the case of the use of beryllium, it has been found that small amounts of beryllium, added to copper, make it very tough, hard, strong metal. And there is research on the use of some of the rare earths in special cases, not only with steel. That field I think has received a great deal of attention.

QUESTION: We see in our times the development of a competitive metal to steel, such as aluminum. I wonder if any plans may be in the making, regarding the development of any mineral or nonmineral materials that will be a strong competitive material of steel or a substitute for it.

DR. FRASER: I think the outstanding one is titanium. It is a light metal, heavier than aluminum, lighter than steel. It is very abundant in the earth's crust; but it is difficult, under present known metallurgical practice, to recover it. It will be largely a matter of improved technology when titanium is produced in quantity. It is going to be very important, I think. I have not talked to our research people about it. But anyone who has seen the curve of the uses for titanium in the very short time it has been produced realizes that the Du Pont people and the National Lead Company are the two most concerned with this at the present time. Kennicott Copper and New Jersey

Zinc are interested in titanium production at Allard Lake in Canada. The National Lead people are producing titanium dioxide at McIntyre, New York.

The problem is in getting it into metallic form. It can be done but the process will require a great deal more work to bring it to the industrial level. The problem is how long it will be before the price of titanium comes anywhere near approaching the price of steel. That seems to go over into the future for most of the uses.

For many years aluminum was measured in pounds. We are talking about 120 million tons of steel. Aluminum however has grown and has taken the place of steel in some places.

The advantage titanium will have is that it is a strong, hard metal. Aluminum is not at all strong, in terms of steel, and is much lighter and softer. That is its advantage for certain uses. I noticed in one of the television ads recently that by the extrusion of aluminum it is possible to improve its strength and quality. It still is a light-weight metal and its uses are limited.

Steel has other uses that the lighter metals would not find. As far as weight goes, they might be used, but they would not be strong enough.

COLONEL O'NEIL: Dr. Fraser, you have given us an excellent study of materials and the additives that go to make up steel. On behalf of the Industrial College, I thank you very much.

(6 Jan 1955--250)S/sgh