SEARCHING FOR NEW MINERAL DEPOSITS

11 October 1951

CONTENTS

	Page
INTRODUCTION--Mr. J. W. Swaren, Member of the Faculty, ICAF	1
SPEAKER--Dr. Donald M. Davidson, Vice President, E. J. Longyear Company, Minneapolis, Minnesota	1
GENERAL DISCUSSION	12

Publication No. L52-34

INDUSTRIAL COLLEGE OF THE ARMED FORCES

Washington, D. C.

Dr. Donald M. Davidson, Vice President of the E. J. Longyear Company, Minneapolis, Minnesota, was educated at the University of Minnesota, receiving his A.B., Magna Cum Laude, in 1925; M.Sc., Sigma Xi Prize, in 1926; and his Ph.D. degree in 1928. From 1928-1939 he was geologist, chief geologist, and senior engineer, Selection Trust Buildings, London, England, Selection Trust, Ltd., and participated in the exploration and development in Central Africa of the great copper mines in which total investment ultimately reached 100 million dollars. Dr. Davidson has also been active in the examination, appraisal, and development of metallic and nonmetallic mineral properties in Africa, Near East, Far East, Europe, North America, and Central America. Since 1939 he has been Chief Geologist, Director, and Vice President of the E. J. Longyear Company. Dr. Davidson is a member of the National Minerals Advisory Council and is a consultant to the U. S. Corps of Engineers, U. S. Bureau of Mines, and the President's Material Policy Commission. He has published numerous articles on geology and ore deposits. Among the professional societies of which he is a member are: American Association Advancement of Science; American Institute of Mining and Metallurgical Engineers; Canadian Institute Mining Engineers; Gamma Alpha and Sigma Xi, Honorary Scientific Societies; Geophysical Union; Society of Economic Geologists, vice president and council member; Fellow of Geological Society of America; Institution of Mining and Metallurgy, London.

SEARCHING FOR NEW MINERAL DEPOSITS

11 October 1951

MR. SWAREN: Prospecting, or the search for minerals and mineral deposits, is one of the most glamorous arts in which man engages. From the legendary time of Jason and his seeking of the Golden Fleece to the weird and uncanny paraphernalia used in explorations today, this questing has led to rare adventure and to stark tragedy, but never to satiation. Once the prospecting fever enters the veins of a man, only death will stop his pursuit, never ending even though his quarry is in hand, for mineral deposits follow tortuous patterns beneath the surface of the earth.

There are as many tales stemming from underground exploring as in the hunt for surface indications. To tell us of the basic facts in this art as it is followed by scientific practitioners, we have brought to you today the dean of this craft. His biography proves that he has reached his position, not by the attrition of seniority, but by skill and application. It is a pleasure to present to the Industrial College Dr. Donald M. Davidson who will now tell us some of the nice things about searching for mineral deposits. Dr. Davidson.

DR. DAVIDSON: General Holman, members of the faculty, and students: Thank you, Mr. Swaren, and after hearing what you have said, I can hardly wait to hear what I have to say.

Mark Twain, after he had made some success in the world as a writer and had funds to spare, was wont to dabble in mining ventures and inevitably he lost. After some time he finally made the sage remark that a mine was a hole in the ground owned by a liar. Now, as a mining engineer, my profession for the past quarter of a century has demanded that I tell the liar where to dig his hole in the ground.

General Holman asked me if I thought there were any more deposits to be found--and I replied that there are plenty more but it will require a kind of exploration different from the present to locate them.

During the past two decades in this country, searching for new mineral deposits has undergone a vast change. No longer does the old bearded prospector, with his burro and his gold pan, follow the trackless wastes of the desert in search of a bonanza. This romantic figure has gone from the scene of prospecting and in his place we now have what we please to call scientific exploration. The reasons for this change stem from the fact that ore bodies--I speak now of the nonferrous metalliferous

deposits--are distributed throughout the earth much in the fashion of plums in a pudding. If we liken the earth to the pudding, then we will find some plums at the surface, and if our baker has been a person of integrity, we may expect plums deeper within the pudding. The present surface of the earth, to a geologist, is an accidental one. It is an erosion surface which is being worn away at the average rate of one foot every thousand years. During this erosional process, at any certain time a certain number of ore bodies will be exposed, and in our generation most of the ore bodies which have been exposed in this country have been found and either have been or are now being exploited. The rate or the trend of new discoveries was very high beginning with the Gold Rush of the forty-niners and continued in great activity after the Civil War let loose a flood of soldiers who followed Greeley's advice and went West and were responsible for the discovery of most of the ore bodies since that time.

The rate of discovery diminished gradually until about the First World War, but the rate of discovery has fallen off to practically a standstill during the last few years. Now while this situation is serious, it is by no means catastrophic because our scientific experts who are devoted to the replenishment of our mineral ore material have faith and confidence that they know how to find these so-called buried plums. We have both the means and the methods as well as the scientific ability to unearth these so-called buried bodies of ore.

Other things being equal, these bodies will be discovered and exploited, but there are many and varied influences which bear on this vital search about which I shall speak this morning.

First of all is the matter of scientific exploration itself: What is it and how do we do it? Let me give you a typical example of how the problem is attacked. It is built up in stages more or less like this: First comes the idea, the conception of where to look for substantial mineral deposits. We have a saying in mining geology: "If you want measles, go where measles are." In other words if you want big ore bodies, go into those great districts in the West which have yielded tremendous tonnages in the past. These districts we study with the microscope--both figuratively and literally--as we try to determine the answer to the question: Why are the ore bodies where they are? Technically speaking, What are the structural controls for the emplacement of ore? Once we have determined what these controls are, then we look for similar conditions, and when we find them we subject them to testing by one or more of several geological, geochemical, and geophysical methods.

After we have picked our district and believe that we know the underlying conditions which determine ore deposition, then the next stage is to sell our principals as to the desirability of exploration.

These principals may be one's own board of directors, some investment house or, in these days, even Uncle Sam himself. The job is essentially one of education, especially with the older mining companies, as these mining companies have boards largely made up nowadays of bankers and lawyers, and considerable missionary work is usually needed on such gentlemen to induce them to see the light. To this end it is wise to put the proposition somewhat as follows:

a. What is the size of the possible reward or prize if the exploration is successful?

b. What are the chances of success? (Incidentally, in mining exploration the chances are very long, the odds being something like 100-to-1 against success.)

c. What do you propose to do in the first steps of this exploration?

d. How long will this investigation take?

e. How much will it cost? (Very important to the banking element.)

Let us suppose now that we have been sufficiently persuasive to get a green light from our principals, after which comes the acquisition of the desired ground or at least the mineral rights thereto. This is in most cases an extremely complicated and frustrating proposition, because in most of our old mining districts the ground is held under location or possessory right, or patent mining claims held in fee simple. These claims are small in relation to the size of the desirable plot of ground, and therefore many of them are needed to complete the picture and afford protection for exploration. In this day and age these claims are usually held by heirs of the third generation, and grandpa told his son who told his son and daughter that each claim is worth a million dollars. All of the many holders of these claims have to be patiently educated to the point where they are willing to pitch in for the common good in order that long-drawn-out and expensive exploration may be done to prove or disprove the potential value of the area. In passing, I might remark that regardless of the complications, the aggravations and the frustrations which devolve in putting together complicated private ownerships in a district, all of us in the mining business are most thankful that we still have private ownerships to bargain for.

Again, assuming that we have been persuasive so that the heirs have come together in agreement concerning exploration of their ground, the next stage is a more thorough examination of the area geologically, which may involve the following steps: first comes a very detailed mapping of the geology, that is, the various rocks themselves, with notations as to their nature and distribution as well as those all-important structural features which may have a great deal to do with the localization of ore bodies. Next we are often wont to carry out so-called geochemical

exploration which is based on the theory that ore bodies are conducted from the depths of the earth up to their place of deposition by means of hydrothermal solutions. Now these hot waters, after they have brought the copper, lead, or zinc to their final place of deposition, cannot just evaporate in thin air as they are still at a point of considerable pressure and high temperature, so that as they go their way upward to the surface of the earth they leave telltale traces for the eager geologist to find. These indicators form a sort of bloom or halo above the deeper-lying ore deposit. The form it takes is largely mineralogical; that is, hydrous minerals, and in minerals containing iron and sulphur together with some silica. These hydrothermal alteration aureoles, as we geologists call them, are attractive places to search for deep-lying prizes. And in one district alone have led us to the discovery of a quarter of a billion dollars' worth of lead, copper, gold, silver ore. (Unfortunately, not every hydrothermal halo is an indicator of an underlying ore body.)

Further with regard to geochemical exploration, we have recently unearthed a new technique whereby we can test accurately for the most minute quantities of base metals. For instance, we can now detect as small an amount of lead as one part in ten million. We are beginning to believe that ionic particles of metal are sent from an emplaced ore body just like the hot waters, and these too, form a halo.

This method of testing has come into wide use only very recently; but one famous and perspicacious geologist, connected with one of our oldest and largest mining companies, had such an idea a good many years ago. It was his thought that he might find some of these buried copper deposits, all of which in his district contained minute traces of bismuth, by testing for very infinitesimal amounts of bismuth in plants which grew in this thickly forested country. A methodical testing was carried out whereby samples of leaves and shrubbery were duly burned, these being taken at regular intervals across the country. And lo and behold, after the results of the testing of the ashes of these plants were plotted on a map, a distinct pattern of bismuth concentration began to show up and hopes were high that this might lead to a new ore body in the district. As the search progressed the interest rose to fever pitch--only to be exploded when the tests led them straight and true to a copper smelter, the smoke from which had contaminated the surrounding country with bismuth fumes.

Other important methods are known as geophysical, of which there are several novel and valuable techniques. Briefly, the important ones are magnetic, gravity, seismic, and electrical surveys. The most successful and easily interpreted are the magnetic, which nowadays, are largely carried out by aerial surveys, using what we call a "doodle bug" which is a flux magnetometer either built into the aircraft or towed behind it on a cable. This instrument was first used to prospect for

oil, or rather for conditions favorable for oil accumulation, but in recent years has come up with some spectacular successes in finding iron ore. One of the most thrillingly successful explorations of our time was the discovery of a deposit of high-grade iron ore at Morgantown, Pennsylvania, which deposit we estimate at over 100 million tons of material, but which does not come at its highest point within a quarter of a mile of the surface. It was discovered purely and simply as a result of an areal magnetic survey.

Gravity methods of search are based on the principle of mass attraction. Our present-day gravity meters are of such delicacy that they can measure the pull of the earth's gravity in the order of one one-hundred-millionth of the weight of the earth. Put in everyday language, this simply means that if we have a body of material which is appreciably denser than the surrounding material in the earth, we can detect it by means of a gravity meter provided it does not lie too deep. If we know the density of the material we are looking for and we know the density of the material which surrounds it, by using the inverse square law we can calculate with fair accuracy how detectable this material will be depending on its depth. This method has been spectacularly successful in finding areas favorable for gold deposition in the great ore bodies of the Witwaterstrand district near Johannesburg, South Africa. The conditions here are unusual in that gold-bearing quartzites have a complete blanket of heavier lava, but to complicate matters the whole area has been broken up, faulted--as the geologists say--and later eroded, so that we may liken these quartzite blocks to paving stones that have been tossed about aimlessly, then covered completely by a layer of tar. Picture, then, some of these paving blocks having a very thin layer of tar covering them, while others lie at great depth. On the Witwaterstrand these quartzites are worth looking for if they lie within a mile of the earth's surface; or put another way: if they have less than a mile of lava cover. Modern drilling methods are too expensive as a means of testing to ascertain the depth of the gold-bearing quartzite, but by means of a gravity meter the relative depth of these blocks was readily and cheaply ascertained, after which drilling was justified on more elevated blocks, the final results unearthed gold-bearing deposits worth hundreds of millions of pounds sterling. This is one of the great modern triumphs of exploration.

Seismic geophysical methods have largely been used in oil search and more recently are being employed in the mining business to determine the depth of the sand, gravel, or clay which overlies so much of the solid rock which contains valuable metals. The principle is simply one of creating artificial earthquakes waves, and by measuring their velocity we can ascertain the depth to changes in rock formation. This is very important in the area where most of our high-grade iron ores come from--in the Lake Superior region--which is largely covered by a heavy mantel of glacial drift left there when the continental ice sheets melted only a few thousand years ago.

Finally are the electrical methods which have the greatest potential value (not a pun) of all, inasmuch as metalliferous deposits are much more conductive than the rocks in which they occur. Many and varied are the techniques employed in electrical methods, but the newest one and the one which holds the most promise is a technique whereby we believe that we can detect the presence of the so-called disseminated deposits. In this class lie the vast copper ore bodies well illustrated by the famous Utah Copper Mine which is the greatest man-made hole on earth, from which is mined over a hundred thousand tons of ore a day. This method is still in the restricted class, but I am at liberty to describe in general terms the methods employed; namely, that we liken a certain block of earth to a storage battery, and we subject this block to a series of pulsations of electric charges. The drop of potential in this block of ground is measured, and the theory is that most blocks being nonconductors the drop in potential will be measured and rapid, whereas if a block of ground is composed of nonconductive rock which has dispersed through it disseminated particles of conductive material such as copper, then the drop in potential will not be as rapid as in a block which does not contain copper. When such a situation is encountered, we will then naturally probe that ground by core drills to get samples of material which has accounted for the diminution in potential drop.

So much for geophysical methods. Now as to the actual mechanical methods for probing the depths of the earth, these begin with so-called drilling techniques, chief of which is diamond core drilling; this is a simple mechanism which uses as a cutting tool an annular piece of steel known as a bit which is set with diamonds, by far the hardest known material on earth. This bit is rotated by several types of motive power and lubricated by water or air, and as it cuts its way down into the rock it carves out a cylinder of rock known as a core. We have effectively employed this technique down to depths of over two miles in mining and four miles in oil search. Inasmuch as the American technologists are the most enterprising and ingenious class of fellows in the world, we expect no end of improvements in these devices which will make them cheaper to employ and assure us of even greater depths of penetration. In my opinion it is safe to say that the mechanical and technological advances in mineral exploration are the surest of any. Unfortunately, there are other important aspects of mineral exploration which are far from certain.

Some of the important trends in the mining industry today which have a vital bearing on mineral exploration should be brought to the attention of you gentlemen. Chief among these is the trend for the smaller mining companies to disappear and the bigger mining companies to become bigger. The reason for this is not far to seek: It is a matter of money, and from two directions. First comes the high cost of searching for ore. Only wealthy companies can afford to carry out

the extensive and expensive search now necessary to unearth valuable ore deposits. Forty or fifty years ago one could undertake a fair amount of exploration for from 10,000 to 25,000 dollars; in the second half of this century, however, you can be assured that most well-devised exploration programs start as a lady couturiere would say, from 100,000 dollars; and, second, there rears its ugly head the matter of taxation which will be dealt with more fully later.

Another all-absorbing matter of the moment is the ever-increasing trend for government to encroach on the mining business--a little here and a little there, always inching in and forward to greater and greater control of the mining industry. Regardless of one's belief either for or against Socialism, those of us who are seasoned in the mining industry know full well that it will be an irrevocable catastrophe if our Government should assume the prerogative of taking over the mining industry. This is purely and simply because of the unique nature of mining wherein it exploits an irreplaceable material. Ore is a wasting asset. There is no means of replenishment save to find entirely new reserves. In the history of the world the only successful means of finding new reserves is to create a tremendous incentive. So far the most potent incentive, we know, is that of monetary reward on a practically unlimited scale. In countries which have allowed this system to obtain, exploration has been successful; in Socialistic countries exploration has been a costly failure.

A third big trend in modern exploration, and a very hopeful sign, one which promises great fruit, is the system of joint ventures wherein two or more large mining companies pool their resources for the development of a very large project which requires tens or even hundreds of millions of dollars. A recent stimulating example of this was the case of a joint exploration by two of our largest base metal mining companies: Kennicott Copper and New Jersey Zinc. Together they have pooled some 50 million dollars to develop hundreds of millions of tons of titanium and iron ore in eastern Quebec. Other examples are not wanting, but the point is that two minds are better than one. One company lends the other courage and large risky ventures are undertaken which otherwise would have lain dormant, but in the long run the fruits of such enterprises will pay off in terms of tons of metal.

Technically or scientifically the trend in our thinking is all to the good. These days the geologists are training both managements and directors to comprehend that mining is a business; admittedly one fraught with more risk and hazard than most others; but nevertheless a business which ends in a manufacturing process and therefore behooves those in charge to take stock of the inventory which in the case of mining is irreplaceable save by the detection and development of unknown ore in the ground. Personnel of an alert mining company will see to it as a continuing part of the business, that for ore which

is taken out every year they should look to the matter of replenishment, and that they should make this matter of replenishment an orderly, consistent part of the business. I can say without qualification that the majority of the medium-sized mines which are idle in this country are idle simply because of the fact that the management was shortsighted in the aforementioned regard, so that when one particular ore body was fully exploited management never knew where to look for more ore; nor had it put by the money necessary for further research.

Nowadays, too, exploration geologists and engineers press their principals to conduct at an even, which means an efficient, rate. It is known that our national economy, up to the present anyway, has expanded at an average rate of about 3 percent compounded annually. Naturally there are dips and peaks, as we go along, but the average rate is about 3 percent. In view of this then, when we deal with natural resources and if we have adequate capital, we can proceed with confidence to predict the rate of consumption for any particular mineral; and accordingly we can estimate the amount of exploration necessary to replenish the cupboard, so to speak. This exploration should then be set at the required rate and should not be subjected to the whims of any particular economic stress. To illustrate what I mean: During World War II and at the present we are in a time of acute stress with regard to mineral exploration. The demands on exploration facilities are tremendous. Both equipment and personnel are highly overtaxed with the result that exploration is both expensive and inefficient. Much more would be accomplished for much less money if exploration could be done at a more nearly even tenor. One of the important responsibilities of mining geologists of the present day is to educate those having to do with the mineral industry about this aspect.

Finally, with regard to our thinking comes a concept of great moment--the concept of geological ore. In former times, and as a result of the excellence of Herbert Hoover, thinking geologists and engineers were constrained to be both conservative and precise with regard to reserves of ore in the ground. These had to be measured by rule-of-thumb engineering methods before they could be certified as ore reserves, with the result that our so-called published ore reserves have always been a gross underestimate of what all thinking mining men knew to be the case. Recently, it has resulted in a disservice to the national interest. We have learned so much about the nature of the various types of ores within the last 30 or 40 years, that economic geologists having vision and courage can make estimates based on their scientific knowledge which are far beyond so-called measured reserves of ore bodies. This type of reserve we call geological ore and, while it is subject to some speculation, we can take comfort in the fact that geological ore far, far exceeds in value the known or proved ore reserves. These geological reserves are the most

important of all from a standpoint of national welfare, and at the present time this fact is being lost sight of by the President's Materials Policy Commission (for which I am a consultant) with the inevitable and undesirable result that the executive branch of our Government may be badly misinformed about the potential wealth of various kinds of critical metals in this country.

In Fortune issued September 1951 there is a startling account of the acute shortage of engineers in this great country of ours. They refer to "shocking fact sheet" which tabulates the need for 60,000 additional engineers in this country currently, which will be inadequately met by a graduating class of some 25,000 in 1951, but of only 12,000 in 1954, of which 6,000 will be drafted unless we can enlighten our manpower directors. The current need for engineers is at least 30,000 men a year, and a somber note may be injected here by the fact that best-informed sources indicate that Russia is training no less than 100,000 technicians and scientists annually.

A serious but little-known factor bearing on searching in mineral deposits is the decline of first-class consulting engineering services. I shall venture a guess that there are not a dozen first-class consulting mining firms in the United States that could stand bad times. The reason is purely and simply taxes. If a consultant's fees are 100,000 dollars a year, he is allowed to retain less than one-half of this; but, in years when his fees are lacking, he has nothing with which to take up the slack. He therefore inevitably gravitates toward the security of working for a large mining company or an educational institution, or on an ever-increasing scale for government bureaus.

Human relationships and imagination are matters of extreme importance in searching for mineral deposits. To hark back to our old prospector, he had no vital need to learn how to "win friends and influence people" in his relationships to other human beings; probably all he had to do was to know how to get along with his burro. Today, however, a scientific prospector is only one man in a complicated system, and it behooves him to learn about the niche in which he finds himself. As mentioned before, he has to learn how to sway not only those above him in selling his ideas, but he must be able to persuade landowners to his way of thinking; and the technological end of his business is enormously complicated these days by having many highly trained technicians who have to learn how to work with one another. Unfortunately, somehow in the past half century we have got away from the old ideas engendered in family training whereby we learned how to share with one another and to be unselfish, nor do our modern schools teach these important things to students. These lacks show up in our organizations from top to bottom in these pressing times, and I may say that in many companies there is as much trouble with Ph.D's as with daily paid men.

To my way of thinking, one of our first concerns in modern times should be to reinstate a way of life in our families and in our churches and our schools which will bring people out emotionally mature and ready to go to work in a spirit which will ensure cooperative efficiency. This is largely a matter of the spirit, and as most thinking people know, it is matters of the spirit which make for the really important and creative changes in human affairs.

Imagination is a priceless quality which I regret to say is much lacking in our present-day exploration. It is the quality which we prize above all others, yet somehow we have lost the knack of developing it in our schools of higher education--in fact I fear we do just the opposite, and it goes further into our mining companies. To illustrate what I mean let me tell you a true story.

Several years ago we had a rather promising junior engineer, and yet we had no real opening for this lad at the time, and therefore advised him to take a position which was offered with one of our oldest and best-known mining companies. After he had been with this concern for about two years he came back to us asking to be reinstated. Naturally we were curious and wrote to the chief geologist of this company inquiring as to the reasons why he had left. In reply we received this astonishing letter--mind you, from the chief geologist of one of our greatest mining companies. "Mr. X is a man of unorthodox views, so much so that I expect that he may even be a Communist. His ideas about finding ore are unique and wild, and I could not permit them to be broadcast in the organization. In view of this and in spite of the fact that I must truthfully say that some of his ideas did result in our finding new ore, I felt it in the interests of the company to dismiss him."

Last, but certainly not least, is the maddening, confusing, frustrating matter of taxes as they affect the mining industry in the U.S.A. Those of us who have had to do with the mining taxation in this country, for the past decade, are often wont to wonder if the laws could be worse if the making of them had been premeditated on the basis of injuring the mining industry. For the effect of these taxes is the opposite of what it should be if we want to find new mineral deposits. I have only time to mention here two typical examples of types of taxes which have an adverse effect on mining exploration. The first is the so-called ad valorem tax on iron ore reserves in the Lake Superior districts whereby as soon as a ton of ore is discovered a tax is slapped on it for 50 percent of the appraised value (personal property taxes are at a rate of never exceeding 40 percent). The direct result of this tax is to stop all exploration for iron ore, practically speaking, from 1916 until the Second World War. This tax is not only iniquitous, but it is an example of blind stupidity wherein it kills the goose that lays the golden egg; and regardless of the fact that is has been in effect for 50 years it is still on the statute books and will probably remain there.

This is a state tax. The other tax, which is equally harmful and unfortunately more widespread, is the regulation by the Bureau of Internal Revenue under our existing Federal tax laws whereby those searching for new mineral deposits are not allowed to treat monies spent on exploration as an expense and therefore deductible in figuring taxes. There are some variations in this law, but by and large this is a plain statement of fact, and in passing, I might say that further inequity is added in that this does not apply in the search for oil. The effect of this has been to dry up venture capital, the proof of which I have witnessed in my own office a decline in the offer of mineral properties from a matter of hundreds a year down to practically a trickle. This means that promoters are disappearing. They simply cannot get capital because those people who have money are not willing to risk it, inasmuch as this legitimate expense will not be allowed. Exploration monies have to be capitalized and there are tax deductions only when they can be charged against a capital gain. On the other hand should the money be ventured and the venture successful, the return on that venture would be taxed in accordance with the bracket in which the adventurer happens to be. It has efficiently taken all the attractiveness out of mining exploration--so much so that even mining companies themselves are turning to the oil business. One of our largest is spending 8 million dollars on wildcat oil exploration during the current year and only nominal sums for mining explorations.

I cannot close without telling you about one further matter bearing on the search for new mineral deposits, and although this is an intangible to me, it is one of the most important of all the features mentioned; namely, it is a matter of loyalty and faith in order to find new ore bodies: first, to believe there are more ore bodies to be found; and second, that by wisdom, perseverance, and courage you will find them. Unfailingly, over the past quarter of a century, I have noted that those who were successful in finding great mines were possessed of the quality of belief in things. These people had a positive outlook on life, people with this outgoing nature were successful in too great a percentage of the time for their success to be accidental. Such courage and faith will pervade an entire mining organization so that we have today certain companies that are noted for their success in exploratory ventures. There are enough of such companies and such people to ensure that we will find the ore we need in this great Nation. The consensus of those who know best is that so far as ore reserves are concerned, we have "enough and to spare"; and let us hope and pray that we shall be allowed the freedom both abroad and more importantly the freedom here at home to go out and find these vitally necessary mineral deposits.

Thank you, gentlemen.

MR. SWAREN: You are now invited to ask questions.

QUESTION: Dr. Davidson, to what extent do you believe it is possible to locate additional mineral deposits here in the United States, (a) which are profitable to work and (b) which may lessen our dependence on foreign sources of supply?

DR. DAVIDSON: In reply to that I have to be specific with regard to the particular mineral involved, so let us just choose a target at random and choose copper. The outstanding recent discovery of copper, or at least one of the best, is the deposit at San Manuel in Arizona. That was found during the recent war, but we have several years to go yet before it will be brought into production. However, if and when it is brought into production--because it is a marginal deposit--it will require from 30-50 million dollars capital and it will be at least 10 years from the time it was discovered until the time it is producing the necessary metal.

Meanwhile we are short of copper. Therefore we must go abroad for additional supplies, simply because of the time element involved. These big deposits take such a long time to get into the picture. However, were we to continue our exploration on the even basis that has been recommended here, I think it is possible that ultimately we might get back to a point where we could keep our rate of discovery up to where we could produce almost indefinitely 60 percent of the copper we need in this country, or at least in our time. That is only a guess, of course. We must necessarily--because of the situation we find ourselves in today--go abroad for a great many of the metals which used to be of sufficient supply in this country. Our cupboard has become too bare.

QUESTION: Dr. Davidson, what is the difference between the Government, which is composed of all the people, getting into the mining business and having just a few large companies controlled by a few?

DR. DAVIDSON: I would say that we could go around and around on this point for a long time! The difference will be the result due to individual incentive. When we want a man to do a job in our company, we tell him, "We will give you the best assistance we can find, we will furnish you with the best equipment we can, the finest supervisors we can, then we will reward you--give you an incentive for your men and for yourself."

In a government by the people and for the people you get the first three of those, but today no means has been devised, certainly, to give government bureaus the proper incentive for urging these men to go out and find something the way private enterprise can do. It doesn't work out that way. I have seen government bureaus explore an ore body in a way which private industry would believe extremely wasteful,

spending ten times the manpower and doing ten times the amount of exploration work necessary on a particular deposit, simply because they did not have to account for results when they got through, and because they didn't have any specific prize to go after. They don't have to count the cost. The cob of corn is not out in front of the horse's nose as temptingly as it is in private industry.

QUESTION: What I was primarily interested in is that any time the price of copper drops, all these little marginal mines are out of business; the minute the price goes up, all these little marginal mines come back in business. It costs the little fellows a lot of money to put the marginal mines into operation.

DR. DAVIDSON: That is quite true. We have a certain contingent in the mining industry who say the mining business would be better off if the little mines never started up.

QUESTION: Dr. Davidson, I would like to explore that same question a little bit further. You indicated that industry appreciated the importance of exploring for new deposits. We are concerned with the depletion of existing deposits. You also indicated, very realistically, the management within industry is very naturally concerned with the appearance of the profit-and-loss statement at the end of the year. That means that you explore where there is profit. You also indicated opposition to government interest. I come to this question: Other than the amelioration from this tax burden that you have mentioned and other than legislation to permit you to write off your exploratory costs or to capitalize those--which is another way of doing the same thing--What good can government underwriting financially--not by entering into the business to the point of actually conducting exploratory work but underwriting as we do civil air lines--in your opinion, do to bring out more deposits in regard to large explorations?

DR. DAVIDSON: A tremendous amount of good, along lines presently established through the Geological Survey and the Bureau of Mines so far as its long-range research program is concerned.

To give you a specific illustration, the U. S. Geodetic Survey is mapping the entire United States in detail. Now to a mining geologist, a geological map is not an end in itself. It is at best a place to start from. From a study of the map, we begin to find a place where we will have an idea of where we will look for more ore. The Government is the only agency which can properly make the necessary maps. The Government can do most for the mining industry by getting together basic fundamental scientific data needed to start the search.

Then we do like the amount of good work the Bureau of Mines is doing in developing research projects on things which we know will come sooner or later but which are currently uneconomic. For instance, the

matter of getting oil from oil shale--things like that. We don't want them carried any further than research but we believe in them to a certain extent. That is the sort of thing the Government can do here at home.

Abroad the Government could assure by political means that metals and minerals that we don't have in this country would be provided us in an emergency. The best example of that is industrial diamonds. Wherein there is a perfect monopoly in that a group exists which controls over 95 percent of the diamond production in the world. We ought to have, under world conditions today--I think anyone will agree--the lion's share of those diamonds and at a fair price. We need them. We must have them in machine tools and mining. The Government, I think, should see to it that those diamonds don't get to places they shouldn't go--Iron Curtain countries--but get to us.

QUESTION: What do you think of replacing the raw materials we get from mines and oil wells by agricultural products?

DR. DAVIDSON: I think most mining geologists welcome the idea. I think substitution will take place. We hope for it in many respects.

QUESTION: Doctor, I have two short questions: First, Does color photography as an exploration method have value? Second, When mining for zinc, would you not use a different type of mining? Stope mining development is not as lengthy if you are fortunate enough to find ore where you can use stope mining.

DR. DAVIDSON: Color photography is used effectively where ore may lie below certain favorable rocks. In the area of the Tennessee Copper Company in Eastern Tennessee color photography showed up certain trends in the rocks which showed up certain colorful soils. We hope it will be of great help out west where there is not so much vegetation covering the alteration haloes of which I spoke.

Your point is well taken in regard to different mining methods. When I spoke of so much time, I was talking about large ore bodies in this country which you have to reach by means of shafts a mile deep. It doesn't take very long today to open an open pit mine. The mines where we can go in and develop by electric shovels, we can strip the overburden and start mining. You are quite right in your reference there. I keep thinking in terms of depth because that is where we will have to look for ore deposits in the future.

QUESTION: But if your depths are in the mountains, you can go through from the bottom on the outside.

DR. DAVIDSON: Take off the top of the mountain and remove the bottom by electric shovel as at Utah Copper!

QUESTION: Would you discuss exploration in foreign countries such as Venezuela?

DR. DAVIDSON: I don't want to infringe on these gentlemen who will follow to talk about foreign minerals. That was a very fascinating discovery of iron ore that United States Steel has just been through in Venezuela with so much publicity. My company is connected with it and I know it quite well. It has been thrilling from the beginning to the stage they have reached now. It is regrettable that there was so much publicity on it.

QUESTION: Could you tell me if anything is being done and if it is possible to get any ore out of the so-called tidelands. I know oil and salt are being taken out.

DR. DAVIDSON: We have our eye on the tidelands. There is nothing strictly new to it. The Cornish people mined miles out under the Atlantic Ocean. In Newfoundland they mine a mile and a half out. The hardy Cornish miners put shafts down from the surface. They are not bonanzas. I believe in some ways the tidelands are not as favorable places to look for ore bodies as for oil because the rocks are not the right kinds of rocks, ordinarily speaking, for metalliferous ore bodies. The rocks which occur out in the tidelands are younger rocks which cover the rocks which contain the metalliferous ore bodies.

MR. SWAREN: I would like to make a comment on that question. Perhaps the greatest under-water mining is off the island of Kyushu and there is one coal mine that goes out about 10 kilometers from the shore. As you go out in it, the water pours down and you think the ocean is coming down on top of you.

QUESTION: Dr. Davidson, I gather from your talk that you feel our potential reserves are far greater than our proven reserves. How do you feel about the proposition that we should restrict further depletion of our reserves and go into importation of most of our minerals?

DR. DAVIDSON: Our basic feeling is that there is enough and to spare and we should only restrict exploration of mineral resources where we can see a catastrophic end. Take zinc, which is such a hard-pressed item these days. Some people said the Second World War ran us out of zinc ore; that is not so. By means of two companies doing some very intelligent, aggressive exploration in the East, our zinc reserves were greater after the war than before the war. If you have a rich country, you begin to know the environment which is favorable to the ore bodies and begin to feel confidence in what our ore reserves may be.

QUESTION: I don't follow your last remark, Dr. Davidson. Less than a minute ago I thought you mentioned a new copper deposit found in Arizona which is of such magnitude as to give us most of our

requirements in our time. If we are talking of our time and our whole economy is built on our technological know-how with mineral support, Where do we go in our time? What happens to our children? What is the country going to come to? If we don't have enough for conditions such as we are in ourselves--after all, we are pretty short-ended on this thing--Why shouldn't we be importing a greater amount of our minerals and save our natural resources for a rainy day just as you said the Indonesians are doing already, particularly tin and tungsten, and not let those go except through very controlled means?

DR. DAVIDSON: Perhaps, I didn't make myself too clear about this deposit in Arizona. That will not take care of our needs in our time. It will only contribute in a substantial way in helping out. The question you bring out is a little bit too large for any one person to answer. I have one or two things to say about it. I think the condition will be solved by compromise, as so many things are. If we are going to have a free economy, we can't have too many controls, or you will throw too much out of gear in our economy. You may, as you say, injure some of our domestic reserves if you allow the law of supply and demand to operate. If you have a high enough price, then aggressive financiers in this country will go after ore bodies and any ore body will ultimately be entirely depleted. We have hopes, however, that we as geologists will find not only enough for the needs of this generation but for generations to come if we have a free economy in which to encourage development and exploitation. But I believe, too, there are many, many great ore bodies in foreign countries, such as the Rhodesian copper deposits, which will supply an ever-increasing percentage of basic metal to this country and allow us to prolong our ore life here. It is admittedly a big question.

QUESTION: You have likened this problem to a plum pudding. It certainly can be a pretty deep pudding that we are playing with. Could you give us the latest scientific theories, maybe, on what goes on at really great depths or what might be available there and perhaps look into the future from an engineering viewpoint as to the possibilities of probing to not two to four miles but to much greater depths?

DR. DAVIDSON: That is a fascinating idea to pursue. To give you facts, South Africa mines gold ore at a profit with the stopes at depths of over 10,000 feet vertically and the room temperatures over 110 degrees F. at the face. Most of those mines are not air cooled; some of them are. Certain types of ore bodies, we feel sure, will go down to depths of 10 miles--what we call our deep type or hot type ore body. We are now investigating some nickel zones in northern Minnesota which we think were buried 10 miles under the earth's surface. That much surface has been eroded. If we have the right kind of economy, I feel confident that mines can be carried to depths of two miles if we don't get a physical condition which will make it economically unsound.

Mr. Hoover made a remark some years back that 90 percent of our ore gives out at depths less than 2,000 feet below the surface, but we didn't know as much about ore bodies in those days as we do now. Many ores go well below that. But as depth increases, the cost increases, and it gets to be a matter of economics. What is the product worth? How much will it cost to get it out? We are constantly devising new techniques, not only to probe deepinto the earth but we are cheapening our methods of getting down there. We are the greatest tunnel people in the world in this country, but we are probably the poorest shaft-sinking people in the world. We never had to sink deep shafts so we don't have a measure of what we can do in sinking shafts. Our people are the best technicians in the world. Given time—as we view the earth's plums down there, the ore plums—I am not a bit afraid of looking down a mile for them. I like to think of an ore district as a cube. Don't put any limits on it until you have gone down 5,000 feet, or more, in many types of ore that we need.

QUESTION: Would you comment on the research developments regarding the taconites in northern Minnesota. I may have misunderstood your statement regarding the Mesabi Range, but I thought you said there might be more rich ore there but the exploration is just not taking place. Would you relate that to the present development of the taconite range?

DR. DAVIDSON: I repeat I don't believe any one engineer or any group of engineers has a specific idea of how much rich ore we have left in the Mesabi Range. If we could extrapolate a curve which would mean that some day we will get through the high-grade ore and will develop the taconites, it will be because perspicacious engineers see that downward curve and also because one company owns most of the good land on the Mesabi Range. The other six or seven substantial companies haven't as good pickings as this one company. They are constrained to go out and develop other mines, because in 5, 10, or 40 years they may run out of high-grade ore in the Mesabi Range. In view of the fact that these companies have to keep growing, everybody will shift over to the taconite business. I wouldn't hazard a guess as to whether it is going to be an economical plum.

QUESTION: Dr. Davidson, Would you tell us what you think about the possibilities of additional finds of uranium deposits?

DR. DAVIDSON: I think the chances are excellent that we shall find a lot more uranium ore in the United States. We have a great deal of low-grade uranium mineral, but we are so niggardly about the price that it is not being as fully exploited as it would be if the price were on a level of a high-price incentive. The reserves of this kind of material are vast indeed. It is a new sort of prospecting and we are just learning about it, but, we have some very hopeful signs these days. There may be a great deal more high-grade uranium ore in

this country than we once thought. I would say it looks good in the United States. We haven't found anything yet that we think compares with the Belgian Congo ore, but on the other hand, the prospects are hopeful.

In Canada, which is the second greatest source of uranium, a great area starts at Great Bear Lake and runs southward which is a very highly mineralized uranium zone to Athabasca. One of the government mines is now bringing into production what looks like a very great uranium ore body. We, here, are fortunate that this U_3O_8 ultimately benefits us. I think that area will eventually be very fruitful because the sum of at least 8 million dollars is being spent to bring uranium ores which we know exist in the Athabasca-Great Slave Lake region.

QUESTION: Since we have to go abroad for our minerals, Where are they prospecting in Canada and what are the restrictions the Canadian Government places upon it, our opportunity for capital to work up there and develop, what are the opportunities for securing the ore by prospecting and the extraction of it?

DR. DAVIDSON: The prospects in my opinion are excellent. In my way of thinking, Canada is the finest country in which to mine in the entire world. The Canadians' laws are more favorable to mining because of the fact that a larger percentage of their economy is devoted to mining than in this country. There are new mines being developed all over Canada; things look good. So far as restrictions are concerned, there are no real restrictions except those involved by the exchange rules which will not allow you to bring money back and forth across the border as freely as you would like. A good many of us, though, don't feel that will last. As best proof of that, one of our large mining companies here has guaranteed a sum in excess of 15 million dollars for the development of a new nickel property in Manitoba. I wouldn't say there are any really serious restrictions except those existing at the moment regarding the withholding of certain dividends.

QUESTION: Dr. Davidson, as a representative of industrial management, What do you think Selective Service should do about the deferment of geologists and mining engineers in colleges within the next few years? Also, What do you think the military services should do about the reserve personnel who are in that field?

DR. DAVIDSON: To me mining is a critical necessity and it ought to be judged on that basis. We need technicians so badly they should be deferred regardless—what I am trying to say is that one of our troubles in our deferment has been "If you defer Joe in this category, you should defer Harry in that category." Instead, we ought to look at the ultimate need. Here in our country the most primary need is metal.

The mining industry is highly understaffed with technical men, without whom we are helpless. If a fellow is going to be a bona fide engineer or geologist he should be deferred, simply, because he can't be replaced by anyone else. That fact should be taken into consideration. Our needs are unfilled at the moment; the incoming potential supply is vastly under what we require. If we continue this way, half of that supply in 10 years will be taken into the draft; it will cripple us. We already feel the pinch. Now it has reached the point where we are stealing men from one another--this is not good.

QUESTION: With the increasing requirement for titanium, What progress has been made in the production of titanium in the amounts that will fill our needs?

DR. DAVIDSON: As titanium reserves go, we are very fortunate. We are now opening up an ore body that has at least 100 million tons of known reserves. I think it will run ultimately into many hundreds of millions of tons; so the supply is there. The tough part is to produce metallic titanium--that is our big difficulty at the moment. There is no shortage of supply in the ground.

QUESTION: Dr. Davidson, it appears to be general practice in the oil business that the extraction process--that is, getting the raw materials--and the processing of that material are done by one company. Is it in other types of mining profitable to have the extraction process done by one company and the processing done by another company, selling the mineral to the processing company? Can they operate and make a profit in that manner?

DR. DAVIDSON: They can, but the trend is toward integration in the mining industry. Kennecott used to have all copper concentrates in Utah smelted by the American Smelting and Refining Company. Now Kennecott does its own smelting.

MR. SWAREN: I'm sorry but our time is running out. Dr. Davidson, we are very happy to have a man with a real prospector's outlook before us. I thank you on behalf of the college and the Commandant for a very interesting lecture.

(8 Jan 1952--750)S/sgh