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PORCUPINE, CANADA'S GREATEST GOLD CAMP

Geological Formation of Porcupine and Location

A Gold-Bearing Formation Extending Over 4500 Acres, Proving Itself to Be One of the Richest Gold-Producing Areas in the World.

Porcupine is south of the 49th parallel on the Hudson Bay slope, at an elevation of 1000 feet above the sea. The principal mining area contains approximately 4500 acres. It extends from the south boundary of Tisdale Township northward three miles, with an average width of over two miles to the extreme width from the Dome mines on the east to the Hollinger on the west is three and a half miles. The rocks of this area are all of Kewatin or Archean age, and form a complex of basic and acid volcanics including basalts porphyries and intermediate types.

The greater part of the region has been very much sheared, schistized and altered by great intrusions of granite and diabase in post-Temiskaming times. Minor portions of the area are less schistized, and here the rocks are for the most part massive basalts standing as hills 50 to 100 feet above the soft and schistose rocks adjoining.

There are scattered outliers of Archean or pre-cambrian schists in other parts of the district, and a narrow band of sedimentary rock of later age stretches north-easterly from the Dome mines to Night Hawk lake, but the main area is in the basement igneous rock, and therefore not subject to change in the contents of the veins with depth.

The Granite Magma. According to Dr. W. G. Miller, the provincial geologist, this area may be described as an island of schistose rock in a sea of granite. This granite intrudes some miles away, and is believed to be the source of the gold. In writing on the Kolar field in southern India, which is also a pre-cambrian schist, J. Malcolm MacLaren, D. Sc., refers to the association there of auriferous veins with granite intrusions. He thinks that the granite underlies the schist, but a shaft down 5000 feet at the Mysore mine has not met with any change in the formation. And it may be that the granite at Porcupine will not be encountered for thousands of feet below the present surface.

Identity with Other Pre-Cambrian Schists. A perusal of the great work of Dr. MacLaren on "Gold, Its Geological Occurrence and Geographical Distribution," shows that the conditions at Porcupine conform very closely to those in the other pre-cambrian fields, including South Africa, and western Australia, as well as southern India. In all there are dikes of diabase and banded iron formation with granite as the fundamental rock and an igneous magma as the source of the gold.

In fact, Dr. MacLaren says that the pre-cambrian schists in all parts of the world form "a single petrological and metallogenetic province."

The Origin and Formation of the Ore Bodies. Assuming the schist at Porcupine occupies a great basin or syncline formed in the one plastic granite, it would appear that upheavals in this magma account for the shearing and vein formation. Peter MacLaren, F. G. S., who has for several years made a very careful study of these ore deposits, thinks that there were at least four separate igneous intrusions each followed by important depositions of gold. The last in point of time was an eruption of diabase which formed the cross courses and materially added to the gold contents of all the veins.

The igneous magma was the source of the gold. It probably did not occur there in sufficient quantity to be classed as ore. The metal was at later periods leached, or washed, from its matrix and deposited in the veins in more concentrated form, and the agent of solution and concentration was water highly heated and under great pressure. This water was derived from, or at all events set in circulation by the heat of the magma

and intrusions of granite and diabase. These intrusions also massed the schist zones and vein systems, and altered the original rock from a hard and massive to a soft and schistose one. As the channels were formed the heated waters brought up silica gold and other elements in solution, and deposited the same therein. And these processes occupied long periods of geological time and, involved great dynamical and chemical action and changes in the original rock and in the shear zones and vein systems.

Form and Nature of the Ore Bodies. Mathematical regularity was not a necessary element in the formation of these great ore bodies. Well defined veins of uniform width and length are the exception rather than the rule. Occasional masses of quartz are found in the veins, but the veins themselves are somewhat irregular in form, and the vein stone varies. The principal ore of the camp consists of interbedded quartz and schist with highly schistose bands of country rock very much impregnated with secondary quartz calcite and iron pyrites. The larger and usually lensular veins occur where the rocks are extremely schistose, while the narrower, better defined veins are found in less disturbed areas.

Visible Gold and Payable Values. Visible, or free gold does not necessarily mean payable values. It seems to be mainly of secondary origin. Spectacular specimens found upon the surface are no doubt due to a local enrichment from the concentration of surrounding values," is quoted by P. A. Robbins, M. E., general manager of the "Hollinger." And from the same authority we learn that payable values are commonly found where no visible gold has been observed.

Changes in Value With Depth. Underground, there is some oxidation—along recent watercourses, but surface oxidation is practically negligible. There is, however, a considerable change in the character of the ore at a moderate depth. The quartz masses tend to fade away and are already stated, mixed quartz and schist, or silicified and mineralized schist, becomes the prevailing gangue of the gold.

In depth the metal also is fine, invisible and evenly distributed, whereas, as it shows at all at the surface, it is coarse and "spotty." At the leading mines there has been a notable improvement in values below the 500-foot levels. In elevated regions where there is considerable oxidation decreases in value are very marked at the ground water where concentration from weathering ceases. But there is practically nothing of this nature at Porcupine. The change in the ore with depth is not from external causes; it is inherent in the formation and is not a diminution, but an increase in value below the influence of surface conditions.

Trunk and Branch Veins. Peter MacLaren, F. G. S., holds that contiguous veins which on the surface may appear to be unconnected ore, in fact, generally branches from one main trunk vein at greater depth and this will carry more consistent values and be much larger and better defined than its branches or offshoots. Developments at several properties tend to strengthen this view.

Irregular Ore Bodies. Numerous small fissures running in many directions tend to great positions of metal. On this point Dr. MacLaren says that interlacing stringers or what is known as stockworks, "are favorable to ore deposition probably because opportunity is afforded for the intermingling of the solutions carrying the metallic salt and the precipitant, respectively." This form of ore body also promotes deposition by a rapid decrease in temperature



Dome Mines, Mill and Plant. (Photo by Tomkinson, South Porcupine.)

on account of the increased surface of the cooler country rock. On the same principle the richest ore is generally found along the walls or contacts of quartz and schist.

At the "Dome Mines" there was the largest mass of quartz in Porcupine but in this the ore was low grade. With depth the percentage of silica decreased and the ore is of better grade than any mass of equal size in any part of the world.

Cross Veins. Most of the veins at Porcupine have a northeast or southeast strike but at the time of the diabase eruption they were cut by many cross veins and the solutions thus set in motion traversed both systems and very materially added to their gold content. Dr. MacLaren emphasizes the constant association of diabase intrusions with the auriferous schist of the pre-cambrian era.

Precipitants of Gold. "Gold will be deposited wherever physical and chemical conditions are suitable irrespective of the nature of the walls of the fissure or cavity through which the auriferous solution happens at the time to be passing." Precipitants materially aid in deposition and of these the most important seem to be carbonates and sulphides. At Porcupine practically all the veins which are gold bearing contain considerable carbonate of varied composition. Wherever the enclosing rock is schistose it always carries dolomite or ankerite.

Iron pyrite is by far the most prominent sulphide. It forms about four per cent of the auriferous schist and occurs also in the quartz and calcite. Other sulphides sometimes seen are copper pyrites, pyrrhotite, arsenopyrite, galena and zinc blende.

The most prominent vein stones are quartz, calcite, dolomite, sericite, chlorite and tourmaline. Occasionally we find perleite, serpentine, feldspar, molybdenite and scheelite.

Even Values to great Depths. The older igneous rocks are favorable for large and permanent ore bodies, but not for specially high values. The accumulation of the precious metal was a gradual process of long duration, and now it is such below the original surface in a zone where there were no sudden changes of temperature or pressure at the time of precipitation. And changes in the tenor of the ore do not occur with the same rapidity or to the same extent as in more recent rock formations.

No Values Apart From Ore Channels. Some engineers not familiar with the ore deposits of Porcupine have looked for gold in the shear zones as such, but mere physical change in the originally massive rock is not sufficient.

There must also be chemical change from the action of the solutions which accompanied the later igneous eruptions. The dynamic agencies, however, opened the channels through which the heated waters circulated and deposited their precious burden. And the numerous fractures which ramified thru the schist were, as already pointed out, very favorable to the deposition of the gold.

And as a rule where shearing has been pronounced, ore will be found at a moderate depth even where there is no vein showing on the surface. A special instance of this is the fine vein on the "Porcupine Crown," which came in at a depth of 100 feet. Its ore is more silicious and also of higher grade, but in less volume than the more basic ore which is the mainstay of the principal mines of the camp.

Surface Contour of the Ore Zone. Rocks which have been much broken and fractured readily yield to the action of glaciers and atmospheric agencies. They weather down more rapidly than the hard massive complex. We may therefore expect to find the best ground practically level unless where there are masses of solid quartz. Owing to their superior resistance power these "dome" hills of varying sizes, while alongside the shear zones, are often hills of amygdaloidal basalt. An even surface in this region may be evidence of intense dynamic agencies and much shearing and fracture.

The Great Shear Zone. Shearing has not taken place to the same extent over the whole mining area. But all the development indicates that the most promising ground is that which extends in a general south-easterly direction from the "Millerton" and "Hollinger" on the west to the "Dome Mines" on the east. In this belt the shearing has been more extensive than in any other pre-cambrian field, and there are as a result groups of three or more veins to each well defined zone of fracture.

At the "Hollinger" development is well advanced and over fifty-four veins have been located. They are close together and can be worked from one central shaft. To this will be brought by electric locomotives, not only the ore from the 150 acres of the "Hollinger," but also that from the "Millerton" and "Acme" adjoining. The number of veins and the great volume of ore are important and unusual factors, and tend greatly to reduce the costs and increase the profits of mining.

There is only a single fissure in the Kolar field, but Dr. MacLaren pronounces it the greatest ore shoot in the history of mining. Several large mines are operating on the shoot. A depth of about 5000 feet has been attained and the total output is over \$300,000,000.

Importance of Pre-cambrian Schist. Ontario is by far the greatest metal mining province in Canada, now leading in gold, silver, nickel, copper and iron. But Porcupine is its only great gold camp. Very rich ore has been found from time to time over wide areas in other parts of Ontario, but the production has been limited. In respect to its great shear zones and vein systems and the large quantity of payable ore Porcupine differs from all other gold regions in Canada. Here the pre-cambrian schists are strongly developed, and these are the most productive type of the world's auriferous rocks.

Persistence of the Deposits. In his third annual report on the "Hollinger," Mr. Robbins says: "We are located in one of the great pre-cambrian areas of the earth's crust, and the results of mining in similar areas in other countries—the only country—Western Australia, Southern India, South Africa and Brazil have all contributed to a building up of knowledge concerning the occurrence of gold in deposits in these older rocks. And as pointed out by Dr. MacLaren before the recent Canadian meeting of the International Geological Congress, gold deposits of this type are deep seated in their origin, and persist in depth until some unfavorable change in rock formation may occur adversely affect the gold bearing zone."

The Great Future of Porcupine. When it is remembered that the new Canadian camp has larger ore bodies than any other field, there is a tendency to shrink from specifications as to its ultimate production. We know it must be very large, but we have no other region with which it may be fittingly compared. Elsewhere there are veins which also persist to great depths, but they are single fissures in ground not so intensely sheared as that at Porcupine. We have nowhere so many veins and vein systems. The camp is yet in its infancy, and it is impossible to say how many veins will be found as work proceeds. After four years' operations on the 100-foot level of the "Hollinger," occasional and unexpected bodies of ore are still being met with. But for the present only 12 of the 54 veins are being exploited. But since the last of July, 1912, production has been over \$7,000,000. Total dividends are \$3,550,000, and there is a surplus of \$1,270,000, notwithstanding heavy expenditures on betterments. It is now believed that there is \$100,000,000 in gold above the 775-foot level in the "Acme," "Millerton"

War Demands Development of All British Gold Areas

World-Wide Necessity for More Gold Will Regard the Development of the Porcupine Camp as That of Part of the Work of Patriots.

Events have freely justified the wisdom of the call made soon after the outbreak of war for increased production and purchase of Canadian goods. That effort in that direction has been successful, as shown by the important and favorable change in the ratio between the imports and exports of the Dominion. In 1913 the surplus imports nearly reached \$200,000,000, and even last year to more than half that amount. Now a parity has been secured with the prospect that before long exports will exceed imports and provide a credit balance on the Dominion's international trade. Consideration for the future prosperity of the Dominion requires that this policy be continued and that every effort be taken to ensure the employment of capital on profitable enterprises only.

For the time being international credit has ceased to exist and the question for each nation engaged in this colossal war is how best to mobilize its wealth. Mr. Lloyd George, during the debate on the last war budget, is reported to have said that the difficulty of the chancellor of the exchequer was not that the United Kingdom was not rich enough to wage war for twenty years, if necessary, but that its assets had to be liquidated to pay for expenditure as the war went on. What counts now is not wealth in the forms that are associated with peace times but wealth in the shape of arms and munitions of war. It is very necessary too, that the British Empire live as far as possible within itself and make use of its own resources.

When war broke out the first concern of each of the great belligerent nations was to look after its credit and its gold. Germany has been assiduously combing the country for gold, even the women's wedding rings have been commandeered and added to the reserves in the Reichsbank. Britain, France and Russia have not found it necessary to go to this extreme but have camp has larger ore bodies than any other field, there is a tendency to shrink from specifications as to its ultimate production. We know it must be very large, but we have no other region with which it may be fittingly compared. Elsewhere there are veins which also persist to great depths, but they are single fissures in ground not so intensely sheared as that at Porcupine. We have nowhere so many veins and vein systems. The camp is yet in its infancy, and it is impossible to say how many veins will be found as work proceeds. After four years' operations on the 100-foot level of the "Hollinger," occasional and unexpected bodies of ore are still being met with. But for the present only 12 of the 54 veins are being exploited. But since the last of July, 1912, production has been over \$7,000,000. Total dividends are \$3,550,000, and there is a surplus of \$1,270,000, notwithstanding heavy expenditures on betterments. It is now believed that there is \$100,000,000 in gold above the 775-foot level in the "Acme," "Millerton"

remarkable instance of this phenomenon. Values exceeding \$20 are however unusual in the pre-cambrian. On the other hand specially high values in whatever formation they may occur rarely, if ever, go to depth.

The Great Future of Porcupine. When it is remembered that the new Canadian camp has larger ore bodies than any other field, there is a tendency to shrink from specifications as to its ultimate production. We know it must be very large, but we have no other region with which it may be fittingly compared. Elsewhere there are veins which also persist to great depths, but they are single fissures in ground not so intensely sheared as that at Porcupine. We have nowhere so many veins and vein systems. The camp is yet in its infancy, and it is impossible to say how many veins will be found as work proceeds. After four years' operations on the 100-foot level of the "Hollinger," occasional and unexpected bodies of ore are still being met with. But for the present only 12 of the 54 veins are being exploited. But since the last of July, 1912, production has been over \$7,000,000. Total dividends are \$3,550,000, and there is a surplus of \$1,270,000, notwithstanding heavy expenditures on betterments. It is now believed that there is \$100,000,000 in gold above the 775-foot level in the "Acme," "Millerton"

No Secondary Enrichment. In considering the future of Porcupine it is also important to bear in mind that glaciation has been very heavy and very recent in geological time. Consequently there is no secondary enrichment which generally means the accumulation of values in the oxidized zone, and a marked decrease in the metallic contents of the veins a few hundred feet down. In Nevada there has just been a very

Also the great mines in the Rand District of the Transvaal and in Rhodesia were supposed to have passed the period of maximum output, there has, of late, been a marked increase in their production. In normal times an average of \$3,500,000 of the metal reaches London every week. On this basis during the forty-five weeks from the middle of last August to June 30 of this year, a total of \$157,500,000 would have been shipped. But, as matter of fact, the actual production for that period was \$388,000,000, an increase of \$17,000,000 over expectations. That increase continued during July and will probably be maintained unless the supply of native labor diminishes, of which there are some indications.

In order to avoid the risk attending shipments of gold in war times the Bank of England opened an agency at Cape Town about the middle of August for the deposit of gold from the South African mines. These deposits were estimated at the beginning of July to total between \$150,000,000 and \$180,000,000, or about sixty per cent of the bullion holdings of the Bank of England. As the gold shipped from the United States to Ottawa has nearly all been returned, the probability is that should further gold require to be sent to New York to strengthen exchange on London the bank will release the metal from its Cape Town deposits rather than from its vaults in London.

In these circumstances it is the duty of every British state possessing gold areas that can be profitably worked to utilize them to the best advantage. Among the known areas that are likely to repay wider development none is more promising than the Porcupine district of Northern Ontario. For calendar year 1914 the total gold production was 252,327 bullion ounces valued at \$5,203,229. Every year since 1912, when real work began, has shown a progressive improvement in output and ore reserves of higher contents are looking to the future. Indications of the quality and extent of the deposits it is reasonable to hold that Porcupine will before long take a high place among the gold producing districts of the world. It is as patriotic to produce gold for the empire as it is munitions and those assisting to the development of Porcupine present a double purpose to serve, first, the patriotic side, and second, the profitable side.

Labor and Capital are both necessary to make Porcupine, and Capital is the immediate necessity.

Many Properties of Merit. Porcupine is not a region of two or three mines. If the "Hollinger" and "Dome Mines" are at present the most prominent it is because they have been the most extensively developed. There are many other properties of equal merit now seeking capital. The mining and metallurgical problems have been solved in the camp. There is an efficient railway service and two hydro-electric power plants. The great war has added to the value of gold, and has shown the superlative stability of the industry. Many of the other gold fields of the world are nearing exhaustion, but Porcupine is still young, and when all its properties are being worked to capacity it will be the greatest producer of the twentieth century.

S. R. Clarke.

Scene Showing Mill and Plants of the Hollinger and McIntyre Mines.