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BUREAU OF GEOLOGY AND TOPOGRAPHY

GEOLOGICAL SURVEY

PRELIMINARY REPORT

GOLDFIELDS AREA, SASKATCHEWAN

BY

H. C. Cooke

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Goldfields area lies on the north shore of lake Athabaska, near the extreme northwestern corner of Saskatchewan. It may be reached by plane from Prince Albert, Saskatchewan, or Edmonton, Alberta; or by steamboat from Waterways, Alberta, from which point a weekly train runs to Edmonton. The centre of the area is Goldfields village, with a small hotel, radio stations, and a number of stores and dwellings. The two principal gold discoveries, the Athona mine and the Box property, lie within a mile of the village, to the south and west respectively. The village is situated at the upper end of a deep, sheltered bay, which afford ideal conditions for airplanes to take off or land in any weather.

A preliminary reconnaissance of a very large area around Goldfields and to the northward was made in 1935 by F.J. Alcock.[1]

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[1] Geology of Lake Athabaska Region, Saskatchewan; Geol. Surv., Canada, Mem. 196.

Geology

The rocks in the immediate neighbourhood of Goldfields include sediments, granite, and amphibolite.

Sediments

The commonest rock of the sedimentary series in the area east of Vic lake is a fine-grained, almost cherty quartzite that weathers to a bright reddish tint. The average strike varies between north 35 and 45 degrees east, and the dip is 40 to 45 degrees southeast. At the northeast end of Goldfields bay the strata flatten into a broad drag-fold, in which the strikes are roughly at right angles to the normal strike, and the dips are

southwest, corresponding to the plunge of the fold. A number of smaller and sharper drag-folds occur on this larger drag, one of them forming a small rock ridge directly east of the hotel; and on these the plunge can be accurately determined as about 30 degrees southwest. To the northwest of Vic lake is the mass of Beaverlodge mountain. The writer was unable to visit it but from a distance the sedimentary strata can be seen again to flatten there, plunging southwest as before, so that the hill is either a second large drag-fold or the top of a major anticline.

A second rock type, well exposed near Goldfields village, is a brown-weathering crystalline limestone, in large part altered either by addition of silica or elimination of lime to coarse aggregates of pyroxene and other silicates.

Granite

Alcock's study of the general region led him to believe that two granites occur, one pre-Beaverlodge in age, the other post-Beaverlodge. In the neighbourhood of Goldfields village, however, only one granite appears, which was mapped by Alcock as the later of the two. It is a rock of medium to coarse grain, that varies in tint from grey to rather bright roddish. There is some reason to believe that the redder varieties have been altered, but this question will be more fully discussed later. Prior to alteration the rock probably consisted mainly of albite feldspar containing several per cent of the orthoclase molecule in solution, together with quartz and very small percentages of ferromagnesian mineral, now mainly altered to chlorite. The granite magma was extremely vigorous in its action on the country rocks, particularly on the reddish quartzite. Clean, weathered surfaces show the country rocks extensively attacked and replaced by granitic material that

entered the minutest crevices, even down to pore spaces; yielding hybrid types that vary in composition all the way from granite to quartzite. On this account it is particularly difficult, where granite is in contact with the reddish quartzite, to know whether one is dealing with true granite or one of the hybrid types. To distinguish them with certainty it is necessary to examine a number of freshly broken specimens. If the rock is granite, the specimens will be uniformly of medium to coarse grain; but if it is a hybrid, they will vary in grain, some parts having the fine grain of the quartzites, other parts the coarser grain of the granite.

Studied in this way, bodies of pure granite are found to occupy a much smaller area than at first appears to be the case. A large part of the Box property west of Goldfields, for example, was at first supposed to be underlain by granite; but the greater part of this eventually proved to be more or less highly granitized quartzite, and true granite, within the area studied, is confined to two masses, one a little more than half a mile long and 150 to 200 feet wide, the other a much smaller body lying southwest of the first.

In addition to their granitizing action the granite bodies send off dykes into the country rock which, after cross-cutting the bedding for a few feet, commonly turn and follow it and eventually break across again to connect with the parent mass. Thus long slabs of country rock become included in the granite masses near their edges. Where the country rock was originally a basic greywacke or shale, its recrystallization by the heat of the intrusive produces basic mica schists which, if care is not taken, may be confused with the amphibolites next to be described, and the true age relations of the latter may thus be obscured.

Amphibolite

The rock here termed amphibolite is dark-coloured, commonly almost black, but with a distinct reddish tinge. In most places the grain is rather fine, but in one mass, on the Athona property, it is coarse. For the most part the rock forms thick, stumpy lenses, the long axes of which parallel the general strike of the sediments and are two or three times as long as the shorter axes. Other bodies are more dyke-like, and of thicknesses from 2 or 3 inches upward. A few bodies are quite irregular in shape and crosscut the original bedding or the schistosity along lines so straight as to suggest that some pre-existing joint or fault controlled the injection.

The coarse-grained variety on the Athona property looks at first sight like a very coarse gabbro of 8 to 10 mm. grain; but closer inspection shows it made up of large, broken crystals of black, ferromagnesian mineral in a brownish, rather fine-grained matrix. Under the microscope this matrix is seen to consist mainly of andesine feldspar, $Ab_{55}An_{45}$, with an average grain size of 0.1 mm. The remainder of the matrix, perhaps 5 per cent, is biotite in small flakes, with some greenish hornblende. The large black crystals or crystal aggregates that look like phenocrysts are biotite, green hornblende, or a mixture of the two. In thin section a few crystals were seen that have the general appearance of pyroxene, but they have been so bent and squeezed that the features characteristic of pyroxene cannot now be identified.

The finer grained types have the appearance, on very clean weathered surfaces, of very basic gabbro. Their average grain is 1 mm. or less. As these rocks, at the surface, seem badly altered, only one specimen taken from the 100-foot level of the Box property was examined microscopically. It is possible,

therefore, that this specimen is not characteristic. It proved to be a fine-grained, black schist, composed almost entirely of black mica with a few needles of muscovite and a few grains of feldspar too small for precise identification.

Alcock has stated that the amphibolites of the district are older than the later granite. The writer's facts do not confirm this, however, and it is felt that during the preliminary rapid reconnaissance made by Alcock and his parties the basic mica schists found as inclusions in the granite were confused with the true amphibolites. The age determination of the amphibolites is most important, as it bears directly on the question of the age and origin of the gold deposits, and for this reason it was investigated with particular care. The facts indicating the age are as follows:

(1) On the Athona property, some five or six trenches cross the amphibolite-granite contact, and have been cut a few inches into bedrock. In all but one, the amphibolite exhibits strong chilling over a width of 2 feet from the contact. The large crystals of biotite and hornblende that characterize the interior of the mass become smaller, and close to the contact disappear entirely or almost so, while the whole rock becomes fine-grained and basaltic in appearance. In the exceptional trench mentioned, the amphibolite is filled with slabs and stringers of granite, and that exposure is not large enough to show whether these are dykes or inclusions.

(2) On the 125-foot level of the Athona mine, the northernmost crosscut crosses the amphibolite-granite contact and penetrates about 30 feet into the amphibolite. Here the amphibolite again displays the chilling observed on the surface, and includes many fragments of the granite. A dyke of amphibolite about a foot wide penetrates 8 or 10 feet into the granite along a small fault; and in three or four places narrow fingers of the amphibolite were

observed to project about an inch into joints in the granite. The same joints are filled with quartz beyond the little fingers of gabbro.

(3) On the Box property of Consolidated Mining and Smelting Company the amphibolite in many places includes fragments of granite. The fragments vary in size from small bits 1 inch or 2 inches in diameter to great slabs 40 or 50 feet long and several feet wide, which are easily mistaken for dykes. If the contacts of the latter are painstakingly traced, however, the amphibolite is always found to surround them completely. One of the best and most easily accessible places for seeing these inclusions is on the trail from the cookhouse to No. 1 shaft, near survey picket No. 90 (Figure 1). Here moss and lichen have been worn away by passing feet, exposing in the amphibolite a swarm of small, rounded fragments of granite up to 3 inches in diameter.

(4) Southwest of No. 1 shaft (Figure 1) the main granite body is bounded on the south by an amphibolite dyke. An offshoot from the dyke penetrates the granite mass and was traced a distance of 150 feet. On the first level south and southwest of No. 1 shaft there are several dykes of amphibolite in the granite, and one of them appears to cut completely across the granite body.

(5) In places the amphibolite cuts almost at right angles across the bedding and schistosity of badly granitized quartzite and displays a gneissic texture parallel to the contacts, <u>not</u> to the general structure. This texture is particularly well developed on the northwesterly-striking contact at diamond drill hole No. 2, and again on the similar contact southeast of survey picket No. 82. As these gneissic textures are at right angles to similar textures developed by folding, they must be interpreted as original gneissic textures, developed by flow movement during injection of a viscous magma.

(6) The amphibolite dykes invade the granitized quartzite in such an extraordinarily irregular manner (Figure 1) that they can only be regarded as intrusive; and as they themselves show no sign of granitization, they must have been injected after granitization was complete.

It may here be mentioned that the shapes of these dykes as shown on the map are not obtained by inferring connexions between scattered outcrops. The area is one of almost continuous outcrop; and the course even of dykes a few inches wide can readily be determined by walking along them. Where boundaries had to be inferred, they are shown by dashed lines.

Geologic History

The first event of which there is record in this district is the deposition of the sedimentary rocks. These are very fine-grained quartzites beneath, passing upward into greywackes with important amounts of limestone. The succession indicates deposition in water of shallow to moderate depth at first, followed by a clearing of the waters with decrease in the amount of clastic sediment. This may have been due either to sinking of the sea bottom or to lowering of the adjacent land by erosion. Folding followed, along axes that strike northeast, but it was not extreme, as the strata rarely dip at angles greater than 50 degrees.

The folding was followed by injection of granite masses. In general these formed sill-like bodies paralleling the strike and dip of the tilted sediments, but in places cutting sharply across them for short distances. Gases or fluids from the granite, laden with silica and the constituents of feldspar, penetrated long distances into the country rocks and granitized them.

After the granite masses were consolidated, some further movement took place along the former axes of folding. Drag between the massive granite masses and the surrounding rocks gave the latter a pronounced gneissic texture for a few feet from the contact. At the same time the brittle granite was much crushed and fractured, with production of a vast number of tension cracks running off from the contact. The exact time of this movement, with relation to the injection of amphibolite, is not known. The amphibolite is not shattered and fissured like the granite, so that the movement probably occurred before the amphibolite was injected; but the conclusion is by no means certain, because the granite, being more brittle, may have shattered where the amphibolite would not.

Following the consolidation of the granite, and probably also the movement that shattered it, came the injection of the amphibolite. This tended to form thick, stumpy lenses, perhaps connected with adjacent bodies by narrow dykes or necks, perhaps entirely isolated. The shapes suggest that it was viscous and near its temperature of consolidation when injected, a conclusion supported by its usually fine grain and somewhat gneissic textures.

In two places on the Box property, near survey picket 54 and 120 feet northwest of picket 102, small dykes of amphibolite bend sharply and at the bend display a sort of fragmental texture, as if partly consolidated material had been broken by movements and the fragments recemented by liquid amphibolite. In the first-named instance, a pronounced schistosity has also been developed in the amphibolite, following around the bend parallel to the edges of the dyke. These structures could not have been caused by a lateral stress acting on the amphibolite after consolidation, for the dykes bend in opposite directions. Further, if there had been sufficient lateral movement in the area to twist and brecciate

some dykes at the time they were partly consolidated, other dykes and masses, which must have been in about the same condition, should show evidence of disturbance; but they do not. The writer is, therefore, inclined to consider the brecciation and schistosity of these dykes as caused by forward movement in the magma itself, at the time that partial consolidation had taken place, and the remaining liquid material was presumably highly viscous.

Some small faulting took place after the injection and consolidation of the amphibolite. The granite in the underground workings is much broken by small faults with steep to vertical dips. As far as can be learned, there was no great movement along any of these, the largest known having a lateral displacement of about 20 feet. They had a profound effect, however, in shattering the granite and thereby making fissures that were afterwards filled with quartz, for great numbers of tension cracks branch away from them on either side.

After the faulting, came injection of the solutions that albitized the granite and deposited the quartz veins. As this change seems to have been mainly one of subtraction of potash from the rock, it may well have been carried out by the same solutions that deposited the quartz.

The final event of which there is record is post-ore faulting. On the Box property a few veins, made up largely of quartz and calcite, include vast numbers of angular fragments of altered granite and older quartz. In places these veins contain large vugs lined with large quartz crystals, many of them amethystine. There are also faults that contain no vein material. Movement along all these later fissures appears to have been small.

Economic Geology

Two companies, Athona Mines, Limited, and Consolidated Mining and Smelting Company of Canada, Limited, own properties in the area containing ore-bodies of sufficient promise to justify underground work. Some 25 miles to the northeast the Borealis Syndicate, under the field direction of J.W. Warren, have opened up a large sulphide deposit of considerable promise. In the remainder of the territory examined, active prospecting is going on, but up to the present time has not yielded particularly favourable results. Gold seems widely scattered throughout the region, however, and good assays have been obtained in many places, so that it seems reasonable to suppose that minable deposits may eventually be found.

Consolidated Mining and Smelting Company

The Consolidated Mining and Smelting Company of Canada, Limited, owns what is known as the Box property about a mile west-southwest of Goldfields village. The claims lie between Goldfields bay and Vic lake, and the mine workings are close to the south shore of Vic lake. In addition, the company owns or has under option several other groups of claims in the neighbourhood, on which trenching and diamond drilling were done in 1936.

The underground work on the Box property consists of two inclined shafts that follow the dip of the formation, approximately 42 degrees southeast, and are 1,280 feet apart. The westernmost, known as No. 1, extends to the 500-foot level. No. 2, intended to be the main working shaft, has been carried to date only to the first level, approximately 170 feet below the collar. At this level a drift has been carried the full length of the granite sill being prospected, a total distance, including bends, of somewhat more than 2,800 feet. Six crosscuts have been

carried from this drift completely across the granite mass, with a total length of 1,080 feet, and, in addition, the mass has been further explored by a number of drill holes both from this level and from the surface. The 500-foot level, as mentioned, is reached only from the No. 1 shaft, and a similar program of exploration is being actively carried on there.

This granite mass has a total length of about 2,500 feet and a maximum width of about 250 feet. As Figure 1 shows, however, the width varies considerably, and in places abruptly, along the strike; and similar variations occur in depth. Thus, opposite No. 1 shaft, the calculated width for an elevation of 120 feet above Athabaska lake is 180 feet, whereas at the first level, 175 feet below, a crosscut shows the width to be 240 feet.

The granite mass, especially throughout the central section some 1,700 feet long, has been greatly shattered and the fissures filled with quartz mineralized with auriferous pyrite and some free gold. In places the quartz includes small nests of tourmaline crystals. The silica-bearing solutions also penetrated all the pores of the rock and deposited quartz in irregular veinlets and blebs. So much quartz has thus been introduced that it was found impossible to secure a single thin section that did not contain much of it. Either the solutions that carried the silica, or others introduced before them, in large part altered the potash-bearing albite of the original granite to albite and oligoclase-albite. As this reaction was one mainly of subtraction of potash from the original rock, it may well have been affected by the silica-bearing solutions.

The fissures thus filled with quartz belong to several distinct sets. One of the most prominent is a set of rather irregular, discontinuous cracks which roughly parallel the sill in strike but have a shallower southward dip. They are best developed along the hanging-wall, over a horizontal width of 25 to 40 feet,

but are also numerous in some places along the foot-wall. The position and arrangement of these indicates that they are tension cracks produced by a continuation of normal folding movement in the sediments after the granite was injected and consolidated. This set also includes a few fairly strong shear zones that parallel the hanging wall.

A second set of prominent pre-mineral fissures strikes roughly north and dips 70 to 80 degrees west. On the Box property the average strike is north 10 degrees west, but in the surrounding region the strike varies to north 10 degrees east. Well-defined and persistent quartz veins fill these fissures, the majority less than 4 inches wide, but a few up to 8 inches. In the underground workings it can be seen that these fissures are small faults with almost horizontal displacements, as the walls exhibit striations that dip about 10 degrees south. Numerous tension cracks, likewise filled with quartz, run off from these faults. The tension cracks, on the Box property, strike about north 20 degrees east and dip 55 to 60 degrees west. The pattern is interpreted as indicating that the west sides of the main faults moved northward and up, i.e., they are right-hand faults. There is no evidence, however, that the total displacement exceeded a few inches.

A third set of pre-mineral fissures strikes north 20 to 50 degrees east and dips about 40 degrees southeast. They do not carry much quartz, and may have been formed toward the end of the period of quartz deposition.

There are also at least three sets of post-mineral fissures. Probably the earliest is that already mentioned, which has been filled with calcite and barren quartz forming a matrix to a multitude of angular fragments of granite and older quartz. These fissures strike north 70 to 80 degrees west and dip vertically to steeply south. The second set contain no vein

material. They strike about north 60 degrees east and dip about 60 degrees north. Where they cross quartz veins, the latter are cracked and in some cases displaced an inch or so. The third set strikes north 20 degrees east and dips 80 degrees west, and some faces exhibit horizontal striae. On the surface, at least one fault was observed with this strike, and it displaces the granite contact about 20 feet horizontally. The west side moved south, so that the fault is a left hand one.

The veins are composed of a rather coarse-grained, white, and glassy "bull" quartz, which here and there contains splashes of auriferous pyrite and a few widely scattered specks of free gold, galena, and sphalerite. Where sulphides are absent the quartz is barren of values. Practically all the gold occurs in the pyrite, some of which is extraordinarily rich. One lump of pyrite assayed during the writer's visit ran nearly $1\frac{1}{2}$ ounces of gold, Troy weight, to a pound avoirdupois of mineral, or roughly 9 per cent gold. The pyrite is usually coarse-grained and occurs as aggregates or lumps in the quartz rather than as scattered crystals. In most Canadian gold deposits auriferous pyrite is usually fine-grained, and coarse pyrite is low grade or barren.

As the individual veins are too small to be separately mined, operations must be directed toward mining the whole or selected parts of the silicified granite. The dilution of the valuable part, in this way, by worthless granite, brings the general tenor near the point of unprofitable operation. It is expected, however, that by mining and milling several thousand tons a day costs can be reduced to a point at which a profit can be made.

Athona Mines, Limited

The active workings of Athona Mines lie near the shore of Athabaska lake about a mile south of Goldfields village. At the time of the writer's visit the principal workings consisted of a 3-compartment vertical shaft to the first level, 125 feet below the collar, and some 2,000 feet of drifting and crosscutting at that level. A second shaft was being sunk some 800 feet south of the first, close to the lake shore; and presumably it is planned to connect the two by drifting. In addition, a considerable amount of trenching and drilling has been done. Good camp buildings has been erected, and also a 15-ton sampling mill which was used for the bulk sampling of the drifts and crosscuts.

The geology in the vicinity of the ore-bodies is simple (Figure 2). A thick sill of coarse amphibolite, 250 to 400 feet in horizontal width, intrudes a reddish granite of the type described from the Box property. The amphibolite, whose composition has already been given in the section devoted to rock descriptions, strikes north-northwest and dips 45 to 60 degrees west. To the north of it, and separated only by a drift-filled valley 100 feet wide, is another body of amphibolite that dips southwest. The writer considers it probable that some dyke-like connexion between the two masses exists at the surface beneath the drift of the valley; and drill results also indicate that the dip of the northern mass flattens so that it probably runs into the southern at no great depth. The two may, therefore, be looked on as branches of a single underlying mass, including between them a shoe-shaped mass of granite.

As on the Box property, the granite is cut by a great number of quartz veins that contain grains and splashes of auriferous pyrite and occasional grains of galena, sphalerite, chalcopyrite, and free gold. Most of the veins stop abruptly at

the contact with the amphibolite, though here and there they run a few inches into the amphibolite. Veining and mineralization are most intense throughout an irregular zone that parallels the contact, and decrease with increasing distance from this contact. The best values, up to the time of examination, had been found in the north end of the workings, in the shoe-shaped body of granite between the two bodies of amphibolite. As on the Box property, those parts of the granite that carry sufficient values will have to be mined as a whole. The general tenor of the ore, therefore, is low, about $4 a ton at the present price of gold. Operations, presumably, will have to be on a large scale if a satisfactory profit is to be made. Further exploration will be required to demonstrate whether sufficient ore is present to justify the initial expense of large-scale operation.

Origin of the Gold Deposits

The close association of the gold deposits with bodies of the later granite inclined Alcock[1] toward the view that the

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[1] Alcock, F.J.: Gold Deposits of Lake Athabaska; Can. Min. and Met. Bull., 1936, pp. 542-3.

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gold was probably derived from the granite itself, and he suggested, tentatively, that the now mineralized parts of the granite are the upper parts or border zones of a large underlying mass, which, cooling and consolidating before the main body, were fissured and mineralized by solutions emanating from the main body as it in turn crystallized. In one specimen from the Athona mine he found gold deposited along cleavage planes in a feldspar crystal, a fact he interpreted as indicating that the gold had been a constituent of the original granite magma. Attractive as this hypothesis appears, however, the facts obtained during the past season do not seem to support it.

The principal objection is, of course, the fact that the mineralized quartz veins are not only later than the granite, but also than the amphibolites that intrude the granite. How long a time elapsed between the injections of the two intrusives there is, at present, no means of ascertaining, but it seems certain that it was long enough for the granite to become thoroughly consolidated even at depth. Had some granite magma remained liquid at depth, the same earth forces that ejected the amphibolite would surely also have brought up some of the granite magma, to form a set of later dykes that would intrude all the other rocks as do the amphibolites. As no such late granite bodies have been found, it may be concluded that the granites were thoroughly consolidated when the amphibolites were injected; and, therefore, that the vein-forming solutions did not originate from underlying bodies of this granite.

That gold was not an important constituent of the granite magma is also directly indicated by a number of facts. On the Murmac claims, at a point about half a mile north of Goldfields village, granite intrusion has been locally controlled by a bedding plane of the sediments, and for a few hundred feet granite is in direct contact with crystalline limestone. The limestone has obviously acted as a precipitant of mineral matter emanating from the granite, so that the limestone for 2 or 3 feet from the contact, and the granite itself for a foot or more, are both heavily pyritized. The pyrite zone has been deeply trenched in several places, and carefully sampled, but no gold values beyond a few cents have been found. Had gold been a constituent of the magma, it would presumably be found here, where conditions for precipitation were so favourable.

In a number of places, as near the southwest end of the granite on the Box property, and again in a number of places on the Murmac claims, the sediments close to the granite boundary

have been intensely silicified, and in places converted into masses of almost pure silica. Farther from the contact silicification becomes less intense, until the rock passes into sediments of normal character. These relations point to the conclusion that the silica was derived from the cooling granite. Had the granite magma contained gold, it would probably have passed off with the silica-bearing solutions and been precipitated in the silicified sediments. No gold is found, however; the silicified materials are barren.

About 2 miles north of Hayter bay, some 12 miles east of Goldfields, a rather flat-lying sill of coarse, reddish granite caps a long ridge. Beneath it lie gneisses, which appear to be altered and recrystallized sediments with varying proportions of greyish granite. For several feet below the contact the gneisses are enriched with pyrite, and enrichment is greatest close to the contact, fading out as distance from the contact increases. The length of the exposed contact, and of the mineralized zone beneath it, is about a mile; and throughout the whole distance the width of the zone and the extent of its mineralization are so uniform as almost to compel the conclusion that the pyrite-bearing liquids or vapours emanated from the cooling granite itself. Had the granite contained important gold values, the pyrite should also be auriferous, but, the writer is given to understand, preliminary assays indicate that it contains little or no gold.

On the west side of Neely lake, some 14 miles due north of Goldfields, gold has been found in a number of sporadic and apparently isolated occurrences, most of them in drill cores. The rocks are sediments intruded by numerous dykes of red granite. Gold, when found, has generally been in the sediments close to some granite dyke, or just within the edge of a dyke. Scattered values have also been found in a pyritized zone that follows the bedding of the sediments. The impression gained from a study of

this locality was that a little gold may have been introduced by the granite, but that, if so, the amount was insufficient to enrich more than small spots of the surrounding rock.

It must, therefore, be concluded that the granite magma carried little gold and gave rise at best to small, scattered occurrences. The solutions bearing the important amounts of gold were introduced at a considerably later date, after the injection of the amphibolite masses. Their source is unknown, as in the case of most Precambrian gold deposits. They formed deposits within granite masses rather than other rocks, apparently, because the granite was brittle and fractured readily so as to yield a multitude of open channels that made it easily permeable. Thus, as in so many instances, it was the physical character alone of the rock that determined its suitability as a host for veins.

Dinty Lake Nickel Deposit

Dinty lake is a hitherto unnamed lake between 1 and 2 miles long lying 24 miles almost due northeast of Goldfields village. In the early part of August 1936, J.W. Warren, field director of the Borealis Mining Syndicate, while flying over the area observed a rusty gossan capping a low ridge on the northeast side of the lake. Investigation showed this to be the outcrop of a large body of nickeliferous pyrrhotite, on which exploratory operations were immediately started.

On September 7 the writer was flown to the property, where he remained about five hours. This time was spent in studying the existing trenches, and collecting a number of specimens on which the following notes are based. Bad weather and other factors unfortunately prevented any further visit.

The area explored up to the time of the writer's visit is a low ridge about one-quarter mile north of the lake. The ridge

trends practically due north, and at about the middle is broken by a shallow draw trending northeast. On the east, the ground descends into a swamp; on the west and south, into sand-plain. Over the crest of the ridge, where the soil is thin, a number of east-west trenches cut through a few inches of rusty gossan into the fresh rock beneath. The area thus explored was roughly 800 feet from north to south, and 75 to 80 feet across.

The material exposed by trenching is a breccia composed of rock fragments of all sizes cemented by sulphides. Few of the rock fragments have sharp corners or edges, suggesting that they have been attacked and partly replaced by the sulphides; and this conclusion is confirmed by the occurrence in many places of bands of disseminated or massive sulphide running through the individual fragments. The original cause of brecciation was undoubtedly fault movement, as numerous slips and slickensided zones can be observed. These strike north 50 degrees east, and dip from 30 to 60 degrees northwest. The steeper dips are the commonest. Here and there bands of unbrecciated and unmineralized rock cross the ore zone, paralleling the strike and dip of the faults. These are 25 to 50 feet in horizontal width, and will probably make mining difficult.

The rock of which the fragments are composed is rather fine-grained, equigranular, and dirty grey, about the texture and grain size of loaf sugar. In hand specimen it is readily mistaken for a fine-grained, rather basic granite or gneiss. Thin sections show, however, that it contains no quartz whatever, and that the composition is that of a norite. The feldspar is andesine, $Ab_{60}An_{40}$ to $Ab_{55}An_{45}$, and on the whole is fairly fresh, though to a small extent replaced by sericite and carbonate. Its proportion varies, in different fragments, from about 30 per cent of the thin section to nearly 100 per cent. The ferromagnesian mineral is largely a monoclinic pyroxene closely related to hypersthene, but

exhibiting petrographic peculiarities that are being made the subject of a separate paper. In some fragments this mineral is all perfectly fresh, in others it is partly or completely altered to uralite and magnetite. A little biotite and garnet are also present in some thin sections, and some garnet is also associated with the sulphide ore. The garnet of the rock is of the ordinary reddish variety, and the garnet associated with the ore is black, with an index of refraction above 1.90, so that it would appear to be a titanium-bearing andradite, or schorlomite.

The two dyke- or sheet-like horses of unmineralized rock observed by the writer within the ore-body are both pegmatitic in character. They are made up of irregular patches up to an inch in diameter of light grey feldspar with a little quartz, interspersed with smaller, dark spots composed mainly of ferromagnesian mineral with some feldspar. In thin section the feldspar was identified as oligoclase-andesine, $Ab_{70}An_{30}$, or slightly more sodic than that of the ordinary rock; and the quartz is very irregularly distributed in masses of crystals 2 to 3 mm. in diameter, as if either the very last product of crystallization, or introduced after the rock had consolidated. The patches of dark mineral are aggregates of magnetite crystals and chlorite flakes, suggesting that they are alteration products of a pyroxene or hornblende.

Two polished sections of the sulphide ore show it to consist almost entirely of pyrrhotite. A small amount of chalcopyrite is also present in small veinlets and areas, and a little sphalerite, a little of a mineral probably the iron-copper sulphide cubanite, and a very small amount of an unidentified mineral. No pyrite appeared in these samples, but in the field considerable amounts of it were noted.

The main body of mineral, consisting of pyrrhotite with some pyrite and included rock fragments, is cut by numerous little slips and joints that are filled with chalcopyrite and a little pyrrhotite. One fissure paralleling the main set, which strikes north 50 degrees east and dips northwest, is filled with a 6-inch vein of fine-grained, white to slightly greenish material resembling quartz, but consisting almost entirely of feldspar, oligoclase-albite $Ab_{85-80}An_{15-20}$. This vein is fissured with numerous cross cracks filled with chalcopyrite and a little pyrrhotite, and thin sections show the sulphides accompanied by quartz and a good deal of chlorite, which is replacing the feldspar. From these occurrences it is evident that mineralization took place in two stages, the first a deposition of the main body of pyrrhotite, the second an introduction of chalcopyrite accompanied by a little pyrrhotite. Such a conclusion suggests further the possibility of greater copper enrichment at depth.

Two or three samples of the sulphide ore were taken by the writer, averaging between 1 and 2 pounds each; and such parts as were not used for polished sections and other study were lumped as one sample and forwarded to the Bureau of Mines, Department of Mines and Resources, for assaying. The results obtained were

Nickel	0.94 per cent
Copper	0.04 per cent
Gold	0.01 oz. per ton
Silver	0.19 oz. per ton
Platinum metals	nil

In size, the deposit appears to be large. As already stated, the area explored at the time of the writer's visit was about 800 feet in length by 75 to 80 feet in width; and at neither end was there any sign of decrease in width or in amount of

mineral. The writer had no time to trace the body throughout its full length, but was told by J.W. Warren that the rusted zone had been traced from outcrop to outcrop over the length of four claims, or approximately 1 mile.

Drilling is now being carried on to determine the true areal extent of the ore-body, its extension, if any, beneath the drift on either side, and the change of grade, if any, with depth. After the passage of a year or so much further information should be available on this interesting occurrence.