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CONTENTS

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SUMMARY REPORT, 1922, PART C

FLINFLON MAP-AREA, MANITOBA AND SASKATCHEWAN

By F. J. Alcock

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INTRODUCTION

Since 1913 the mineral belt north of The Pas, Manitoba, has attracted considerable attention. It has produced one important mine, the Mandy, from which over $2,000,000 worth of copper was recovered. Another ore-body, Flinflon, has been shown by diamond-drilling and underground development to contain over 16,000,000 tons of iron-copper-zinc sulphides carrying, in addition to the copper content, values in both gold and silver. Other sulphide showings in the region have also been staked. In addition to these sulphide bodies many claims have been taken up for gold. The more important of the gold-bearing veins yet located lie at the eastern end of the mineral belt in the vicinity of Wekusko lake. In 1914, the Geological Survey commenced mapping this whole region and by 1920 two sheets had been issued, covering the entire mineral belt. The first or western is on a scale of 3 miles to 1 inch, under the title of the Athapapuskow Lake region and the second, on a scale of 2 miles to 1 inch, is known as the Reed and Wekusko Lakes sheet. Recently need has arisen for more detailed geological information regarding the area, and the writer, consequently, was instructed to map an area of about 50 square miles surrounding the Flinflon and Mandy properties.

FIELD WORK AND ACKNOWLEDGMENTS

The surveys of Schist, Phantom, and Flinflon lakes were made by plane-table and alidade from a transit and stadia control. The surveys of streams, trails, roads, and the lakes in the western part of the map-area were made by telemeter and compass, with ties wherever possible to the

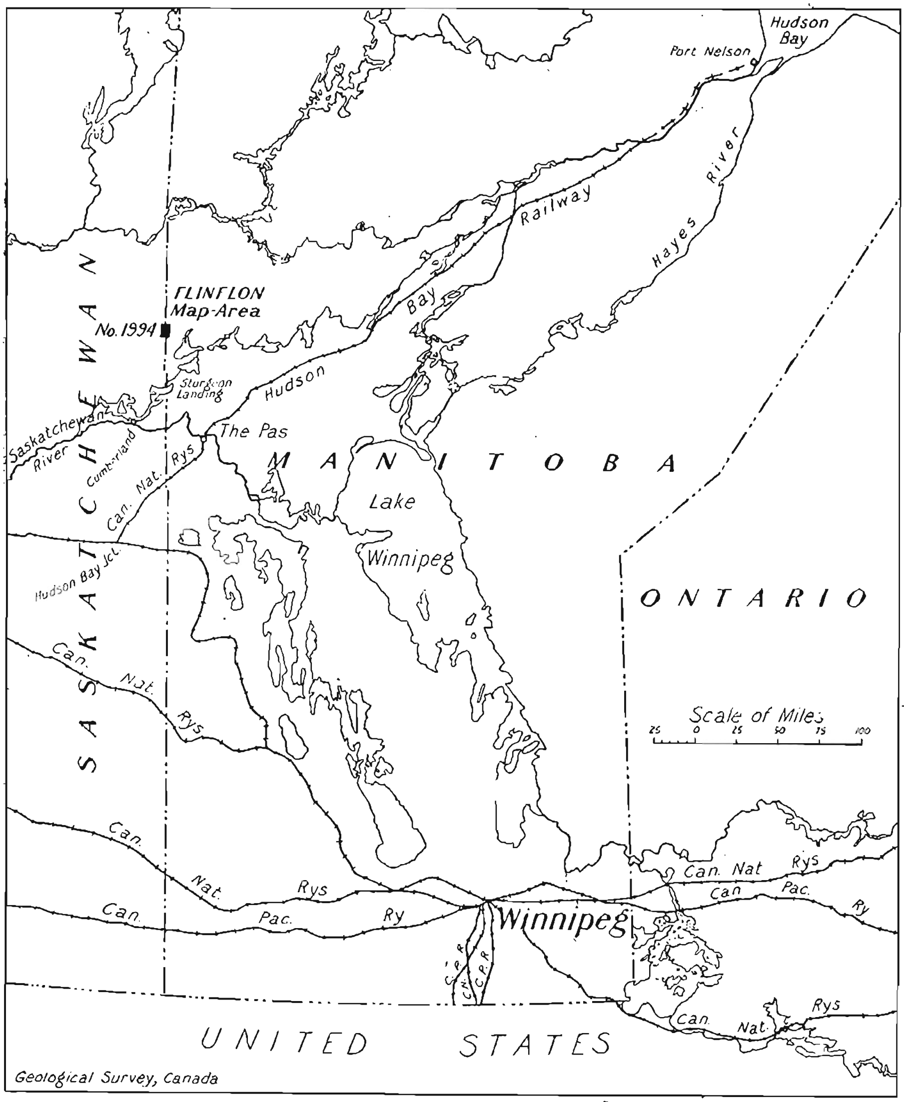

Figure 1. Index map showing location of Flinflon map-area.

Manitoba-Saskatchewan boundary, to transit and stadia stations, or to posts of surveyed claims. The inland traverses to locate geological boundaries were made either with chain and compass, telemeter and compass, or pace and compass.

The writer is indebted to the Mining Corporation of Canada for many courtesies. Their maps, mine plans, and geological information were placed at his disposal and their officers assisted the work in every way in their power. Special thanks are due for the permission to incorporate on the map the detailed work carried out on some of the company's claims by Professor E. S. Bastin. Assistance in the field was efficiently rendered by C. A. Merritt and J. S. Stratton, and by P. Armstrong after the completion of his work at Elbow lake.

LOCATION AND MEANS OF COMMUNICATION

The area lies along the boundary line between Saskatchewan and Manitoba with approximately half in either province. It has a length in a north and south direction of 8 miles and a width in an east and west direction of 6½ miles.

The nearest point on the railway is the town of The Pas, Manitoba. From June until October steamboat service is maintained between The Pas and Sturgeon Landing, Saskatchewan. The route lies up Saskatchewan river to Cumberland House on Cumberland lake and across Cumberland and Sturgeon lakes to Sturgeon Landing. This is ordinarily a one-day journey either way. From Sturgeon Landing, a wagon road 16 miles in length leads to what is known as Camp Two, on lake Athapapuskow. From Camp Two the journey by canoe to the Mandy property is about 28 miles; it follows across lake Athapapuskow, up Schist creek, and then north up the northwest arm of Schist lake. A wagon road from the north end of Schist lake leads to Flinflon. The journey from Sturgeon Landing to Camp Two can also be made by canoe by ascending Sturgeon-weir and Goose rivers to Goose lake and from Goose lake by Rat creek to lake Athapapuskow. The long journey around by Rat creek can, however, be avoided by making a portage of 2½ miles from Goose lake to Camp Two.

GENERAL HISTORY

The route up Saskatchewan river past The Pas to Cumberland was one of the first river routes explored in western Canada and, later, became part of a trade highway that maintained its importance as the main avenue to the Athabaska-Mackenzie country until the days of the railway. The first exploration was by Pierre and René Gautier de la Verendrye, explorers from Quebec, who as early as 1742 had explored the Saskatchewan as far as the forks. An old French fort, known as Basquia, was established where the town of The Pas stands today, but with the transfer of Canada to the British in 1763, this and the other French forts of the west were abandoned.

A new interest in the west, however, was soon aroused at Quebec and Montreal. The change of flag in Canada brought a great many merchants—mostly of Scottish descent—to those two cities. The possibilities of the western fur trade were soon recognized. Canoe expeditions were fitted out to journey west to trade with the Indians. Among the earliest of these were two in command of Benjamin and Joseph Frobisher, who in 1772 ascended Saskatchewan river and built a small temporary trading post on Cumberland lake while on their way to Churchill river. The Frobishers were very successful in intercepting the Indian brigades on their way to York Factory, the Hudson's Bay Company's post on Hudson bay. This aroused the company to the fact that to retain the trade for the more valuable furs they must establish inland forts. Accordingly, in 1774, Samuel Hearne, who had just returned from an overland exploration between Coppermine river and Fort Prince of Wales, at the mouth of Churchill river, was sent inland, and established Cumberland House on Cumberland lake, the first trading post built by the Hudson's Bay Company inland from the shores of Hudson bay. Saskatchewan and Sturgeon-weir rivers then became the scenes of rivalry between the French-Canadian voyageurs of the Montreal companies in their swift canoes, and the men of the Hudson's Bay Company in their heavier, slower York boats. In 1784 the various Montreal companies united to form the North-West Company, and this intensified the competition, for there were now two strong organizations each striving for control. A great period of exploration was inaugurated, for it was soon recognized that the Indians traded with those posts nearest their hunting grounds. These conditions continued until 1821, when the two companies were merged into the Hudson's Bay Company. Some of the fur traders, such as Peter Pond and Alexander MacKenzie, made maps of their traverses. In addition, surveyors, such as Peter Fidler and David Thompson, were employed by the companies. The work of Thompson was particularly good. It was he who first surveyed the Goose River route to lake Athapapuskow and from there by way of Grass river to Reed lake.

HISTORY OF PROSPECTING

Almost the first prospecting done in the region was in 1896 when a Mr. Loucks made an expedition to Reed lake, where he staked a claim for gold. It was not until 1908, however, that any substantial interest was taken in the region. About this time Brunne, Woosey, Krug, Vickers, Todd, and Mosher, names still familiar in The Pas region, began active prospecting. In 1913, the finding of gold-bearing quartz veins on Amisk lake caused a great deal of activity in that region. In the following year Woosey and Hackett found good quartz showings on the Kiski-Wekusko property at Wekusko lake, and active prospecting commenced in that part of the mineral belt. In the summer of 1915 the Flinflon ore-body on Flinflon lake was staked, and in the autumn of the same year the Mandy lens was located by Reynolds and Jackson. The latter property was taken over almost immediately by the Tonapah Mining Company, whose engineer, Mr. J. E. Spurr, was in the region at the time, and work was begun without delay. Active prospecting has been continued up to the present time and a great many claims have been taken up, both on quartz veins and on sulphide showings.

PREVIOUS WORK

The surveys of David Thompson and the fur traders remained the only maps of the region until the Geological Survey commenced a systematic exploration of the canoe routes of the northwest. In 1896, J. B. Tyrrell made a track survey from Namew on Sturgeon lake to Wekusko lake by way of lake Athapapuskow and Grass river. In 1899 D. B. Dowling followed Goose lake, lake Athapapuskow, and Pineroot river to Kississing lake. A map of the explored routes of the Churchill and Nelson basins, which accompanies Memoir 30 of the Geological Survey publications, includes these surveys.

With the discovery of gold-bearing veins on Amisk lake in 1913 there came a demand for more detailed maps and geological information; and in the following year the Geological Survey began the mapping of the entire region from Amisk lake on the west to Wekusko lake on the east, a distance in an east and west direction of approximately 125 miles. The western part of this belt was mapped by E. L. Bruce in the years 1914-1918 and a map on a scale of 3 miles to 1 inch accompanies Memoir 105 (Amisk-Athapapuskow Lake District). The eastern end of the region is covered by a map on a scale of 2 miles to 1 inch which accompanies Memoir 119 (The Reed-Wekusko Map-area). These maps, which were made from compass and micrometer surveys, show almost all the lakes and streams that can be used as canoe routes, and the boundaries between the important geological subdivisions.

The Department of the Interior has made some instrumental surveys in the region. An east and west line was carried by F. H. Kitto, D.L.S., in 1916, from the second meridian to Flinflon lake, and a stadia traverse of this lake was made. In 1918, the Interprovincial Boundary between Manitoba and Saskatchewan was run by T. Plunkett and in the following year the shorelines of Athapapuskow, Schist, and Phantom lakes were surveyed by him. The boundary survey served as the main control for the work of 1922.

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GENERAL CHARACTER OF THE DISTRICT

TOPOGRAPHY OF THE REGION

Flinflon map-area lies within the Canadian shield near its southern margin close to that other great physiographic subdivision, the Great Plains. Its topographic features are typical of the plateau in general.

The Precambrian plateau, comprising about 2,000,000 square miles of Precambrian rocks, forms a great shield-shaped area surrounding Hudson bay. One of its chief characteristics is its low relief. In northern Manitoba the difference in elevation between the highest ridges and the adjacent lakes is seldom 200 feet and as a rule is considerably less. In other parts of the shield a greater relief is found, but only in Labrador is this sufficiently pronounced to form true mountains. From any elevation a remarkably even sky-line meets the eye in every direction. Though the relief is slight, the surface of the country in detail is very rugged, consisting of hummocky hills and ridges separated by depressions.

The second most characteristic feature of the plateau is the great number of lakes, from tiny ponds with no outlet, to bodies of water, like Reindeer lake, with a length of 130 miles, or lake Athabaska, with a length of 200 miles. As a rule, the lakes have very irregular outlines, a great length of shoreline for the amount of area covered, and commonly are dotted with numerous islands. The rivers as a rule consist of a series of lake expansions or quiet reaches separated by swifter parts in which falls and rapids are numerous. The depressions which are not occupied by lakes are almost uniformly wet muskeg swamps.

Rock exposures are plentiful throughout the plateau. In certain areas covered with lake clays or terminal moraine deposits exposures are few, but over most of the region the ridges are bare rock, and the shores of the lakes offer almost continuous outcrops. There is, practically, no residual soil, and over much of the region the amount of drift is slight.

Part at least of the physiographic history of the plateau is known. By early Palæozoic time the tilted, folded, and intruded Precambrian rocks had been eroded down to low relief and the successive advances of the Palæozoic seas swept over an old-age surface. This is known from the fact that the profile at the base of the Palæozoic sediments uniformly shows a low gradient. Though of low relief, the pre-Palæozoic surface had minor irregularities much like the present surface of the region today.

The strata laid down in the Palæozoic seas once covered much wider areas than they do now, and it is probable that Cretaceous deposits had also once a much greater areal extent than at present. The Tertiary was a period of erosion in which much of this mantle of sediments was removed, exposing the old Precambrian surface. In late Tertiary time the country was of low relief with a well-organized drainage system in which the streams were smooth-flowing, and where no lakes were present.

A great change took place in Pleistocene time. An ice-sheet advanced from its gathering ground west of Hudson bay and spread out over the region. It scraped off the residual soil, smoothed down the hills and ridges, polished, grooved, and striated the rock surfaces, locally widened and deepened some of the valleys, and by irregularly depositing the loose debris over the country completely disorganized the drainage system. When the ice retreated a great lake formed to the south of the retreating mass and the clays deposited in this lake form the fertile belt of southern Manitoba. Even with the final disappearance of the ice-sheet much of the country remained under water on account of the damming up of the old drainage lines. The streams in many places had to seek new channels and in some places the drainage system is a mere chain of lakes where the water spills from one basin to another.

After the retreat of the ice came uplift which gave to the region its present plateau character.

Local Relief. The average elevation of the plateau surface in the Flinflon area is about 1,100 feet. Schist lake has an elevation of 954 feet and on either side the ascent is abrupt for over 100 feet. Flinflon lake has an elevation of 1,025 feet, and within 1,200 feet from the shore ridges reach an elevation of 1,130 feet. Along the east shore of Cliff lake, cliffs rise abruptly to a height of 160 feet. In the western part of the area the difference of relief is less. In the neighbourhood of Creighton lake the land rises only slightly above the lake-level. This is true in general of the areas underlain by broad expanses of granite. It is in the areas of schist or along contact zones that the maximum difference of relief is seen.

Relation of Surface Features to Bedrock. Faulting, folding, intrusion, and metamorphism have been influential in determining the topography. The most striking feature of the area is a depression that extends through Cliff and Grant lakes to the northwest arm of Schist lake. Along the eastern side of Cliff lake is a well-marked fault, and the depression which the northwest arm of Schist lake occupies with its steep cliffs on either side is undoubtedly the result of the same fault zone.

Geological contacts are nearly always marked by depressions. The contact between the greenstone and the arkose in the region of Ross and Little Cliff lakes is along one of the deepest valleys of the area. The valley lies largely in the arkose, showing that it was the more easily eroded. A similar feature is well shown on the Flinflon wagon road. There is an abrupt rise from the flat land underlain by arkose to the top of the greenstone plateau surface. The contacts of intrusives with older rocks very frequently also lie along depressions that are occupied by lakes or swamps. They were evidently lines along which preglacial weathering and erosion acted more readily and some of them were undoubtedly emphasized by glacial erosion.

The character of the bedrock, also, has influenced the topography. Some of the depressions follow the strike of the schistosity in the foliated rocks, whereas the more massive rocks form the higher interfluvial areas. The granite is the more resistant rock of the region, and there is commonly an abrupt rise from the lake basins with their common narrow fringe of older rocks to the summit of the granite uplands. These uplands are mostly fairly flat; they have much less soil than the areas underlain by the more easily weathered volcanics and consequently have less forest covering. A typical example of a granite upland is the region east of Cliff lake. There is an abrupt rise of 160 feet at the lake shore and then a comparatively flat surface to within a short distance of Embury lake.

In the arkose belt east of Beaverdam lake the structure and character of the bedrock have affected the topography. The surface here consists of a series of strike ridges. The rocks have an average dip of about 25 degrees to the east, and in traversing from west to east an abrupt slope with a rise of from 10 to 40 feet is met, and then a long, smooth, downward slope along the bedding planes of the arkose. In other words the topography is a series of low, broad, hogback ridges. Joint planes have been largely responsible for the abrupt rises, but it is possible that block faulting may also have been an influential factor. It is probable that glacial erosion with plucking along joint and bedding planes has emphasized their particular type of topography, for here the glacial advance was along the strike of the formation. Beaverdam lake itself lies in one of their strike depressions.

Drainage. The whole map-area lies in the drainage basin of Sturgeon-weir river. The larger part drains into Schist lake and thence by lake Athapapuskow into Goose river. The southwestern part of the area drains by Sucker creek through Amisk lake into the Sturgeon-weir. All parts of the area are fairly easily reached by canoe. The streams are typical of the plateau in general, consisting of smooth-flowing reaches separated by rapids. Present day erosion is slight, owing to the fact that the transported material settles out in the lakes, robbing the streams of their cutting tools.

Climate. The nearest point at which meteorological records have been kept is The Pas. These show that the annual precipitation varies from 15 to 20 inches, including both rainfall and melted snow. A large part of the rainfall comes in the months of June, July, and August, the growing season, when it is most needed. The average snowfall is about 35 inches.

The summers are short and hot, the winters long and cold. The average monthly mean temperature for the summer months is a little higher than that at Prince Albert or at Edmonton. The smaller bodies of water, as a rule, freeze over in October, but it is usually early November before the larger lakes are frozen. The lakes are seldom free of ice until the middle of May, and often not until early June.

Agriculture. Potatoes and other garden vegetables are raised successfully in the area. The amount of clay land suitable for agricultural purposes is, however, very limited.

Forests. The trees of the region include white and black spruce, balsam, tamarack, jackpine, birch, and poplar. Much of the region has been so swept by forest fires that the amount of good timber is rather limited.

Waterpowers. Power for mining operations in the area would probably be derived from Birch rapids, on the Sturgeon-weir, situated about 35 miles from Flinflon.

GENERAL GEOLOGY

Flinflon map-area lies within the Amisk-Athapapuskow district in which the rock succession is given by Bruce as follows:

Quaternary	Recent Pleistocene	Peat, river alluvials Lake silts Till, sand, gravel
	Unconformity	
Palæozoic	Ordovician	Dolomite
	Unconformity	
Precambrian		Kaminis granite Granite gneiss Hybrid granite rocks
	Intrusive contact	
	Upper Missi series	Arkose Conglomerates
	Unconformity (?)	
	Lower Missi series	Slate Greywacke Quartzite Conglomerate
	Unconformity	
		Cliff Lake granite-porphyry
	Intrusive contact	
	Kisseynew gneisses Amisk series	Sedimentary and igneous gneisses and schists Lavas, tuffs, agglomerates, and derived schists

Most of these rocks are represented in the Flinflon area. The Amisk series with its various types is abundantly represented. The Kisseynew gneisses are not present, but are characteristically developed to the north of the area in the region surrounding Kisseynew lake, and similar rocks occur at the eastern or Wekusko Lake end of the mineral belt. Similarly, the Lower Missi series does not occur in Flinflon area. Its chief locality is along the west shore of Amisk lake in Saskatchewan, and a small area of similar rocks occurs along the northeast arm of Schist lake. The Upper Missi series is, however, well represented in the area, as are also the granites, granite-gneisses, and dyke rocks of the region. Two small outcrops of dolomite, which are Ordovician outliers, are the only Palæozoic rocks of the area.

The rock succession in Flinflon area may be tabulated as follows:

Table of Formations

Quaternary....................	Recent........................... Pleistocene......................	River alluvials, peat Clay Till, sand, gravel
	Unconformity	
Palæozoic.....................	Ordovician.....................	Dolomite
	Unconformity	
Precambrian	Basic intrusives.................	Dioritic dykes
	Acid intrusives..................	Granite and related rocks
	Basic intrusives.................	Lamprophyre Amphibolite Gabbro Peridotite
	Upper Missi series..............	Arkose Conglomerate
	Unconformity	
	Acid volcanics and intrusives....	Flows, quartz-porphyry and rhyolite porphyry dykes, and fragmental volcanic rocks
	Basic volcanics and intrusives..	Basic lavas, tuffs, agglomerates, irregular intrusive bodies, and derived schists

BASIC VOLCANICS

The basic volcanic rocks cover nearly three-fourths of the map-area. They consist dominantly of lava flows, but beds of fragmental rocks are also fairly common. The massive flow rocks, on account of their prevailing greenish tone, are commonly given the field term of greenstone. Certain of these greenstones have the appearance of diorites and represent either the interior of flows or else are intrusives derived from the same volcanic sources as the flows themselves.

Basic Flows. That most of the massive greenstones were originally lavas is shown by their amygdaloidal and ellipsoidal structures. Amygdaloidal rocks are very abundant. They are well developed near the Flinflon ore-body, on the portage between Key and Douglas lakes, in the neighbourhood of Grant and Little Cliff lakes, and in many other places throughout the map-area. The amygdaloidal structure occurs characteristically in the upper part of the flows, where bubble-holes formed by the escape of steam were afterwards filled with quartz, chlorite, carbonate, or epidote. Of these, quartz is much the most abundant, but the others may occur either singly or associated. The amygdules are of all sizes up to 2 inches across.

Ellipsoidal, or pillow, structure is also fairly common in the flow rocks. One very good example is exposed on the east side of the Flinflon wagon road less than one mile from the mine. The ellipsoids are here large, varying up to 10 feet in length, and are characterized by broad, well-marked borders. Many of the pillow lavas are also amygdaloidal, showing that they are surface flows. They have commonly been interpreted as lavas which were poured out under water.

The ellipsoidal structure was used in an attempt to work out the structure of the lava flows. The longer axes of the pillows mark the strike of the flows. The upper and lower surfaces could commonly be inferred from the shape of the pillows for, during cooling, the viscous materials, making up the ellipsoids shaped themselves against the underlying layer of pillows, filling the irregularities of the surface. Care is necessary in applying this criterion, but often both strike and dip can be determined with a reasonable degree of confidence. A considerable number of such determinations were made, but not enough to work out the structure of the flows over the whole area and to plot structure sections.

In composition the greenstones present considerable variation. The majority are apparently basalts, but rocks of intermediate composition, such as andesites and quartz-andesites, are very common. Many of them are porphyritic, and some of the porphyritic varieties approach rhyolite in composition. Others in thin section are seen to have an ophitic texture and are to be classed as diabase or quartz diabase.

With regard to structure the greenstone rocks may be divided into massive and schistose types. Massive varieties are the more abundant in the Flinflon area. In hand specimen many of them appear quite fresh, but in thin section they are all somewhat altered. The ferromagnesian minerals have gone over into a felt of chlorite and pale green hornblende, and the feldspars are mostly altered to kaolin, sericite and zoisite, and carbonate. Albite is commonly developed from more basic feldspars with the production of calcite from the liberated lime.

The schistose varieties belong to two main types, depending upon whether chlorite or hornblende is the dominant ferromagnesian constituent developed. The chlorite schists appear to be developed from the massive greenstone rocks where shearing has been effective, whereas the hornblende schists are characteristically developed along granite contacts. Along the eastern margin of the intrusion of porphyritic granite east of Cliff lake, crystals of hornblende can be seen in hand specimens of the greenstone rocks. Along the granite contact west of Hamell lake the basic volcanics have locally been altered to a still greater degree and have gone over into hornblende schist. In thin section the rock is seen to consist of hornblende to an extent of about 70 per cent. The hornblende is pleochroic in shades of green and bluish green and contains considerable quartz as inclusions. Many of the hornblende crystals are long and narrow and there is a decided tendency to a parallel arrangement. The material between the hornblende crystals consists of quartz, fine shreds of brown biotite, a little iron ore, and some carbonate. It is a rock which has suffered entire recrystallization.

Fragmental Volcanic Rocks. Fragmental rocks are common in the volcanic complex. In places, they are flow breccias produced by movements of the lava during its solidification. Others consist of material ejected from volcanic vents. These show all degrees of coarseness and sorting from fine-grained, well-banded tuffs formed from volcanic ash material to coarse beds consisting of volcanic bombs as much as 3 feet in length. Certain beds consist entirely of these coarse fragments; in other places the masses apparently fell into viscous lava.

A good example of a coarse fragmental rock is well shown along the western border of the Ord claim southwest of Flinflon lake. Here a band from 200 to 300 feet wide extends for a distance of over 1,500 feet. The rock consists of oval masses of quartz-porphyry associated in places with fragments of greenstone material. The light-coloured acid fragments (Plate I A) are harder than the matrix and stand out on the eroded surface. The fragments are often fractured but never extensively sheared, whereas the matrix is commonly rendered schistose. Similar fragmental rocks containing both basic and acid bombs are found on the Maybe and Ryan claims south of the Mandy. This association shows that the basic and acid rocks belong to the same period of volcanic activity.

Banded tuffs formed from ash blown out from volcanic vents are well developed at various places throughout the area. Along the west shore of Schist lake, south of the Mandy, good exposures of such well-banded rocks are to be seen. Similar rocks are exposed along Meridian lake and particularly good exposures occur on the east side of the northwest arm of Wekach lake. At the extreme northeast end of this bay the zone has a width of about 400 feet. The tuffs stand on edge with a general strike of north 20 degrees west and are well banded. They are light coloured on the weathered surface but mostly dark grey on freshly broken surfaces. The bands vary in width from a minute fraction of an inch to bands of uniform colour 2½ feet wide. These tuffs are acidic in composition, but dark-coloured basic tuffs occur in other parts of the map-area. Along Meridian and Wekach lakes the acid tuffs show a certain degree of silicification due to solutions given off from the granite intrusives. In hand specimens narrow bands of quartz can commonly be observed along the bedding planes of the tuffs. The dark-coloured basic tuffs have been more easily deformed than the massive greenstones or acid tuffs and are commonly sheared into schistose rocks.

ACID VOLCANICS AND INTRUSIVES

The acid fragmental rocks have already been referred to in connexion with the basic pyroclastics, for in places they occur intermingled. In addition, however, there are several zones of massive acid rocks. Many of them follow the strike of the basic flows and it is probable that some of them at least represent acid flows interbanded with the more basic varieties. The majority, however, were intruded as dykes and sills into the volcanic complex, but clearly belong to the same period of volcanic activity as the extrusives.

Quartz Porphyry. The massive acid rocks have been mapped together, but they really comprise two types, quartz porphyry and rhyolite porphyry. The quartz porphyries are white or grey rocks showing phenocrysts of quartz in a dense flinty matrix. In some felsitic varieties, no phenocrysts can be detected with the naked eye. As a rule the phenocrysts are rounded and in some varieties they have a distinct bluish tint. In thin section the quartz porphyries are seen to consist of phenocrysts in a dense matrix of glass or microcrystalline aggregate of quartz and feldspar. The phenocrysts consist chiefly of quartz; many of them show corroded borders due to resorption, though some are distinctly angular. Nearly all show strain shadows. In addition to the quartz phenocrysts crystals of feldspar are present, but in minor amounts. They consist of orthoclase and albite in nearly equal proportions.

Rhyolite Porphyry. The rhyolite porphyries are rocks in which the feldspar phenocrysts are more abundant than those of quartz. They are light-coloured grey rocks like the quartz porphyries, are usually associated with them, and have clearly been derived from the same sources. They occur as a rule as small dykes. The largest intrusion, found in the central part of the Ord claim, forms a mass from 20 to 50 feet wide and 1,000 feet long. A number of smaller dykes of a similar character occur between Flinflon and Phantom lakes.

Rhyolite Tuffs. Stitt island, the large island in Schist lake, south of the Mandy, is composed of a light grey rock which in thin section appears to be a rhyolite tuff. The rock is fine grained, and the parts that have not been extensively sheared have a cherty appearance. In places, the rock contains disseminated pyrite.

This rock type is featured by irregular masses of a ferruginous carbonate, which weather to a rusty brown and are locally traversed by a fine network of quartz stringers. The origin of the carbonate masses is doubtful, but they have, apparently, resulted from the alteration of the acid tuffs by carbonated waters, probably soon after their deposition. Similar masses of carbonate occur in the pyroclastic rocks at the Mandy.

UPPER MISSI SERIES

The Upper Missi series form a broad band in the north-central part of the map-area, occupying the part between Beaverdam and Cliff lakes and extending southward along the east side of Ross lake to the north end of Schist lake. They extend northward off the map-area to Willow creek, a distance of about 3 miles. The other area where the Upper Missian rocks are developed lies to the north of Amisk lake, in Saskatchewan, about 10 miles west of Flinflon map-area.

Lithology. The series consists of clastic sediments, somewhat altered. The commonest variety is arkose, which passes by metamorphism into mica gneiss. Sandstones pass similarly into quartzites and mica schists, and coarse conglomerates are locally abundant. Greywackes, consisting of fragments of basic rocks, are also locally found and in places pass into biotite schists.

The arkose is commonly fine-grained, individual grains seldom exceeding a sixteenth of an inch in diameter. It is grey in colour and is characterized by rounded grains of bluish quartz, derived, undoubtedly, from the quartz phenocrysts of the quartz-porphyry in the older volcanic complex. Under the microscope the arkose is seen to consist of quartz fragments with minor amounts of feldspar in a matrix of quartz. There is usually considerable secondary material. Biotite and muscovite are, as a rule, present, and where the rock has been sheared it has often gone over into a sericite schist. In places garnet has been developed. West of the small lake lying to the north of Schist lake the arkose contains numerous small stringers of bluish hematite, which traverse the rock in a very irregular manner. Small stringers of quartz cut these hematite bands.

In places the arkose passes into nearly pure quartzite. On the east shore of Beaverdam lake, certain beds are of this character. Similar rocks in the western part of The Pas mineral claim were sampled by E. S. Bastin for flux material. One lens 5 to 6 feet wide, and exposed for a length of 15 feet, was found to consist of nearly pure quartz, with a little garnet, the whole containing 92·7 per cent silica. In the same locality samples of a less pure quartzite taken for a width of 165 feet at right angles to the bedding gave 80·3 per cent silica.

Conglomerate is locally abundant in the series. Along both the east and west shores of Beaverdam lake (Plate I B) good exposures are to be seen. The boulders here consist of granite, quartz, quartz-porphyry, and, to a less extent, basic members of the volcanic complex. The boulders have suffered extreme deformation, for many that had a diameter of over a foot have been compressed to a thickness of little more than an inch. Some of them have been gently elongated by the pressure. An interesting feature is that though the flattening has been in the same plane as the bedding of the formation, the longer axes of the elongated boulders are nearly always at right angles to the strike of the series. This is doubtless because there was shearing movement between adjacent beds during their folding and compression, and the boulders were elongated along the lines of least pressure, i.e., in the bedding planes and parallel to the dip of the beds.

Structure. In many places there is no indication of bedding planes in the arkose and hence it is impossible to determine the structure. Locally, however, such determinations can be made. Bands of pebbles in the even-textured rocks commonly give the strike of the series. Where there are beds of varying coarseness, such as occur in the region of Beaverdam lake, the bedding is evident. Crossbedding was noted at several places, but it is not common.

The prevailing strike of the series is a little west of north and the dip is to the east. In the vicinity of Beaverdam lake the angle of dip is about 25 degrees, but farther south it is steeper. The contact between the arkose and the greenstone rocks east of Cliff lake is a fault contact in which the greenstone rocks have been shoved up relative to the sediments. The contact in the valley of Little Cliff lake is also probably along a fault. South of Beaverdam lake there is evidence of still more faulting where a wedge of vertical sediments extends down into the greenstone area. The topographic expression in the whole region between Beaverdam and Cliff lakes is also suggestive of a series of faults. The structure is suggestive of tilting and faulting such as occurred in the Triassic rocks of the Connecticut valley. The complicated structure and lack of horizon-markers in the series make it difficult to estimate its thickness, which is, however, probably to be measured in thousands of feet.

Relation to Other Rocks. The series clearly lies unconformably on the volcanic complex. The conglomerate members contain boulders of all varieties represented in the complex. Granite boulders are also abundant in the series, showing that granitic rocks were undergoing erosion during its deposition. Whether the granites represented by these boulders were intrusive in the volcanic complex or granites of a still earlier age, is difficult to ascertain. A fact which seems to suggest that granites were intruded into the volcanics prior to the deposition of the Missi sediments is that there are in the Missi conglomerates boulders which were apparently sheared before their inclusion in the sediments. It is possible that two ages of granite may be present in the area, but if so it has been impossible as yet to differentiate them, for wherever the Missi sediments are in contact with granites, the latter have intrusive relationships.

The granite mass east of Cliff lake has certain peculiar lithological features and was thought by Bruce to intrude the volcanic rocks, but to be older than the arkose series. This granite is coarse grained with very characteristic large blue quartzes, and the numerous grains of similar quartz present in the arkose were thought by him to have been derived from this granite mass. A further fact tending to substantiate this view of their relationships is that though greenstone inclusions are common in this granite mass, no inclusion of arkose has been found in it. There are, however, a number of objections to this view. It has already been pointed out that the bluish quartz pebbles were most probably derived from the phenocrysts of the quartz-porphyries of the volcanic complex. They are of the size, shape, and character of these phenocrysts. Moreover, they occur over too wide an area, as represented by the Missi sediments, for all to have been derived from the small area of the Cliff Lake porphyritic granite. There is, furthermore, an entire absence in the arkose and conglomerate of any granite boulder derived from this granite east of Cliff lake. Boulders of granite are common, but the intrusion referred to is like no other granite in the whole region, and boulders of it would very readily be recognized. Moreover, it lies so close to the arkose area that the distance for transportation is much too small for all the debris derived from it to be broken down so fine that only small rounded quartz particles remain. Still another reason for believing this granite to be younger than the Missi sediments is that at its eastern border it gives off a dyke cutting basic intrusives similar in composition to rocks which in other parts of the area intrude, and are consequently younger than, the Missi sediments. The Cliff Lake granite seems, therefore, to be younger than the arkose. The absence of Missian inclusions in the granite is explained by the fault contact. The intrusion was into greenstone rocks, fragments of which became included in it along its border. The present proximity of the arkose and granite has been brought about by faulting and erosion.

Conditions of Deposition. The contacts of the arkose with the volcanic rocks indicate that when the series was deposited the region had considerable relief. The contacts between the two are in places nearly vertical with the harder greenstone rocks standing up above the softer sediments. Allowing for the present dip of the sediments there are places where it is evident that they were deposited against a fairly steep slope, probably in valleys. The coarse clastic character of the sediments, and their irregular and repeated conglomeratic bands, also point to a rugged topography undergoing erosion, with deposition in river valleys, small deltas, or on piedmont plains.

BASIC INTRUSIVES

Under this heading are included a series of small intrusions, which, although they present considerable lithological variation, had, probably, the same origin. Most of them lie in a zone extending from Phantom lake up along Flinflon lake to Beaverdam lake. Some form small dykes, others irregular masses, and still others linear bodies, with a width of 500 feet and a length of several thousand feet. They are younger than the Missian sediments and, where intruded into them, are very readily recognized. Where surrounded by basic volcanic rocks they are less easily recognized, but can be distinguished by their massive character, their greater freshness, their coarser crystallization, and the hornblende and augite crystals visible in hand specimens. In places these rocks are cut by granitic dykes, and, locally, contain quartz veins, for which reasons they have been placed as older than the granites of the region. Following are descriptions of some of the more distinctive varieties.

Lamprophyre. The commonest rock type of this series is a hornblende-lamprophyre. It forms some irregular masses south of Flinflon lake, one outcropping on the shore opposite the power-house. The same zone continues from Creighton point along the east side of the north arm of the lake. Another mass 2,000 feet in length and averaging about 600 feet in width lies south of Beaverdam lake.

In hand specimen the rock is massive and black with a slight glistening effect due to the cleavage surfaces of the hornblende crystals. With a lens, it is seen to consist largely of hornblende with minor amounts of feldspar. Locally, grains and small masses of pyrite are present. In places narrow stringers of reddish feldspar, seldom more than a quarter of an inch in width, cut the rock. Veins or stringers of quartz are rare. The largest one observed outcrops immediately south of Creighton cabin on Flinflon lake.

In thin section, a typical specimen collected on the portage on Beaverdam creek was found to consist almost entirely of hornblende. Some of the crystals are idiomorphic and show centres of dark hornblende pleochroic in shades of green and brown with a bleached border. Most of the hornblende throughout the section, however, does not show crystal outlines and is almost colourless. A little brown biotite is present and iron ore and apatite are fairly common as accessory minerals. A few small crystals of quartz and some of striated feldspar are also present. In places there is so little else present in the rock except hornblende that it might be termed a hornblendite. Locally, a greater amount of feldspar is present, which can be distinguished in hand specimen with a lens. In places, especially along the contacts, the rock has been sheared and rendered slightly schistose. A good example of amphibolite of this character is seen on Beaverdam creek immediately south of Beaverdam lake, where a low cliff of rock borders the stream.

A dyke on the Weston claim immediately west of the road to Phantom lake shows some features of interest. It stands up as a low ridge of dark rock. The rock is coarse grained and slightly banded. Certain dark zones consist entirely of hornblende, and others contain considerable amounts of feldspar. Under the microscope the hornblendic variety shows original hornblende pleochroic in shades of dark green and brown in various stages of alteration. A common change is to colourless amphibole. Crystals show deep embayments and oval areas of colourless amphibole having the same extinction as the green hornblende. Another type of alteration is to fibrous aggregates of actinolite, and still a third is to chlorite. Secondary epidote and carbonate have also been developed. The lighter-coloured varieties show similar features of altered hornblende, but with the addition of considerable amounts of striated feldspar.

Cutting across the dyke of hornblende rock is a narrow dyke of a dense, black, fine-grained rock. It varies in width from 2 to 4 feet and has sharp contacts against the coarse-grained lamprophyre. In thin section the rock is seen to consist of long laths of hornblende in a matrix of plagioclase feldspar. In addition to the long hornblende crystals, there are large masses of hornblende largely altered to colourless amphibole. The dyke is similar in composition to the rock it cuts and is probably a later intrusion from the same source.

Gabbro. Dykes of the composition of gabbro occur in the area. One of the freshest specimens collected was from a small intrusion cutting greenstone rocks just west of the Interprovincial Boundary, about 1,000 feet south of Phantom lake. In hand specimen the rock is fresh and massive, weathering a dark brown on the exposed surface. Individual crystals of pyroxene and feldspar can readily be recognized.

Under the microscope the minerals present are seen to be augite, hornblende, and labradorite feldspar with accessory iron ore and apatite. The most abundant mineral is a colourless pyroxene, locally altered to hornblende. Some crystals have a border of green secondary hornblende. Large crystals of dark-coloured primary hornblende are also present. Some of the feldspar crystals are fresh-looking, others are partly saussuritized. Long, rod-like apatite crystals are fairly abundant, especially in the feldspars.

Peridotite. The islands that lie along the middle of the northwest bay of Phantom lake consist of massive peridotite which weathers dark-brownish. In places the islands are covered with a coarse soil formed from the weathered material of these basic rocks.

A thin section of a specimen collected from the larger of the two islands at the head of the northwest arm showed that the rock is a picrite. The most abundant mineral present is olivine, or olivine largely altered to serpentine. It occurs as large, irregular masses in the section, in places entirely gone over into serpentine. The second most abundant mineral is pyroxene which occurs as large colourless crystals. A brownish hornblende is present in considerable quantities and also a few small shreds of brown biotite. Magnetite occurs as an accessory mineral and hematite occurs in the serpentinized olivine. It is this hematite that gives the reddish appearance to the rock. There is an entire absence of feldspar.

The massive, unsheared character of the rock, its basic composition, and the fact that it lies in the same zone as the hornblende-lamprophyres are taken as evidence that the rock is to be grouped with the post-Missi basic intrusives.

ACID INTRUSIVES

Granitic intrusives occupy the western border of the map-area, an area west of Phantom lake, and a third area east of Cliff lake. Dykes of granite and granite-porphyry, also, cut the older rocks. There is a considerable range of types from the point of view of both composition and structure. Some are gneissic, others are typically granitic; some even textured, others porphyritic. In composition there is a range of granitic, syenitic, and dioritic varieties.

Granite Gneiss. Gneissoid granitic rocks occur in the vicinity of Hamell and Creighton lakes. The chief variety is reddish in colour due to the presence of orthoclase feldspar. A thin section of a specimen collected west of Hamell lake showed the following minerals in the order of their relative abundance: orthoclase, quartz, albite, biotite, and accessory iron ore and apatite. The feldspars occur as large crystals, giving the rock an almost porphyritic appearance. Many of them show zonal banding and all are considerably altered, with the development of kaolin, sericite, epidote, zoisite, and carbonate. The quartz occurs as smaller crystals with interlocking borders between the large feldspars and uniformly showing strain shadows. The only ferromagnesian mineral in the section is a brown biotite that occurs as long shreds, most of which have a common orientation.

Granite. West of Douglas lake the dominant type of granite is a reddish variety containing abundant hornblende. In hand specimens it is fresh and massive and even-textured.

In thin section, orthoclase and albite are seen to be about equally abundant. They are all somewhat altered and some are broken, showing that there was movement after solidification. Quartz is abundant and uniformly shows undulatory extinction. Of the ferromagnesian minerals, hornblende is much the most abundant. It occurs as irregular masses, is pleochroic in shades of green and brown, and is considerably altered to chlorite. Iron ore and apatite are accessory constituents.

The contact phase of this rock along the north shore of the bay at the southeastern extremity of Meridian lake is a dark grey rock of more basic composition. Basic borders to granitic intrusions are not an uncommon feature in the region and are due either to the assimilation of greenstone material or to border differentiation.

West of Wekach lake is an area underlain by a reddish granite, to which Bruce has given the name Kaminis. Another area of the same type of rock extends from Kaminis lake, west of Athapapuskow, northward to Phantom lake. The rock presents considerable lithological variation, but the dominant variety is a pinkish, massive type. In thin section it is seen to consist of orthoclase, acid plagioclase, quartz, hornblende, and biotite, with magnetite, zircon, and apatite as accessory minerals. The feldspars commonly show zonal banding and are more or less altered with the production of the usual secondary minerals. The quartz shows strain shadows. At one place west of Phantom lake the granite carries iron and copper sulphides. In places the sulphides are disseminated through the massive granite, and in others they are concentrated in seams. The occurrence points to the conclusion that the granitic intrusives were the source of the sulphide mineralization.

Along the west side of Wekach lake the border phase of the granite is dark grey, due to the abundance of hornblende. In places there is a gradation from the ordinary pinkish granite to an almost black, dioritic rock. The sections of these rocks studied proved to be so badly altered that their original character and composition are difficult to determine. Most of the hornblende is altered to chlorite and the feldspars are gone over into a mass of secondary minerals. Just to what extent differentiation on the one hand and assimilation of basic rocks on the other are responsible for these dark border zones is impossible to say.

Porphyritic Granite. East of Cliff lake is a mass of granite that presents some distinctive lithological characteristics. It occupies an area about 4 miles in length and has a greatest width of a little over a mile. It is surrounded by greenstone rocks in which it is intrusive. The fault along the east side of Cliff lake has brought the arkose of the Upper Missi series close to its border, and, in the description of the sediments of that series, the age relationships of the granite and the arkose were discussed.

The common type in this area is a very coarse-grained pink or grey granite. The feldspar and quartz occur as large crystals, the quartz crystals having a characteristic light bluish tint. In places the rock is a true porphyry. Along the eastern margin of the mass, crystals of orthoclase feldspar, some nearly an inch long, stand out on the weathered surface. They are embedded in a fine-grained granitic matrix.

The rock is locally sheared along narrow zones; no gneissic structure has been developed on any large scale. In places the feldspar phenocrysts are distorted and drawn out into long, narrow masses.

The granite contains numerous inclusions. They are of all sizes from tiny fragments to bodies over 100 feet long. These inclusions are all volcanic; no Missian zenoliths were observed. Most of them are linear bodies and are badly sheared. Some were evidently schists before they became stoped off; in other places it appears as if the shearing of the granite was taken up to a large extent along the inclusions, with the result that the inclusions are drawn out and rendered schistose.

The granite is cut by numerous aplite dykes. They are generally only a few feet in width, and consist of a dense, massive rock of light pink or grey colour. Some of them are fractured and offset, showing the result of movements after their intrusion. Under the microscope the aplite is seen to consist of feldspar and quartz with only very minor amounts of hornblende. The feldspar consists of orthoclase, microcline, and plagioclase with various intergrowths.

Syenite. Immediately south of Phantom lake, opposite the portage that leads into Schist lake, are two small masses of a reddish rock intrusive in greenstone. Each of the masses is about 900 feet long. At one place the greenstone adjacent to one of the dykes contains disseminated pyrite for a width of about 2 feet, but the amount of mineralization is, apparently, small. In hand specimen the syenite is massive and is seen to consist of reddish orthoclase and dark hornblende. Under the microscope much the most abundant mineral is seen to be orthoclase, clouded to a considerable extent with secondary kaolin and sericite. Brown hornblende is abundant and much of it has been altered to chlorite. Minor amounts of quartz occur as small crystals. The rock is a typical hornblende syenite, apparently related to the granitic intrusives.

Diorite. Mention has been made of the basic zones which in places border the granite batholiths. Many of these have the composition of quartz diorites.

Dykes of diorite, also, are found in the map-area, and are perhaps related to the granitic intrusives. The largest of these, and the only one of sufficient size to be shown on the map, crosses diagonally the La Salle claim north of Flinflon and extends down across the Flin Slam claim to the edge of the Lakeview. The dyke has a length of about 3,000 feet and an average width of 300 feet. The rock is intrusive in greenstone, is fresh and massive, and on the weathered surface is grey and in places reddish. On the freshly broken surface it is dark grey, and individual feldspar and hornblende crystals can readily be distinguished in hand specimens. Under the microscope the minerals are seen to be badly altered. The feldspar is largely labradorite. Hornblende is abundant and is altered to a large extent to chlorite.

Granitic Dyke Rocks. Granite dykes are fairly numerous throughout the area, and some are sufficiently large to be mapped. The reddish cliffs on the east side of Schist lake opposite the Mandy are the edge of a granite dyke that parallels the shore. The rock is a fine-grained, reddish granite, locally porphyritic, with phenocrysts of orthoclase over an inch in length.

Along the portage between Douglas and Bootleg lakes occur several dykes of granite-porphyry. The largest has a width of 40 feet and a length of 500 feet. The rock weathers a light colour, but on the freshly broken surface is dark grey. It is decidedly porphyritic, with phenocrysts of pink orthoclase up to three-quarters of an inch in length in a dense matrix. Under the microscope the rock is seen to consist of crystals of orthoclase and albite in a fine-grained matrix of feldspar and quartz. Finely disseminated hornblende and biotite occur throughout the matrix, and give the dark colour to the rock. Iron ore, apatite, and zircon are present as accessory minerals.

A rather important granite dyke outcrops on a hill back from Carlisle's cabin west of Flinflon camp. This is a reddish rock intrusive in hornblende-lamprophyre and thus establishes the age relationships of these two series of intrusives.

LATE BASIC INTRUSIVES

At a number of places in the map-area are found basic dykes which are younger than the granites. Some of the best examples of these are found cutting the porphyritic granite mass east of Cliff lake. The points that serve to distinguish these dykes from linear greenstone inclusions are the following: (1) The dyke rocks are fresh in hand specimens and very hard and massive. The inclusions are more altered, many of them are schistose, and a large number show amygdaloidal structure and other evidence of their surface origin. (2) In form, the dykes are long and narrow, commonly only a few feet wide and several hundred feet long. The largest observed has a length of about 1,000 feet and a width of 40 feet. (3) Though not very marked, there can usually be observed a texture coarser towards the middle of even the narrow dykes than at the borders of the dykes. (4) The contacts of the dykes with the granite are sharp, and in places narrow stringers branch off from the dyke into the granite. (5) At one place a basic dyke was seen to cut sharply across an aplite dyke traversing the granite. Since the aplite is undoubtedly a late differentiate of the granite, the basic dyke must have been intruded after the granite and aplite had solidified.

Similar dykes cut the Kaminis granite west of Phantom lake between the first and second of the small lakes east of Bootleg lake. The rocks here are dense, massive, and black. In thin section they are seen to be highly altered, consisting of a mass of secondary chlorite and hornblende with laths of plagioclase feldspar forming an ophitic texture. Iron ore is an abundant accessory mineral.

On the east shore of Ross lake is a mass of similar rock which intrudes Upper Missi arkose. It contains numerous inclusions of reddish granite. Some of the inclusions are angular, others have rounded outlines suggesting partial digestion. The black intrusive is traversed by numerous narrow stringers of quartz and by small, irregular quartz masses. Under the microscope the chief mineral present is seen to be hornblende. Chlorite, its alteration product, is about as abundant. Plagioclase of the composition of andesine is also abundant and secondary carbonate and yellowish epidote are present. Iron ores—magnetite and bluish hematite—are also present. The rock can best be described as a diorite.

ORDOVICIAN

Six miles south of Flinflon map-area the Precambrian rocks are overlain by Ordovician dolomite. The edge of these Palæozoic sediments is a low escarpment facing north. There is commonly an abrupt rise from the surface of the Precambrian rocks to the top of the flat-lying dolomite, often marked by cliffs as high as 60 or more feet.

A few erratics of Ordovician dolomite in the Flinflon area show that in Pleistocene time outliers of Ordovician age must have existed north of the area, since the glacial advance was from the northeast. Two small outliers were observed in the area itself. Both of these occur on Schist lake on the big island just south of the Mandy. One has a diameter of 5 feet and the other measures 11 feet in one direction and 7 in the opposite direction. They are flat-lying, and fossiliferous, and are clearly in place. They show that at one time the Palæozoic mantle extended much farther north than it does now.

QUATERNARY

During the Pleistocene the area was overriden by the Keewatin continental ice-sheet, which removed most of the residual soil, smoothed down the topography, polished and striated the rock surfaces, and, by irregularly depositing debris over the country, disorganized the drainage. The advance of the ice was from the northeast, the average direction of movement in the area being south 32 degrees west. Along Beaverdam lake the movement was south 14 degrees west.

Though the ice in its advance extensively scoured and, probably, in places widened and deepened valleys, nevertheless it failed to remove all of even the loose material from the surface. On the islands in the middle of the west bay of Phantom lake the rocks are extensively weathered, with loose material, derived from the underlying rock, still in place. Resting on top of this weathered material are foreign boulders dropped by the Pleistocene glaciers.

The deposits left by the ice consist of boulder clay, gravel, and erratics scattered over the area. The covering in most places is very scanty. The ridges are almost uniformly bare rocks and the only places where any thickness of drift is found are locally in the valleys or the lee side of southward-facing cliffs. Small, flat areas underlain by clay are utilized as gardens at several places throughout the area.

Recent deposits are represented by local accumulations of alluvium along some of the streams, and by peat deposits in the muskeg swamps. Muskeg is found in all the depressions where the drainage is poor. The swamps vary from the floating bog without trees, in which the growth of sphagnum moss and other water plants will in places bear a man's weight, through types of bog in which there is a sparse growth of tamarack and spruce, to dryer muskeg areas supporting a thick growth of spruce.

STRUCTURE

The Ordovician rocks lie horizontally, being separated from the underlying Precambrian formations by a tremendous erosional unconformity.

From the point of view of structure the Precambrian rocks may be divided into three groups: (1) an early volcanic complex; (2) a thick series of clastic sediments; and (3) intrusive rocks cutting the first two groups. The structure of the volcanic complex is difficult to work out in detail. The banded tuffs and the ellipsoidal flows make it possible to ascertain certain facts. The rocks dip vertically or steeply and strike in general north and south. They were apparently folded and intruded before the deposition of the Missi arkose-conglomerate series, for a few volcanic pebbles in the latter series were evidently schistose before their deposition, and boulders of granite are common in the series. The extent of this early deformation, however, is unknown.

The Missi arkose-conglomerate series is a thick formation that has been folded, faulted, and metamorphosed. The dips vary from 20 degrees to almost vertical, but in many places the rock is so massive that bedding planes cannot be determined.

The intrusion of the granite batholiths accompanied the movements which folded the older rocks. These batholiths are linear bodies whose longer axes parallel the strike of the rocks and undoubtedly mark the trend of the Precambrian mountains formed by the folding. The method of intrusion was, partly at least, by stoping, for zenoliths of older rocks are locally abundant along the borders of the batholiths. The common contact metamorphic effect was the production of hornblende schists where greenstone rocks were invaded. The schistosity of the schists follows the granite contacts, showing that the intrusion frequently took place under pressure.

The faulting, which is so well marked along the east side of Cliff lake, took place probably in late Precambrian time, after the igneous intrusions. Nowhere along the fault plane was any sign of mineralization visible. Had the faulting taken place during the granite invasion the fault plane should have been a ready avenue for solutions to travel along.

GEOLOGICAL HISTORY

The first event of which there is a record in the history of the region was a long period of great volcanic activity. Lava poured forth from fissures and craters covering wide areas of country. Volcanoes of the explosive type were abundant, and the ash and the coarser fragments from these gave rise to the beds of tuffs and coarse pyroclastic material that form common rock types in the area today. Acid and basic dykes derived from the same source as the flow rocks were intruded into the volcanic complex. In adjacent regions sediments were locally being accumulated during the period of volcanism. These are now sedimentary gneisses and schists. In some places they are found underlying the volcanics; in others they overlie them; and in still other parts of the region they are interbedded with the volcanic rocks. These metamorphosed sediments have been named the Kisseynew gneisses in the Amisk Lake region, the Wekusko series in the Reed-Wekusko Lakes region, and similar rocks occur in several other areas of Manitoba. What the basement was, upon which these volcanic and sedimentary rocks were deposited, is not known. Wherever their present base is found there is a younger granite which has come up from below and intruded itself into them. The finding of granite boulders in the very oldest sediments, however, points to the conclusion that the ancient terrain was, partly at least, granitic.

Deformation and intrusion followed this period of volcanism and sedimentation. The country was uplifted and a new cycle of erosion was inaugurated. The deposition of two series of sediments followed, a lower consisting dominantly of shale, and an upper one of arkose and conglomerate. Earth movements and an erosion interval separated the deposition of these two sedimentary series, called respectively the Lower and Upper Missi.

This period of sedimentation was terminated by folding and intrusion. The early intrusions were basic, and are represented by dykes of lamprophyre and gabbro cutting the Missian and older rocks. Then came the great batholithic invasions of granite, during which the country was uplifted and folded, and a mountainous topography was produced. In the late stages of the cooling of the granitic magma, solutions carrying iron, copper, and zinc sulphides were given off and, locally, replaced the older rocks, forming such ore lenses as the Mandy and Flinflon. In other places solutions carrying silica travelled along fracture planes and gave rise to the gold-bearing quartz veins. This period of intrusion extended over a long time. The earlier and later intrusives were basic. The batholithic masses were granitic, but all the intrusives were, probably, related.

Following this period of folding and intrusion came a long period of erosion. Little by little, through the action of rain, frost, and other destructive agents, the mountainous topography was worn down and the eroded material was carried away by streams. Steep-sided valleys gradually assumed more gentle slopes, and after a long period of time a flat-lying country of low relief rising gently back from the sea took the place of the former mountains. In this long period of erosion so much of the surface rocks of the region was removed that the granites, which had originally cooled at great depths, became exposed over wide areas of country. Only a few scattered remnants—commonly synclinal masses between granite batholiths—survived, to serve as the prospecting fields of the present day. The Flinflon area is part of one of the larger districts where these older rocks have survived.

Over this region of Precambrian rocks there swept, in the Palæozoic era, successive invasions of the sea. The chief of these took place in the Ordovician, when much of the interior of North America was flooded. In this sea were deposited the limestones of Lake Athapapuskow region. Other invasions took place in the Silurian and Devonian. In the Mesozoic era, sediments were deposited to the southwest of the Flinflon area in the Pasquia hills and they may even have extended over the map-area itself, but if so they have been entirely eroded.

In the Tertiary period the region was once more above the sea, and undergoing erosion. Much of the covering of Palæozoic rock was removed. At that time the country presented a great contrast to what it is like at present. Although it had the same low relief, the streams were smooth-flowing, with no rapids or falls. There were no lakes, and, in place of the bare rock-ridges such as are seen today, there was probably a mantle of residual soil.

The last important event in the geological history of the region, which gave the country its present character, was the advance of great sheets of ice from the northeast. These removed the residual soil, smoothed down the topography, polished and striated the rocks, and, by dropping the debris irregularly over the region, dammed up river valleys and completely disorganized the drainage system. Numerous lakes were formed throughout the region.

During the latter part of the Glacial period, while the ice was disappearing, a great lake formed in front of the retreating ice-sheet. Clays accumulated in it and later became the great fertile clay belt of Manitoba. This old lake has been called Lake Agassiz; Flinflon area lies just to the north of its old shore-line.

ECONOMIC GEOLOGY

The ore deposits of the region are of three types: (1) copper-zinc-iron sulphide bodies; (2) gold-bearing quartz veins; (3) iron sulphide bodies. Only the first type has yet proved to be of economic importance in Flinflon map-area. The second type is important farther east at the Wekusko Lake end of the mineral belt. The deposits of iron sulphides are of no commercial value.

The map-area contains two important examples of copper-zinc-iron sulphide bodies. These are the Mandy and the Flinflon ore-bodies. The former of these was worked until the high-grade ore was removed. The Flinflon ore-body has been blocked out by diamond drilling and underground work so that its size and character are known, but no ore has been smelted.

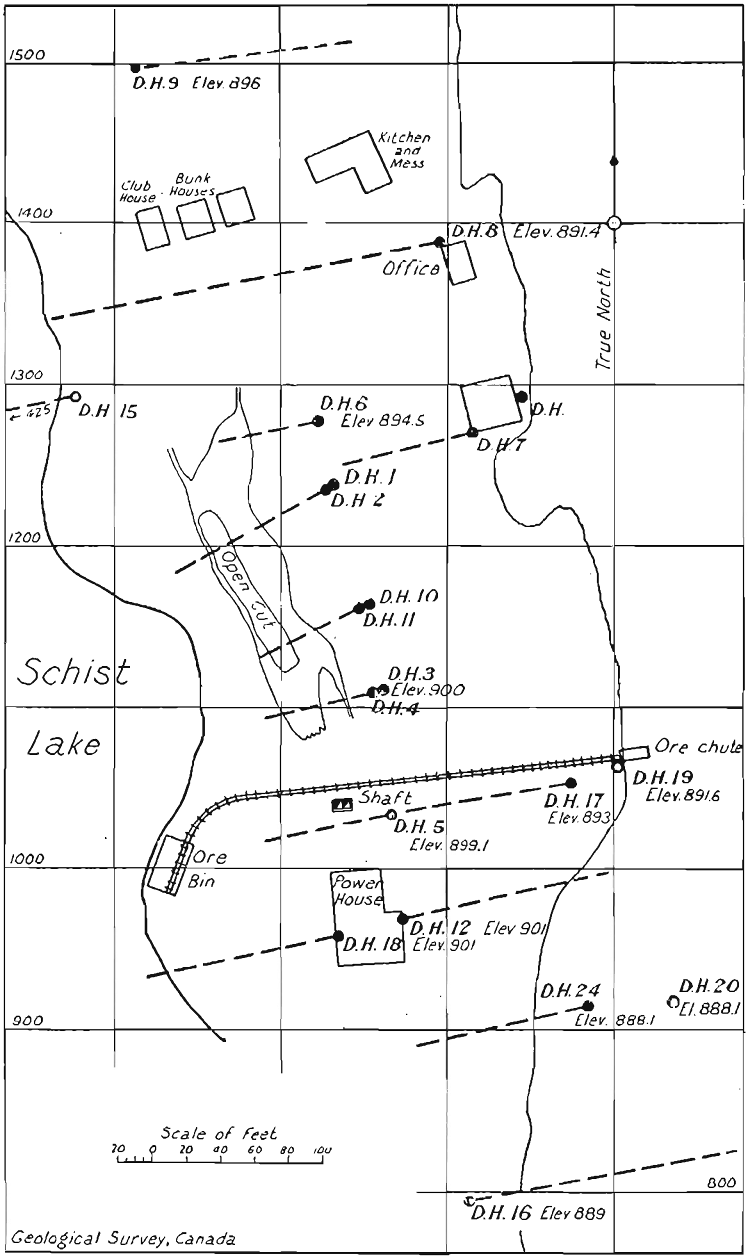

Figure 2. Plan of Maudy mine showing drill-hole projections.

MANDY

Development and Production. Mandy mine is situated on a small peninsula on the west side of the Northwest arm of Schist lake, about 2 miles south of the northern end of the arm (Plate II A). It was located in the autumn of 1915 by two prospectors, Messrs. Reynolds and Jackson. J. E. Spurr, geologist of the Tonapah Mining Company, was examining some other mining prospects in the region at the time and he immediately obtained an option on the discovery for his company. In the following January a preliminary examination was made and it was decided to prospect the property by diamond drilling. In the spring a drill was installed, the first to be used in northern Manitoba, and by midsummer the entire ore-body had been blocked out and the values ascertained. It was found that there were 25,000 tons of massive chalcopyrite averaging about 20 per cent copper, with additional gold and silver values to the amount of $5 a ton, and about 180,000 tons of lower grade ore consisting of mixed copper, iron, and zinc sulphides running from 5 per cent to 8 per cent copper, 20 to 30 per cent zinc, and gold and silver to the value of $5 to a ton.

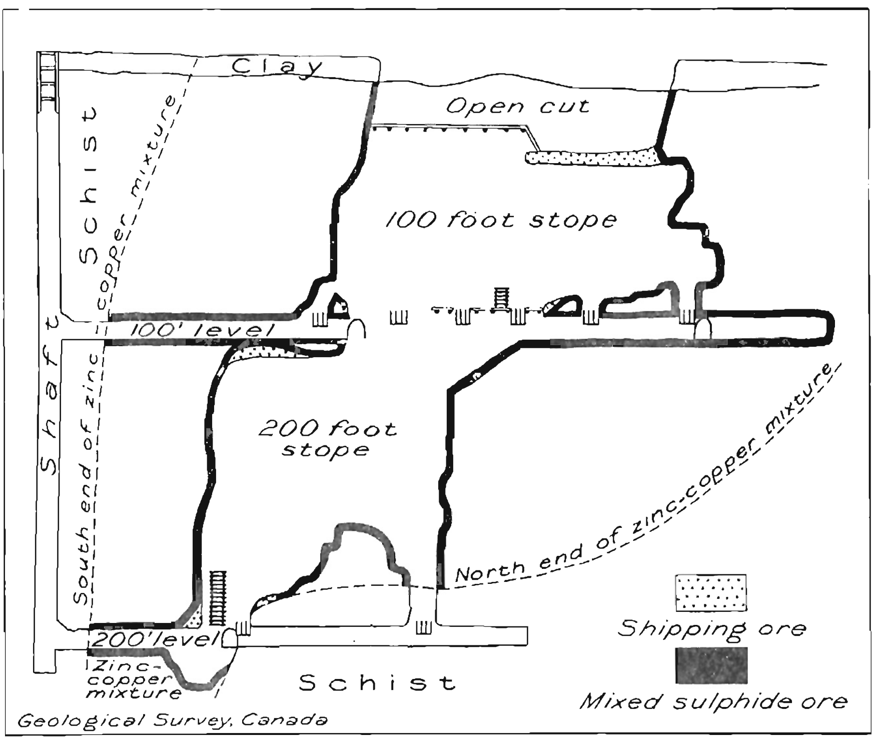

Figure 3. Vertical section of stope of Mandy mine.

The ore-body was too small for a smelter to be erected on the property. Owing, however, to the war price of 26 cents a pound for copper, it was decided to commence mining operations immediately. The main difficulty was that of transportation. Mining machinery had to be taken in and the ore had to be sent to Trail, B.C., to be smelted. Operations began in January, 1916. Buildings and stables were erected and 80 miles of winter road was made. In the first three months of operation mining machinery was taken in from The Pas, and 3,800 tons of ore was mined from the surface and teamed to Sturgeon Landing. In the spring a power-house and other mine buildings were erected and a shaft begun in order to carry on underground operations on the 100-foot and 200-foot levels.

During the succeeding winter, stoping was started from the 100-foot level. The ore mined, which amounted to 7,500 tons, was transported by barges down Schist lake, hauled to Sturgeon Landing, and thence shipped by boats and barges to The Pas. For transport on Schist lake four barges and two steamers were built, and in addition considerable work was done on Schist creek in making a channel and dam in order to get a passage to lake Athapapuskow.

In the third year mining operations were carried on from the 200-foot level. Eight thousand tons of ore was teamed 7 miles and piled near the outlet of Schist lake, whence it was hauled out the following year, and 5,000 tons were teamed from the mine to Sturgeon Landing. Three hundred teams of horses were employed. The average load of a single team for the whole winter was $6\frac{1}{2}$ tons and the cost of the transportation was $37\frac{1}{2}$ cents a ton-mile.[1]

In 1917 and 1918 the Ross Navigation Company, of The Pas, transported the ore from Sturgeon Landing to The Pas, but in 1919 the Mandy Mining Company took over their boats and handled all the transportation themselves. In all, four steamers and seven barges were employed between Sturgeon Landing and The Pas, a distance by water of 120 miles (Plate II B). At The Pas the ore was loaded on freight cars and shipped to Trail. The last shipment was made in August, 1920. Mining operations lasted for three years and the work of transportation for four. The time from the actual mining of the ore until the date of delivery at the smelter was one year. Altogether 25,000 tons of high-grade ore was thus handled. The amount and value of copper produced were as follows:

Year	Lbs.	Value
1917	1,116,000	$ 303,329
1918	2,339,751	576,234
1919	3,348,000	625,775
1920	3,062,577	534,604
Total	9,866,328	$ 2,039,943

In addition to the copper the ore averaged $5 a ton in gold and silver.

Character of the Deposit. The rocks on the peninsula on which the Mandy ore-body occurs are greenstone, pyroclastics, and chlorite schists. The ore lens is in a band of schist with massive greenstone on either side. The lens is 225 feet long and has a maximum width of 40 feet. It is rather irregular in shape, and its longer axis parallels the strike of the schist and greenstone bands. At either end a narrow vein of sulphides branches off from the lens, following the strike of the schist. The ore at the south end is dominantly chalcopyrite, that at the northern end is composed chiefly of pyrite. Bruce is of the opinion that before mineralization took place a

[1]These figures are given by G. R. Bancroft, Mandy Mining Co.

drag fold existed at this place in the schistose bands and that the replacement of the drag-folded rock gave rise to the ore-body. The outline of the deposit is strongly suggestive of this drag-fold origin. The lens dips from 75 to 80 degrees to the east and pitches at a high angle to the south. As shown on the plan of the deposit, the central part consisted of high-grade chalcopyrite surrounded by sphalerite and pyrite. This central lens of chalcopyrite had a maximum width of 12 feet on the surface and a length of 100 feet. On the 100-foot level it widened to over 18 feet. Its strike is not quite the same as that of the whole sulphide deposit. The zones of the various sulphides are not sharply demarcated, but merge into each other. The zone of sphalerite ore shows a well-banded structure, and a rough banding is to be seen also in the pyrite zone. The average values in the chalcopyrite lens were: copper, 19 per cent; gold, 0·10 ounce a ton; silver, 2½ ounces a ton.

The deposit showed the effect of strong glaciation. Practically fresh sulphides were exposed at the surface beneath the covering of moss, the weathered products formed in pre-Glacial time having all been scoured off. Locally, the adjacent rocks show slight copper stains and in certain small fissures in the ore chalcanthite was found encrusting the sulphides, but the amount of secondary minerals in the deposit is very small.

Mineralogy and Paragenesis. The metallic sulphides in the ore-body were deposited in the following order: pyrite and arsenopyrite; sphalerite and chalcopyrite; galena. Pyrite is the most abundant mineral and is the chief mineral of the outer zone of the ore-body. The pyrite zone grades from the massive sulphide type into country rock impregnated with sulphides. It contains much chalcopyrite and pyrite. In places there is a rough, banded appearance due to the parallel arrangement of zones of pyrite, zones of pyrite with chalcopyrite, and zones of pyrite with sphalerite as the chief constituents between the pyrite grains. The pyrite occurs as cubes and irregular grains. In places it shows signs of deformation, grains being fractured, and the fractures filled with later minerals. Other specimens of pyrite show no evidence of deformation. Arsenopyrite is present as small grains throughout the ore-body and was apparently deposited along with the pyrite.

Chalcopyrite formed the central part of the lens. In polished sections it shows inclusions that appear black by reflected light. These inclusions, which consist of country rock, are impregnated with pyrite, and in places their edges are broken and cemented by sphalerite and chalcopyrite. The chalcopyrite and sphalerite were, apparently, introduced at the same time. They are intimately intergrown in many places and often occur as a matrix cementing pyrite grains, filling fractures in pyrite, or less often replacing pyrite. The chalcopyrite is massive and on the freshly broken surface is rather paler in colour than is common for that mineral. An analysis of the purest ore that could be selected gave 28·96 per cent copper. Pure chalcopyrite should contain 34·5 per cent copper and the lower amount in the Mandy ore is evidently due to inclusions of country rock.

The sphalerite is massive and shows no signs of cleavage or crystal faces. It is dark in colour, with a metallic lustre quite different from ordinary blackjack. Locally, chalcopyrite and sphalerite form a well-banded variety of ore, but in this type chalcopyrite is present in the sphalerite bands, and sphalerite in the chalcopyrite bands, with no evidence of fracturing or subsequent introduction of one mineral into the other. These bands vary in width from a quarter of an inch or so to extremely narrow bands. An analysis of the purest sphalerite ore that could be selected gave the following results:

Zinc	46·21 per cent
Copper	1·70 per cent
Iron	12·80 per cent
Gold at the rate of 0·07 oz. Troy per ton	
Silver at the rate of 0·85 oz. Troy per ton	

Some of the iron represented in this analysis may be in the form of pyrite and chalcopyrite, but most of it is certainly contained in the sphalerite. Galena is found in small quantities in the chalcopyrite and sphalerite.

The gangue minerals include quartz and carbonates. They are found filling fractures in the pyrite and between pyrite grains. Of the carbonates, calcite is much the most abundant; minor amounts of dolomite are reported by Hanson. The quartz is later than the pyrite, but most of it is earlier than or of the same age as the chalcopyrite and sphalerite. Most of the carbonates, on the other hand, are later than the sulphides. Some vugs in massive chalcopyrite were found lined with minute rhombohedral crystals arranged in parallel position. Some of these crystals are ankerite; others, owing to lack of magnesia, could be called ferro-calcite. A few cavities were found to contain beautiful crystals of selenite.

Rock Alteration. The lens lies in a zone of chlorite schist which under the microscope is seen to be a mass of secondary minerals. The actual wall-rock is in places a fissile sericite schist. The chief peculiarities of the rock adjacent to the lens as contrasted with the country rock away from the ore-body are the complete removal of the feldspars, the increase in the amount of secondary quartz and carbonates, the presence of sericite and sulphides, and the presence of rutile. This alteration was effected undoubtedly by hydrothermal solutions.

Genesis. It is concluded that the Mandy ore-body was formed in a sheared zone in volcanic rocks. Solutions, probably derived from the granite, deposited pyrite in the shear zone replacing the schistose rock. Later movement took place during the period of deposition, and towards the end of this period the solutions became relatively richer in copper and zinc. Towards the end of the period chalcopyrite deposition was dominant, and the central lens of chalcopyrite and the chalcopyrite veins cutting the sphalerite zone were formed.

FLINFLON ORE-BODY

The Flinflon ore-body is situated on the north shore of the southeastern bay of Flinflon lake, about 3½ miles northwest of the Mandy. It crosses the Interprovincial Boundary, but most of it lies in Manitoba: it is connected by a wagon road to the north end of Schist lake, a distance of 4 miles. Canoes can ascend Flinflon creek to within 2 miles of the property or may be taken all the way to Flinflon lake by way of Ross and Hapanot lakes.

Development. The property was located in the summer of 1915 by the Creighton-Mosher party. The main credit is due to Mr. Thomas Creighton, who had previously seen the iron-stained rocks at this point and recognized the site as a possible ore-body. Some trenching was done and in the autumn the claims were recorded. Other prospectors were attracted to the area by the news of the discovery and it was not long before the whole neighbourhood was staked.

Diamond-drilling was commenced in March, 1916, by New York and Boston interests, and in four months 6,000 feet were drilled. Then, failing to come to an agreement with the owners, work ceased. The next year certain Toronto interests agreed with the owners to continue drilling, and carried on until July, 1918. The total footage drilled was 25,664 feet; the number of holes forty-four. This drilling blocked out the ore-body and showed that it extends 900 feet below the surface. In March, 1920, an option was taken on the property by New York and Canadian interests. In order to check up the diamond-drilling results already obtained, it was decided to do underground development work. Two shafts were sunk on the ore-body, 500 feet apart. From No. 1 shaft, which was sunk 210 feet, a drift 266 feet in length was run along the ore-body on the 200-foot level and on the same level two crosscuts were also driven, one to the north of the shaft for 318 feet and another to the south for 245 feet. Shaft No. 2 was sunk to a depth of 304 feet, and from it a crosscut was driven for 160 feet on the 100-foot level and another for 173·5 feet on the 300-foot level. This work confirmed the drilling results both as regards tonnage and values.

In May, 1921, the Mining Corporation of Canada bought a majority interest in the property, and have so far confined their efforts to searching for more ore deposits in the vicinity of the property, and for siliceous flux material. In 1922, diamond-drilling exploration was also carried out on a number of their claims near Flinflon (Plate III A).

General Character. The ore-body lies in greenstone. To the northeast of the deposit the greenstone is massive and amygdaloidal, showing its flow origin. The ore-body strikes north 30 degrees west. Some banded tuffs associated with flow rocks on the summit of Flinflon hill east of the wagon road strike north 12 degrees west. The deposit dips from 60 to 70 degrees to the northeast and the boring records show that it pitches at a low angle to the south. Dykes of quartz porphyry were encountered by the drill; one of these dykes forms the hangingwall of the ore-body for some distance. The ore-body is a fairly regularly-shaped lens, tapering gradually to the northeast and ending rather bluntly to the southwest. As shown in the plans and cross-sections, it breaks up at the southwest end into two parts with minor mineralized zones. The total length of the ore-body on the surface is 2,593 feet; at a depth of 900 feet it has a length of over 1,000 feet. It has a greatest width of 400 feet, but this includes some bands of unmineralized greenstone which occur in the ore-body. The largest of these masses forms the prominent ridge along the strike of the ore-body between the two shafts. At a depth of 900 feet the ore-body has narrowed to 35 feet. It has been calculated that there are over 16,000,000 tons of ore without including the unmineralized horses of country rock or the ore below the 900-foot level.

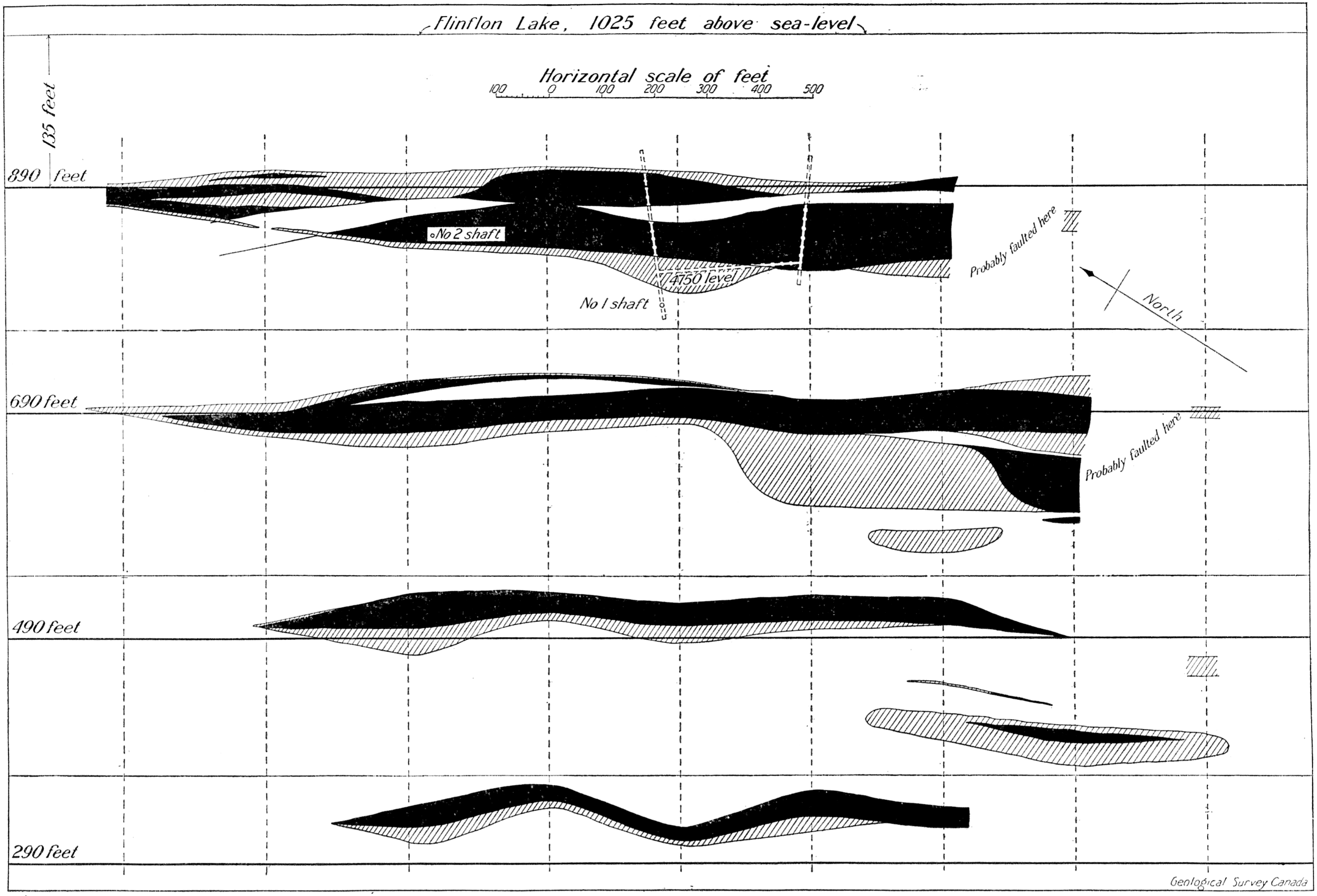

Figure 4. Plans of Flinflon ore-body at levels 200 feet apart. Sulphide ore shown by solid black, and disseminated ore by sloped ruling.

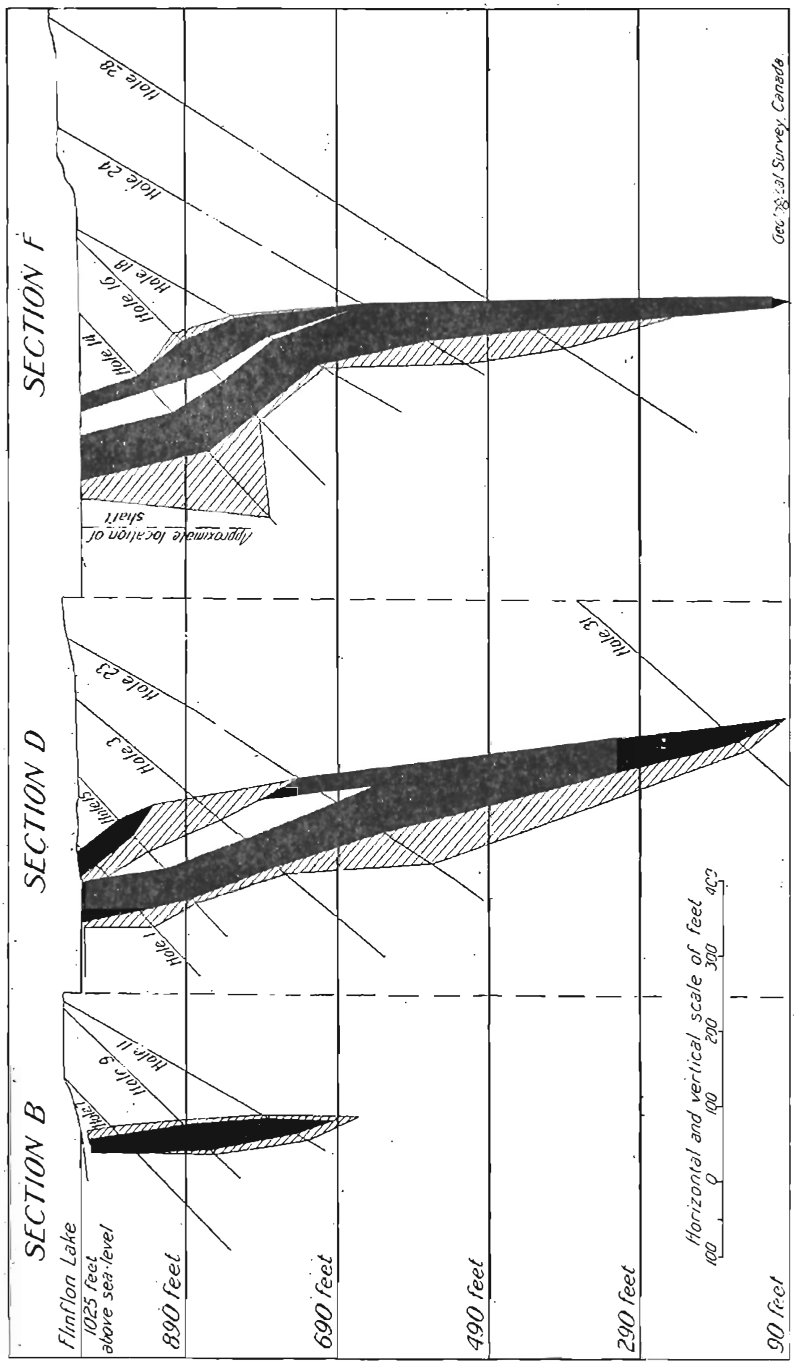

Figure 5. Vertical sections B, D, and F, Flinflon ore-body. Sulphide ore shown by solid black, and disseminated ore by sloped ruling.

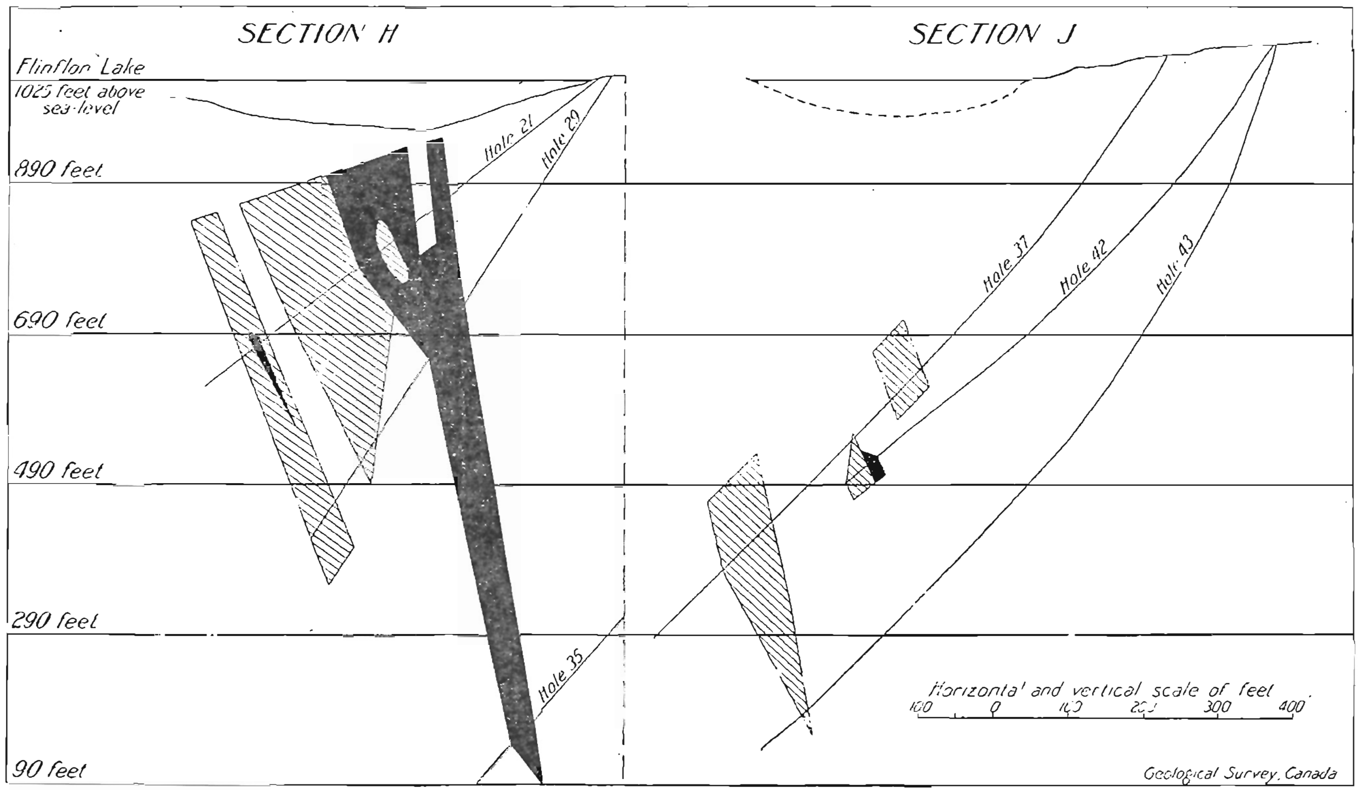

Figure 5a. Vertical sections H and J, Flinflon ore-body. Sulphide ore shown by solid black, and disseminated ore by sloped ruling.

Mineralogy. The principal minerals in the ore-body are pyrite, sphalerite, and chalcopyrite. Assays show that gold and silver are present. Arsenopyrite, galena, and magnetite have also been recorded, and small amounts of native copper have been found in the upper part of the deposit. Quartz is present in places between grains of pyrite, and as local veinlets traversing the sulphides. Calcite is rare, but occurs in places with the quartz.

The ore consists of two fairly distinct types, known respectively as the solid sulphide variety and the disseminated ore. The solid sulphide variety consists chiefly of very fine-grained, pale-coloured pyrite, containing sphalerite, chalcopyrite with some rare fragments of schist, and some quartz and calcite. In places there is a distinctly banded effect where the sphalerite and chalcopyrite form narrow bands in the pyrite. The sphalerite is dark in colour, and on the weathered surface assumes a bluish tarnish, probably due to the development of a film of covellite. The disseminated ore consists of country rock, chiefly chlorite schist, impregnated with sulphides. The solid sulphide variety forms the central part of the lens, though in places it extends to the hangingwall, whereas the disseminated ore is largely confined to a zone along the footwall. Disseminated ore is also found on the hangingwall in the upper part of the deposit, but the copper content is here less than in the disseminated ore on the footwall. In places, as shown in both plane and section, disseminated ore forms a zone on either side of the central solid sulphide type. Boundaries between the disseminated and solid sulphide types are, as a rule, fairly distinct, though in places a gradation between the two varieties is found. Contacts between the solid sulphides and the horses of unmineralized rocks are also, as a rule, quite sharp. In places the disseminated variety of ore runs as high as 3 to 5 per cent copper, though the ore-body as a whole averages only approximately 1·9 per cent copper. The sphalerite is more abundant on the hangingwall side than elsewhere in the deposit. The average zinc content for the whole ore-body is about 3·8 per cent. The gold and silver values are, respectively, 0·074 and 1·04 ounces per ton. Galena is rare in the ore-body, but it has been found lining vugs in the country rock.

A rather interesting occurrence of native copper is reported in the ore-body. In sinking shaft No. 2, the massive greenstone (Plate III B) of the large horse was left behind at a depth of 60 feet and solid sulphide ore entered. Resting on the surface of the ore at this point was found an aggregate of crystals of native copper. Wallace is of the opinion that the copper was deposited by descending solutions in post-Glacial time. The strongest evidence of the age of the formation of the copper is the lack of any secondary minerals, such as chalcocite and covellite, which commonly occur in secondarily enriched zones. The absence of such minerals implies that any products of secondary enrichment which may have been formed in pre-Glacial time were probably removed by glacial scouring and that the present gossan at the surface of the ore-body and the small amount of native copper may possibly have been formed in post-Glacial time. If this interpretation be correct, the native copper must have been deposited below the groundwater-level, for since Glacial time the level of the groundwater has been practically at the surface of the deposit.

Origin of the Deposit. The deposit was, clearly, formed by replacement. The presence of unsupported masses of rock in the ore-body, some of them schistose with the plane of the schistosity parallel to that of the wallrock, and the character of the disseminated ore, consisting, as it does, of country rock partly replaced by sulphides, can be explained only by this method of formation. It is clear also that replacement was along a shear zone. The country rock away from the ore-body and the horses of rock in the ore-body consist of massive greenstone. On the other hand the rock containing the disseminated ore and the minor rock inclusions in the ore are largely chlorite schist. At the end of the crosscut from the No. 2 workings, quartz porphyry, probably a dyke, forms the hangingwall of the deposit. The greenstone was apparently more easily sheared than the harder porphyry. The sheared rock was in turn more easily replaced than those which were less altered; the amount of shearing, therefore, was apparently the chief factor that facilitated the replacement and hence determined the size and shape of the ore-body.

The source of the solutions which caused the replacement is an interesting problem. There are two possible sources: (1) the basic igneous intrusives of post-Missian age; and, (2) the granite of the region. In favour of the former possibility it may be said that, locally, the basic intrusives were found to contain pyrite of apparently primary origin, and at one place the lamprophyre across from the Flinflon ore-body was seen to contain chalcopyrite, this, however, in a narrow zone suggesting later infiltration. In places, also, the Missi arkose in the neighbourhood of Beaverdam lake was found to contain pyrite near the contact with the lamprophyre intrusion. The position, also, of the two known ore-bodies of the region, the Mandy and the Flinflon, in a zone adjacent and parallel to the zone of basic intrusives, suggests a possible genetic relationship with them.

It has usually been considered, however, that the mineralizing solutions came from the granite. The chief argument in favour of this conclusion is the presence of quartz in the ore-body, showing that the solutions which caused replacement must have been siliceous and hence more likely to have come from a granitic magma than from a basic one. Quartz is found interstitially between grains of pyrite and as small stringers cutting the ore. At the east end of the crosscut from shaft No. 2 on the 100-foot level very siliceous bands occur in the disseminated ore. On the surface of the deposit, just east of the unmineralized horse of greenstone, is also found a siliceous rock. It is light and porous, like pumice, and consists of quartz. It is apparently a replacement of country rock by quartz and sulphides, from which the sulphides were subsequently leached out.

Aside from these occurrences of silica, the presence of gold and silver in the ore is suggestive of an origin from the granite. The gold-bearing veins of the region are clearly attributable to the closing phases of the intrusion of the granite batholiths, and it is probable that the sulphides were derived from the same source. Evidence from certain other sulphide bodies in the region points to the same conclusion. On the north arm of lake Athapapuskow, deposits of pyrite and chalcopyrite are found at several places associated with greenstone and acid porphyry rocks. In this region no basic intrusives of post-Missian age are known to occur.

There is also a great deal of quartz associated with these sulphide occurrences and the source of the deposits is, clearly, the adjacent granites. It seems highly probable, therefore, that the Mandy and Flinflon ore-bodies are attributable to the granite intrusives rather than to the lamprophyres and associated rocks.

The solutions which brought the ore were hot. The wall-rock near the sulphide zone contains much sericite. Some of the more badly altered rock, near the ore-body, consists only of sericite, quartz, and pyrite. Irregular masses of talc, also, have been found in the chlorite schist and in the sericite schist of the footwall. It is to be concluded, therefore, that the deposition of the ore was the result of the replacement of a sheared zone in volcanic rocks by solutions from intermediate to high temperatures given off from the granite intrusives. The shearing took place during the period of folding that accompanied the granite intrusion, and the replacement occurred towards the close of the period of intrusion. The solid sulphide ore was formed first. Towards the close of the period of mineralization the solutions were relatively richer in copper and gave rise to the disseminated ore on either side of the solid sulphide mass.

Conditions Affecting Mining. To mine the deposit profitably it will be necessary to have a railway to the property, a smelter, and electrical power. There are also other requirements to be met, such as securing sufficient flux material and determining the proper metallurgical processes to be employed for the solid sulphide type of ore. The electrical power will, probably, be brought from Birch rapids on Sturgeon-weir river, 35 miles west from the property. The sources of silica for flux are quartz veins and silicified greenstone zones along granite contacts. Unfortunately no quartz veins of considerable size have been found in the neighbourhood of Flinflon and distance and lack of easy transportation at present prohibit the use of those at Wekusko lake to the east or those at Amisk lake to the west. Silicified greenstone rocks have been found near Tartan lake, and it is probable that material of this type will be found of sufficiently high silica content to be utilized. It is further hoped that more ore-bodies will be discovered in the region to help bear the cost of a railway, smelter, and power-plant.

QUARTZ VEINS

Gold-bearing quartz veins are the important type of deposit at the two ends of The Pas mineral belt, that is, in the region of Amisk lake on the west and Wekusko lake to the east. They are fissure veins of quartz mineralized with gold, sulphides—of which arsenopyrite is the most common—and silicates, such as tourmaline and feldspar. They were, evidently, derived from the granite intrusives and were deposited at high temperatures.

Few veins of considerable size have been found in Flinflon map-area. Numerous small lenses and stringers of quartz cut the greenstones and, to a less extent, the Missi arkose, but where observed are barren of gold and sulphides and of no economic importance.

The largest vein in the area is on the Frisco claim, held by the Mining Corporation of Canada. This claim is on the northeast side of Meridian lake just north of the bay that extends eastward from the southeast end of the lake. Development work consists of ten trenches that have exposed the vein for a length of 750 feet. The width of quartz observed in the trenches varies from 4 to 19 feet. The vein is in granite, and the contacts are sharp. The quartz is white, and is free from sulphides. Free gold has been reported from the vein, but no sampling has been recorded.

IRON SULPHIDE BODIES

Bodies consisting of pyrrhotite and pyrite, with only minor amounts of chalcopyrite, occur at various places throughout the mineral belt. One such deposit occurs east of Grant lake, on the Beaver claim. It is in greenstone cut by an acid dyke. Both rocks have been partly replaced by pyrrhotite and some pyrite and chalcopyrite over a zone about 10 feet wide.

GEOLOGY AND ORE DEPOSITS OF ELBOW LAKE AREA, NORTHERN MANITOBA

By P. Armstrong

CONTENTS

INTRODUCTION

The widespread interest aroused by the gold occurrences in the Elbow Lake area, northern Manitoba, made a detailed survey of its geology and mineral deposits desirable. This was carried out by the writer between June 10 and September 10, 1922, and the results are given below.

Acknowledgment is made here of the many courtesies extended to the writer by local operators and prospectors, especially by Messrs. J. R. Rutherford, manager of the Murray group, and Andrew Walz, manager for the Exploration Company, Ltd., of London, England.

LOCATION AND AREA

The area examined is shown in the extreme northeast corner of the Geological Survey map of Athapapuskow Lake area (No. 1726). It lies between 54° 30′ and 54° 45′ latitude and is bounded on the west by 101° longitude. Its total areal extent is about 165 square miles and comprises Elbow lake proper, with Webb and Hassett lakes lying to the northwest and northeast respectively, and Claw lake to the southeast.

The region is easily accessible during the season of open navigation, i.e. from June to early November. Steamboats leave The Pas, on the Hudson Bay branch of the Canadian National railway, once or twice a week for Sturgeon Landing, Saskatchewan, whence a wagon road 16½ miles long leads to Camp Two on lake Athapapuskow. Following by canoe the southeast shore of this lake, Cranberry portage, connecting the east arm of lake Athapapuskow and First Cranberry lake, is reached. After traversing First, Second, and Third Cranberry lakes, a distance of about 20 miles northeasterly, Grass river is entered. This stream pursues a course that is in parts tortuous, to the southernmost corner of Elbow lake. The Hollinger interests operating the Murray group of claims have cut a winter road from their property to Reed lake, whence another road leads to Mile 55 on the Hudson Bay branch, Canadian National railway.

The camp came first to public notice after the discovery by G. C. and K. C. Murray, early in 1921, of extremely rich gold ore on what is now known as the Murray group, situated on the east shore of Elbow lake at a point where Grass river leaves the lake.

In October, 1921, interests identified with the Hollinger Consolidated Gold Mines, Ltd., of Timmins, took an option on this group and some adjoining claims. Their entry into the area was followed by that of the Exploration Company, Ltd., of London, England, who optioned various claims in the northern part of the region. Meanwhile much and promiscuous staking had taken place, so that at the time of the writer's visit almost no ground, mineralized or barren, within the area, was open for location. Unfortunately for the camp and the mining industry in general, most of the staking was done by relatively few men, acting under power of attorney for outside speculators. Hence it devolved on the two companies mentioned and a few experienced and energetic prospectors to prove the camp.

On June 10, 1922, the Hollinger interests suspended operations and have since allowed their option on the property to lapse. The Exploration Company also withdrew from the district definitely towards the end of August. At the end of the writer's sojourn in this area only one or two prospectors were continuing to develop their claims, but according to latest reports a new company, the Gordon Murray Gold Mines, Ltd., is operating the Murray group and some adjoining claims with a small force of men.

GENERAL GEOLOGY

The rocks of the Elbow Lake area may be divided into two main parts: the greenstone complex, locally named the Amisk series, and the Kaminis granite batholith with its associated dykes. Both members are of Precambrian age, the granite being intrusive in the Amisk series, and, therefore, younger.

The rocks comprising the Amisk series had been recognized by previous investigators as a complex of very ancient flows, volcanic breccias, and tuffs, of medium basicity and probably dioritic in composition originally. The detailed petrographical study of certain parts of this series in the Elbow Lake area revealed them to have been originally, stated in their order of abundance: diabases and quartz diabases, partly porphyritic; fine-grained or porphyritic basalts; andesites or coarser-grained diorites; and certain presumably sedimentary beds of quartzitic or arkosic character, intercalated between the volcanic flows. In addition to these a great number of hornblende schists and amphibolites were found, mostly situated in regions of intense deformation, the original character of which, owing to their advanced state of alteration, it was impossible to determine.

The alteration of these originally fresh and horizontal flows to the present intensely metamorphosed, sheared, folded, and plicated greenstone complex was the direct result of the intrusion of the Kaminis granite which welled up from below, enfolding pendant-like parts of the flow series. Deep erosion has since exposed these pendants, of which the areas near Elbow, Webb, Hassett, and Claw lakes are examples of greenstone areas entirely surrounded and underlain by the granite.

The Kaminis granite and associated dykes are essentially identical in composition with those described by Bruce for the whole Amisk-Athapapuskow area.[1] The granite is an albite granite, locally showing the effects of differentiation. Its intrusion was accompanied by the injection of various dykes: hornblendites, more or less feldspathic, quartz porphyries, diorite and quartz diorite porphyries, some albite granites, and granophyres.

[1] Bruce, E. L., "Amisk-Athapapuskow Lake district," Geol. Surv., Can., Mem. 105, p. 41.

ECONOMIC GEOLOGY

TYPES OF ROCK OPENINGS

This area offers no example of a true fissure vein, i.e. of a fissure of sustained length, depth, strike, and dip due to faulting or shearing of the country rock with simultaneous displacement, laterally, of the walls and filling of the spaces thus created. The closest approach of any of the deposits to this type of rock opening is found in the Murray group of claims. These deposits occur in a quartzitic gneiss which during the regional folding was sheared along closely-spaced planes, 6 inches in width and generally of limited extent in their other dimensions. Numerous tension cracks, irregular in dip and frequently intersecting each other, also occur, sometimes widening out, where fracturing has been most intense, into larger openings now filled with vein matter. These fractures are too irregularly disposed, and too widely spaced, to be considered a sheeted zone. The Murray deposit is the only one found in this area located within a sedimentary bed, and is also the only representative of the type just described.

A second type is illustrated by the so-called "Garbutt vein," really a quartz porphyry dyke, of post-Amisk age, that cuts across the folded greenstones. During the ore-forming period this dyke was sheared, producing short, narrow, somewhat disconnected fissures or irregular shatter zones in which the vein material was deposited. The direction and intensity of movement are indicated by a border of finely laminated schist, 4 to 5 inches wide, on either side of the dyke and running parallel to it.

The third, and by far the commonest, type of rock opening is exemplified by the Sherlock claim, and shows the close time connexion that must have existed between the folding process and that of ore deposition.

Figure 6A illustrates one of the two high-grade gold-quartz lenses encountered on this property. Close folding here—helped perhaps by the high pressures under which the vein material was introduced—has resulted in displacement of two adjoining beds and, seen in Figure 6, the

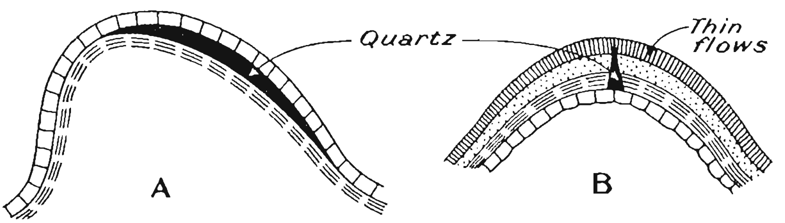

Figure 6. Diagrams showing relationships of quartz veins to folds.

formation of an oval body of quartz. Exploitation of this lens, however, showed it to pinch out within 18 to 24 inches from the surface, thus proving its lens-like character and the probable presence of intense hydrostatic pressure conditions at the time of ore formation. The harmonious ratio between the length, depth, and width of the lenses encountered, and the gradual manner in which such bodies will decrease into knife-blade seams of quartz, not only along their strike but also along the dip, render it difficult to ascribe their origin solely to stress differences set up by folding.

In Figure 6B is shown a similar type. What, from its position, appears to be a tension crack is formed normal to the axis of a close fold. One end is terminated by an unfractured competent bed; the other narrows into a knife-blade seam and finally disappears. As the conditions under which folding and plicating of these greenstone beds took place would appear to inhibit the formation of tension cracks, intense hydrostatic pressure may very well have aided the tendency of the weaker beds to part under the tremendous compression stresses set up during deformation and may have kept them open until the filling of the openings thus created was completed.

MINERALOGY OF THE ORE-BODIES

The examination of polished and thin sections of ores disclosed the following mineral associations:

Gold-Pyrite-Quartz. (Specimen taken from Murray group). The gangue is quartz, enclosing occasional chloritized shreds of the wall-rock. Pyrite occurs in shapeless patches and appears, in this instance, to be of the same age as the quartz. Gold, in thin leaves, is seen along cracks traversing the gangue, but never in the pyrite. If it occurs near the latter mineral it generally stops at the quartz-pyrite boundary, thus indicating its later origin.

Gold-Apatite-Carbonate-Quartz. (Specimen taken from Sherlock claim). The gangue is fine-grained anhedral quartz with some apparently contemporaneous carbonate believed to be calcite, as it effervesces freely. Gold occurs either along the boundaries of, or in cracks traversing, individual quartz grains. Apatite is present in moderate amount. In the hand specimen the quartz appears flinty and semi-transparent, suggestive of a high temperature origin.

Galena-Pyrite-Chalcopyrite-Tourmaline-Quartz-Carbonate. (Specimen taken from the Coupe claim). All three metallic minerals appear to have been deposited simultaneously along cracks in the quartz. Tourmaline is plentiful. Gold, although high values were reported in assays, is not found here; this well illustrates the extremely spotty character of its occurrence. Carbonate, also quartz, appear to have replaced enclosed shreds of wall-rock as is suggested by lines of residuary iron oxide that closely follow the trend of the wall-rock boundaries.

Pyrrhotite-Tourmaline-Orthoclase-Quartz. (Specimen taken from Murray group). Some large, twinned, euhedral individuals of feldspar, presumably orthoclase, occur in coarse-grained quartz. Large pyrrhotite crystals rest in close proximity to abundant tourmaline. Zircon is found in the wall-rock immediately adjoining the vein filling, as is biotite, developed along the lines of gneissose structure. Well-shaped crystals of pyrite cut across the earlier minerals.

Pyrite-Chalcopyrite-Carbonate-Quartz. (Taken from Shamrock group). Here again pyrite and quartz appear to be of simultaneous origin, whereas the chalcopyrite is later, occurring along shear cracks in the quartz and sometimes enclosing the pyrite. The carbonate is dolomite and is idiomorphic towards the quartz. No gold is seen in this section, although a few specks of gold have been seen in the quartz of this property.

It will appear from the foregoing descriptions that quartz is the most abundant of the gangue minerals and is generally contemporaneous with pyrite. Both minerals, as well as the carbonate, are, however, older than either gold, galena, or chalcopyrite. The last two appear to be of simultaneous origin, but their relationship to the gold could not be ascertained owing to the scarcity of the latter mineral even in what was being regarded as ore. Pyrrhotite, apparently, does not occur in conjunction with the other sulphides and may represent, with tourmaline, quartz, zircon, and the rare orthoclase, a separate phase of the mineralization. Arsenopyrite has never been found in the vein matter proper, but sometimes occurs in well-shaped crystals metasomatically in the adjoining country rock.

None of the sections examined record an intergrowth with, or later enrichment by, gold of any of the sulphides mentioned. This fully bears out the experience of local mine operators. The distribution of gold, in general, is extremely erratic and spotty, not only within an individual lens but also in several closely adjoining ones; one of them may be highly auriferous and the others may be entirely barren, even of the base minerals.

GENESIS OF THE ORE DEPOSITS

Although only on one property, the Murray group, is the ore deposit situated in contact with the granite, no difficulty exists in ascribing the origin of the Elbow Lake ore deposits to the influence of the granite batholith. The position of the greenstone area, deep within, and entirely surrounded by, the granite; the absence of any other deep-seated igneous body, not directly connected with the granite, within this region; the high-temperature character of the minerals such as tourmaline, zircon, pyrrhotite, arsenopyrite, are all evidence of this origin. The intrusive relation of the quartz diorite and its close proximity to the sedimentary gneisses of the Murray group suggest the possibility of its having been responsible for the ore-bodies formed on this property. But its barrenness of any of the distinctive minerals commonly associated with the ore, and the high probability that it represents a border phase of the granite, grading into the latter through granodiorite and more acid phases, eliminates this possibility.

There is strong field evidence for the belief that mineralization was effected in at least two distinct periods. In a number of cases of ore-bodies similar to the third type described on page 39, it was found that quartz lenses carrying either precious or base metallic minerals, or both, had been introduced apparently later than similar, generally barren and vitreous, masses of bluish quartz against which they are now resting. In general it may be said that bodies of quartz occur where there have been structural weaknesses of the country rock. These weaknesses are due to folding and slipping of adjoining beds, to especially intense plication, to shearing of hard, non-pliable beds, or to previous intrusions of dykes or barren quartz masses.

DESCRIPTION OF PROPERTIES

The Exploration Company, Ltd., of London, England

This company, in the autumn of 1921, took options on a number of prospects, described below, in the northern part of Elbow lake, and by June, 1922, had erected, on Harbour island, a camp consisting of bunk-houses, dining room, assay laboratory, staff quarters, and office. From fifteen to twenty men were employed in prospecting work under the superintendence of Andrew Walz. The most important claims or groups of claims held under option by this company were:

Harbour Claim. A series of parallel trenches demonstrated the presence of an irregular mass of mineralized quartz injected into intensely plicated greenstone. In places an iron carbonate accompanies the quartz, the metallic minerals being represented by pyrite, chalcopyrite, pyrrhotite, and arsenopyrite in erratically distributed patches. In one or two places samples were secured, assaying up to $5 a ton in gold, but the results were very variable, and it is probable that the gold values come from isolated veinlets within the otherwise barren quartz body.

Hanna Claim. On this property, highly schistose greenstone, with its planes of schistosity standing nearly vertical, is injected with stringers of white quartz which, in favourable places, unite to form a lens, spottily mineralized in much the same manner as the Harbour claim deposits.

Sherlock Claim. This property is situated on the west shore of the lake, south of Webb creek. Staked by two prospectors, Garbutt and Webb, it is one of the few Elbow Lake properties that have actually produced high-grade gold ore. Webb is reported to have panned about $800 worth of coarse gold from a small lens found in a shallow shaft. The lenticular nature of this pocket is well shown by numerous parallel crosscut trenches across the vein and the greenstone. After the exploitation of this lens by Webb, the property was optioned to the Exploration Company. Mr. Walz uncovered, about 200 feet north of this lens, a second one, about 8 feet long and 20 inches in maximum width. It proved to be spectacularly rich. No gold values of any importance, however, seem to have permeated the enclosing greenstone. They appear, together with their quartz gangue, to be confined entirely to the lens which, to the north, ends abruptly against a greenstone fold and, to the south, thins into almost nothing and finally disappears. Further trenching failed to reveal any more ore lenses, and work on this claim was finally abandoned.

Banker Claim. This claim occupies the southern half of a small island, about 700 feet long. The country rock is a highly schistose greenstone in which lenses and veinlets of quartz carrying high gold values are injected. Considerable crosscut trenching was done here by the company, but although mineralization by gold seems to have been more widespread here than in any of the other claims so far described, no ore-body suitable for exploitation by a company was uncovered. Towards the end of August, 1922, the Exploration Company withdrew from the district.

Murray Group

This group, situated at the junction of Elbow lake and the down-stream branch of Grass river, comprises the Contact, Murray, and Yarrum claims, staked by G. C. and K. C. Murray, the discoverers of the camp; and the Yellow Rose, Yellow Rose Fraction, and Wallflower claims located by W. Kerr and J. McDougall respectively. These claims were taken over in October, 1921, as a group under an option agreement by interests closely identified with the Hollinger Consolidated Gold Mines, Ltd. During the following winter a substantial camp was built and a winter road was cut to Reed lake. With a maximum of thirty-five men under the superintendence of J. R. Rutherford, a considerable amount of trenching and some sinking were done, chiefly on the Murray claim.

As already stated the deposits occur in a sedimentary gneiss which prior to the metamorphism of the region was a coarse, slightly feldspathic sandstone. Between this gneiss and the granite batholith which occurs close by is a broad belt of what was locally called a quartz porphyry, but under the microscope proved to be a quartz diorite and is considered to be a border phase of the granite and not a separate intrusive. During the folding attendant on the intrusion of the granite batholith, tension fractures developed in this gneiss. Some of these fractures, subsequently, were filled by quartz containing pyrite and gold; others by an assemblage of pyrrhotite with tourmaline, orthoclase, and quartz. Individual veinlets yielded ore of extraordinary richness, but the fractures were small and far apart, and the pyrite with which the country rock is impregnated carries no gold values that might make profitable the mining of veinlets and country rock together.

Coupe and Thompson Claims

These claims, staked by Dickson and Thompson, lie about 1½ miles north of Elbow lake. In mode of origin and shape the mineral deposits resemble the third type of rock opening enumerated on page 39, being lenticular, 5 to 6 feet in length, and correspondingly limited in their other dimensions. They are remarkable for their high content of argentiferous galena in addition to gold; assays taken from the Coupe claim are reported to have given $8.80 in gold and 14 ounces of silver a ton. No ore-bodies of any size were uncovered on these properties, the deposits found so far being limited to small, isolated lenses.

Gordon Murray Gold Mines, Limited

This company was incorporated in June, 1922, to develop claims on Elbow lake, consisting of the Thelma, Babs, Jack, Bud, and Sultan. At the time of the writer's visit no work had been done on them. Since the conclusion of the field season, however, and after the expiration of the option held by the Hollinger interests on the Murray group, these claims were optioned to the above company, who, it is said, are employing a small force of men on prospecting work.

Garbutt-Bow Group

Garbutt Claim. On this property a quartz porphyry dyke of Kaminis granite age cuts across the folded greenstone and may be traced in a straight line for nearly 2,000 feet. As already mentioned, shearing of this dyke resulted in the production of short, narrow, somewhat disconnected fissures running parallel to the strike of the dyke. These are now filled with milky white quartz, carrying a little pyrite, chalcopyrite, and galena, and said to assay from 40 to 80 cents a ton. A grab sample gave 40 cents in gold.

Bow Claim. On this property a serpentine vein, following with remarkable persistence the close plications of the greenstone country rock, was uncovered. It has an average width of about 10 inches. The vein-filling consists of quartz, sparsely mineralized with pyrite and chalcopyrite and carrying gold values up to $50 a ton, although the average is said to be $20.

Elbow Lake Mines Corporation

This company, in the winter 1921-22, staked or acquired under option twelve claims, mostly on Elbow lake, but a few on Claw lake. Work sufficient to satisfy the legal requirements was done under the supervision of Mr. Julius Cohen, principally on a group of four claims, the Shamrock I, II, III, and IV, situated about a mile east of the mouth of Webb creek. A crosscut trench uncovered a wide body of quartz, in places heavily pyritized and carrying a little chalcopyrite and galena, which was said to have assayed up to $8 over 20 feet in width. Further prospecting during the summer showed this quartz body to dissipate into a zone 40 feet wide of small quartz stringers, nearly parallel in strike and vertical in dip. In places where fracturing had been intense several of these stringers consolidated to form a short, thick lens of quartz. Further trenching revealed a rapid diminution in the volume of quartz injected and a more complete lack of mineralization, until, within a short distance from the original find, all traces of it were lost. Although a quartz chip showing a speck of free gold was found, the assay returns generally proved to be discouraging. The remainder of the claims likewise failed to yield satisfactory results.

RICE LAKE MAP-AREA, SOUTHEASTERN MANITOBA

By J. F. Wright

CONTENTS

Illustrations

INTRODUCTION

Most of the field season of 1922 was spent in detailed geological mapping, on a scale of 3,000 feet to the inch, of Rice Lake map-area, in southeastern Manitoba (Figure 7). The map-area is part of a mineralized belt of country about 15 miles wide that extends northwestward from about mileage 90 on the Manitoba-Ontario boundary to lake Winnipeg, a distance of about 60 miles. Quartz veins that contain free gold have been known in this belt for a number of years. The Gabrielle claim north of Rice lake was the first claim in this district, and was staked in March, 1911. Since then about twenty-five hundred claims have been staked and up to the end of 1922 over two hundred claims were surveyed. A general reconnaissance survey of the whole mineralized belt was made by the Geological Survey in 1912, and detailed studies of small areas were made in 1916, 1917, and 1921. The field work here described was undertaken to ascertain more definitely the origin and geological relationships of the mineral deposits in this map-area and to provide prospectors with a fairly detailed map showing the distribution of the various rock formations, especially the areas most favourable for prospecting.

The writer is indebted to prospectors and owners of mineral claims in the area for information concerning the routes of travel and the location of mineral claims. Special thanks are due to Mr. S. Walton for information regarding the Turtle Lake group; Mr. Frank Phillips, of the Luleo group; Mr. Charles Andrews, of the Saxton Lake group; and Mr. Dan McRae, Mr. H. Gans, and Capt. Ennis, concerning the claims north of Wanipigow lake. J. B. Mawdsley and J. M. Murray assisted in the topographical and geological mapping.

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GENERAL CHARACTER OF THE DISTRICT

ACCESS

Previous to 1922 the common route of travel to Rice Lake map-area was by steamer from Selkirk to Hecla, by motor boat from Hecla to Manigotagan, and up Manigotagan river by canoe. Since the numerous log jams on Wanipigow river have been removed between Winnipeg lake and Bellevue landing, the quickest and easiest route is by the Canadian Pacific railway from Winnipeg to Riverton, and by motor-boat or small steamer from Riverton to the first falls on Wanipigow river. A wagon road about 3 miles long has been built around the four portages on Wanipigow river and from the upper end of this road a small motor-boat can go either to the Manitoba Government landing or Bellevue landing. From the Government landing a rough wagon road has been built by the Manitoba Government as far as Little Rice lake. This road has been chopped to a point on Manigotagan river about 500 feet west of Quesnel lake, but from Little River lake the country is so rough and rocky that it will cost a great deal of money to build even a rough wagon road to the Gold Lake group of claims. The Selkirk Gold Mining Company, Inc., has a fairly good road about 3 miles long from Bellevue landing to their property on the Luleo group of claims. Last summer this company had boats on the route and made one trip a week to transport their own supplies and mail.

TOPOGRAPHY

Rice Lake map-area lies about 20 miles within the southwestern edge of the great Canadian Precambrian shield, and its topography is similar to that of many other parts of this great physiographic province, though its local relief is not as great as farther to the east and southeast. Turtle lake, near the western edge of the map-area, is 875 feet, and Manigotagan

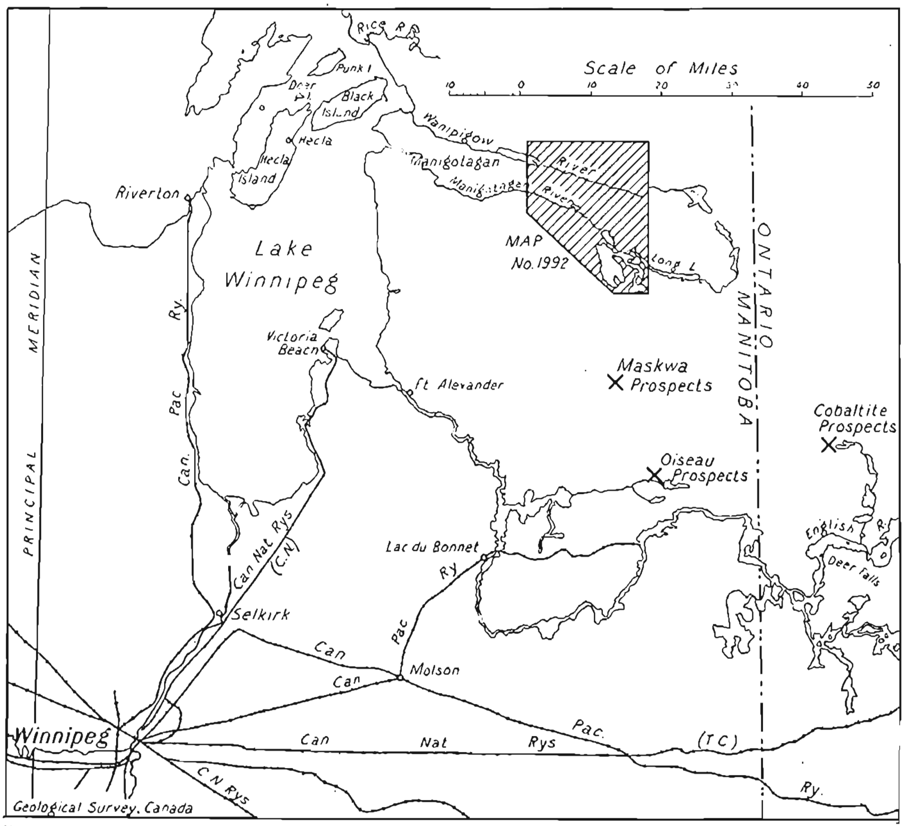

Figure 7. Index map showing location of Rice Lake map-area (Map 1992), southeastern Manitoba.

lake, near the eastern edge, is 922 feet above sea-level; the two lakes are, respectively, 165 and 212 feet above lake Winnipeg. Nearly horizontal early Palæozoic sediments overlap this slope to the south and on the islands in lake Winnipeg, but no remnants of the Palæozoic sediments have been found east of lake Winnipeg to indicate their former extent eastward.

The lakes on this western slope of the Precambrian shield are expansions of the rivers. As far as known, there are few lakes or canoe routes in the large granite areas between Manigotagan and Winnipeg river to the south; or Wanipigow, Rice, and Bloodvein rivers to the north. In these areas large—and in the summer—almost impassable muskegs and spruce swamps are abundant, but beyond the east edge of the westward slope, or about 50 miles east of lake Winnipeg, lakes are abundant.

Rice Lake map-area is rough and irregular owing to many hills ranging from 25 to 90 feet high. These hills, in parts underlain by volcanic and sedimentary rocks, are elongated in a general west or northwest direction, but the hills in the granite areas are discontinuous. A straight and noticeable escarpment facing the north, and with an average height of about 80 feet, extends from the south side of Red Rice lake westward and passes about one-half mile south of Wanipigow lake. This escarpment follows the contact of massive granite to the south, and volcanic and sedimentary rocks to the north. Towards Wanipigow lake it is not as conspicuous as just west of Red Rice lake (Plate IV A).

Almost the whole distance across the map-area Wanipigow river flows in a wide valley the north side of which is continuous and well developed near the contact between granite and volcanic schists. Along this valley from about 2 miles east of Rice Lake landing to Wanipigow lake are deposits of stratified clay and sand. Wanipigow river meanders across these clay areas with few falls or rapids.

Where Manigotagan river crosses the southern part of the area it has no well-defined valley, but follows the general strike of the schist bands; and where it flows at an angle to these bands—as between Long lake and Manigotagan lake—there are many falls and rapids. It is probable that in pre-Glacial time Manigotagan river, instead of turning southwest from the west end of Long lake, followed the depression along the granite-schist contact which is now occupied by Spence lake and creek, the northeast arm of Clearwater lake, and Walton lake.

Bedrock is well exposed in the southern half of the area. In parts underlain by sediments and volcanics, and especially near the contacts of sediments and volcanics, outcrops are few, and they are long, narrow muskegs and spruce swamps. Large parts of the country have been burned by forest fires, and in those parts recently burned, as southeast of Rice lake, rock outcrops are abundant. Off the canoe routes, in the older burned areas, travel is difficult because of the thick second growth which is hard to get through and which hides the wind-falls and partly burned stumps.

Glaciation

The whole area shows abundant evidence of recent continental glaciation. The hills and ridges are rounded, and nearly everywhere smoothed and striated rock surfaces are abundant. When the ice retreated, a few boulders, small local deposits of boulder clays in the depressions, and a few small sand-plain areas—probably outwash material—were deposited. The abundant evidence of intense glacial scour and the small amount of glacial deposits are noticeable features in the area.

The glacial striæ show varying directions of ice movement in different parts of the area. At the eastern edge striæ strike south 50 to 55 degrees west, and in the western part of the area they strike from south 30 to 40 degrees west. Striæ striking almost every degree between south 25 and south 55 degrees west were noted. These variations are probably due to local topographical features, but probably there was a slight westward deflexion in the direction of movement as the ice front approached lake Winnipeg.

No way was found to estimate the amount of erosion accomplished by the ice-sheets in the Rice Lake area. That it was quite extensive is indicated by the fresh and unweathered rocks exposed and the polished, striated, and grooved rock surfaces. Also, all the pre-Glacial gossan along the mineralized zones has been removed. However, on the northwest side of Deer island (Punk island on present maps) in lake Winnipeg, about 30 miles northwest of Rice Lake map-area, glacial erosion was not intense enough to remove the decomposed early Palæozoic shale and sandstone. West of lake Winnipeg the ice, probably, moved south, and at the junction of this south-moving ice and southwest-moving ice to the east there would be a zone where glacial erosion would be slight.

GENERAL GEOLOGY

DESCRIPTION OF PRECAMBRIAN ROCKS

All the known bedrock of the Rice Lake map-area is Precambrian in age and may be arranged in the following five main groups.

Table of Formations

Group	Component rocks
Dyke intrusives............................	Diabase Feldspar and quartz porphyries
Granitic intrusives..........................	Pink hornblende granite Granite, granite porphyry, granodiorite, syenite Banded gneisses Granite and granite gneiss
Sedimentary series..........................	Arkose, quartzite, and conglomerate
Probable sedimentary series...............	Biotite schist and garnet gneiss
Volcanics with some interbedded sediments	Cherts, slates, and volcanic tuffs Rhyolite, feldspar porphyry, and sericite schist Trachyte, andesite, andesite porphyry, and chlorite schist Basalt, basalt porphyry, and diabase

No formation names are here given to the various groups of Precambrian rocks described, but they resemble the groups described as Keewatin or under other local names in the Lake of the Woods and Timiskaming regions and intervening country. There has been little detailed work done in southeastern Manitoba and all the areas where any has been done are considerable distances east of the area under consideration. No attempt, therefore, at correlation will be made. The local formation names, Rice Lake series and Wanipigow series, are not used because, as originally used by Moore, the Rice Lake series included only the volcanic members of the group with interbedded sediments, and the Wanipigow series as mapped included some of the sediments now known to be interbedded with the volcanics, the probable sedimentary series, and the sedimentary series of the above classification. These three groups of rocks may prove to be of widely different ages. Cooke included the volcanic and sedimentary rocks of the first three groups of the above classification under the Rice Lake series. Until more extended field work is done it is not certain whether there is need for one, two, or more formation names or what rocks should be included under each name.

VOLCANIC AND INTERBEDDED SEDIMENTARY GROUP

The larger part of the group of volcanics and interbedded sediments is composed of metamorphosed volcanic rocks ranging in composition from basalt to rhyolite. Interbedded with these volcanic rocks are long, thin beds of slate, tuffs, and chert. These rocks are all steeply folded, the dips varying between 75 and 90 degrees. The volcanic rocks are on the whole fine-grained, but some that are classed with this group are coarse-grained and possess the textures of intrusive rocks. All gradations were noted between such coarse-grained types and true lavas with local pillow structure, but some of the coarse-grained, massive dioritic rocks may be intrusives.

Basalt, Basalt Porphyry, and Diabase

A narrow band of basalt or diabase outcropping along the north shore of Rice lake widens and extends eastward beyond the edge of the map-area. Another basalt band south of Wanipigow lake was traced eastward to near the eastern edge of the sediments which outcrop west of Rice lake.

These basic lavas are dark green or black rocks of about the same mineral composition, but of variable texture and size of grain. In places they are slightly schistose, but on the whole they are massive and fresh. About one mile east of Rice lake good pillows (Plate V A) were noted along what is apparently the base of the flow. Along the north edge of the basalt band and about one mile from the east edge of the map-area, porphyritic phases are well developed. These porphyritic phases have round or lens-shaped outcrops and cannot be traced continuously along the strike for any great distance. In some outcrops white, angular, or slightly rounded feldspar phenocrysts, from one-quarter to three-quarters of an inch in length, form one-half the surface.

In one thin section of these basic volcanics the feldspar is only slightly altered and the original ophitic texture still remains. In a few other thin sections the original outlines of some of the minerals remain, but in most of them there is little evidence of the original minerals or textures. The feldspar is between andesine and labradorite in composition, but is mostly replaced by saussurite, zoisite, and calcite. A few small crystals of augite remain and a light green, highly pleochroic hornblende is abundant. The augite and hornblende are badly decomposed to chlorite and epidote. Pyrite cubes are fairly abundant; magnetite, titanite, and leucoxene were noted in all thin sections.

Andesite, Andesite Porphyry, and Trachyte With Associated Chlorite Schists

Volcanic rocks of intermediate to acid composition are the most abundant members of this group. They outcrop extensively in the area between Clearwater and Rice lakes, but are cut off by granite both east and west. Volcanics of intermediate composition outcrop north of Wanipigow river. A band about 3,000 feet wide swings northwest around the east end of the granite area north and east of Wanipigow lake and continues beyond the northwest edge of the map-area.

The rocks of this class are light grey, greenish grey, or black, and, except where porphyritic, are fine-grained, dense, or schistose. Poorly developed pillow structures are abundant in some of the andesite flows between Red Rice and Rice lakes and for about 1 mile to the east. Pillow structures were also noted at various places near the Gold Pan and Moose claims, but they are not nearly so abundant as they are near Red Rice lake. In one pillow lava flow about 200 feet west of claim 85-124 northeast of Red Rice lake, are numerous large granite boulders (Plate VIA) which must have been picked up on the surface over which the lava flowed.

Examined under the microscope the andesites and trachytes are seen to be holocrystalline rocks consisting chiefly of phenocrysts of plagioclase in a microcrystalline groundmass of lath-shaped feldspar crystals, specks of hornblende, brown biotite, chlorite, pyrite, magnetite, and calcite. In the dark-coloured varieties the plagioclase is andesine and there is considerable hornblende; in the lighter coloured trachytic varieties the plagioclase is oligoclase to oligoclase-andesine, green hornblende is sparingly present, and in most thin sections brown biotite is abundant. Quartz is present in many thin sections. It is probably secondary, but in some cases may be primary, and the rock consequently a dacite. In the band of porphyritic andesite along the top of the hill north of Rice lake the feldspar phenocrysts are up to three-eighths of an inch long and are arranged in lines. A thin section of this rock shows the feldspar completely saussuritized and the small crystals also drawn in lines, evidently by squeezing and flowage of the rock after or about the time it crystallized.

Many outcrops of these andesite-trachytes are greenish grey schistose rocks which consist chiefly of fine, granular quartz and feldspar intermixed with chlorite, sericite, and calcite. Except for the greater abundance of chlorite, they are similar in composition to the sericite schists associated with the acidic volcanics. Also, where these dark-coloured schists have slaty cleavage, it is difficult to distinguish them from sedimentary slates and phyllites which in places are interbedded with the volcanics. A typical thin section of these greenstones or chlorite schists consists of about 50 per cent leafy, chloritic looking material, about 10 per cent calcite, and the remainder albite, microcline, quartz, magnetite, titanite, and leucoxene.

Rhyolite, Feldspar Porphyry, and Sericite Schist

Acid volcanic rocks outcrop north of Manigotagan river in a band about 1,500 feet wide which was traced westward to the edge of the sheet, or about 22 miles. These rocks are light grey in colour and vary little along the strike from Pillow falls, on Manigotagan river, to Spence lake, where they begin to get darker. At the west end of Long lake they are almost chlorite schists and slates. North of Turtle lake the band consists of several thin flows dipping about 85 degrees to the south. Evidently these acidic volcanics are on top of the more basic volcanics to the north. Outcrops of rhyolite were noted north of Rice lake and at other places in the area, but in these places it was impossible to trace these flows any great distance along the strike.

The rhyolites are dark grey, glassy-looking rocks with a few small, white feldspar pherocrysts in a glassy groundmass. The feldspar porphyries are light to dark grey, fine-grained granular rocks with white phenocrysts. The sericite schists are light grey or greenish grey, foliated rocks occurring in mashed zones in the rhyolite or feldspar porphyry. Small, lens-shaped areas of quartz stand out on the weathered surface of some outcrops of these acidic volcanics, and probably represent squeezed amygdules.

In thin sections the rhyolite and feldspar porphyry show characteristically a fine groundmass of quartz and feldspar in which are embedded well-defined phenocrysts of oligoclase-albite, and in one thin section a few small lenses of vein-like quartz thought to represent amygdules. Even the freshest of the feldspar phenocrysts are considerably altered, and contain abundant shreds of sericite. The groundmass of the rhyolite is microcrystalline and probably represents recrystallized glass. Usually the brown biotite and the chlorite, secondary after biotite, are in scales with their long directions parallel. Some of the chlorite is fibrous or in the form of long needles. In some thin sections there are only a few minute plates of sericite, whereas in others sericite or muscovite is abundant and the rock is a typical sericite schist consisting almost entirely of granulated quartz, feldspar, and sericite with a few specks of chlorite, magnetite, and pyrite. Calcite is always present in small specks scattered throughout the groundmass or in large nests. The proportion of these secondary minerals varies greatly in different thin sections. Sericite and calcite are the dominant products, epidote and chlorite being comparatively unimportant. The deformation of the rock is plainly apparent in some of the thin sections showing the flow of the groundmass around the phenocrysts.

Cherts, Slates, and Volcanic Tuffs

The sediments associated with the volcanic rocks already described are of local distribution and outcrop as narrow, long bands or lenses. Both in the field and under the microscope it is hard to differentiate certain slaty rocks from schistose andesites, and in many cases lavas may be mapped as sediments, and some of the areas mapped as sediments may be volcanics. Sedimentary rocks included in this group extend from the east shore of Rice lake east to where cut off by granite east of Gold lake. Many outcrops of slate and chert were noted along the valley of Wanipigow river and on the islands near the east end of Wanipigow lake.

The cherts are distinctly laminated, light to blackish grey, glassy-looking rocks. The thin section studied consists of apparently clastic grains of quartz, so fine in part as to be unresolvable by the high power objective. In this dense, felty-looking material are bunches and lenses of coarse aggregates of quartz and others of calcite. A few specks of chlorite and sericite are sparingly distributed, as well as a few small crystals of pyrite. These chert beds, as far as known, are under 100 feet thick and are lenses between trachyte and andesite flows.

The slates are fissile, fine-grained, greenish to black rocks with good cleavage. The weathered surface of some outcrops is marked by small parallel ridges and grooves which have resulted from the weathering of alternating beds of slightly different composition. At a few places, light grey, round to lens-shaped areas, about 1 inch long, stand out slightly above the weathered surface and probably represent small volcanic bombs. Over three-quarters of a thin section of these slates consists of very small, angular quartz particles. Scattered through this quartz are a few twinned feldspar crystals, a few small flakes of brown biotite, and a little magnetite and pyrite. A thin section at right angles to the cleavage shows the quartz grains arranged in bands alternating with narrow bands of needle-like chlorite and flakes of mica, probably paragonite. Some of these rocks are undoubtedly vitric volcanic tuffs.

Well-developed volcanic tuffs are exposed about 1 mile east of Rice lake. They were traced about 500 feet along strike and dip under the pillow basalt flow immediately to the north (Plate V B). These tuffs are dark to light grey rocks with large lens-shaped areas of white or light grey rock in an ashy, very indistinctly bedded groundmass. The large, white-weathering lenses are rhyolite and are thought to be volcanic bombs. In thin section the dark groundmass is almost identical with the slates described above. Since deposition these rocks have been squeezed and their original character destroyed.

Origin and Succession of Volcanics and Sediments

As the name implies, these rocks are in part volcanic and in part sedimentary, but often in areal mapping and even after microscopic study of thin sections it is impossible to decide whether a particular outcrop is of volcanic or sedimentary origin. However, the greater proportion of the group is of volcanic origin as is indicated by the outcrops of pillow lavas (Plate V A), and of characteristically fine-grained rocks which are sometimes porphyritic with a very fine-grained, almost glassy groundmass. On the surface of a few outcrops what were apparently amygdules are abundant. All these features belong essentially to extrusive rocks. The abundant pillow lavas just east of Rice and Red Rice lakes may have flowed under water, but the dense, fine-grained character and the absence of pillows in the andesites a mile or so east of Rice lake indicate that there possibly the lavas were extruded on land.

That some of the rocks associated with these lavas are of sedimentary origin is indicated by the traces of bedding not destroyed by deformation. The composition of the sediments is essentially the same as that of the lavas, and the materials were derived from rapid erosion of volcanic ejectamenta. As far as known these sediments are in long, narrow bands with their dip and strike parallel to the dip and strike of the lava flows. The composition and close association of these sediments with the known lavas indicate that they are interbedded with the volcanic rocks. The area must have been below or near sea-level at the time of the formation of these sediments and interbedded lavas, or else, as stated by Cooke, the lava flows disturbed the drainage and formed lakes in which the pillow structures were produced and the sediments deposited. However, the continuity of some of the sedimentary bands along the strike indicates widespread and continuous bodies of water, which suggests that the area was below or about sea-level.

The general structure and distribution of the different members of the volcanics and sediments indicate that the thick andesite and trachyte flows are near the base. East of Rice lake these flows are followed by slate and tuffs which are overlain by rhyolite and a thick basalt flow. To the north of this basalt flow there are thick andesite, trachyte, and rhyolite flows with much slate and some chert. These may possibly be a fault striking eastward through Rice lake, and if so there may be a repetition of some of the lava flows north and south of the fault. To the south, the basal andesite and trachyte flows are, evidently, overlain by porphyry and rhyolite flows. The basement on which these andesite and trachyte lavas were poured was not recognized, but the granite boulders in the andesite just east of Red Rice lake indicate that there was granite at the surface in this general vicinity at the time of this flow.

PROBABLE SEDIMENTARY SERIES

Biotite Schist and Garnet Gneiss

These schists and gneisses were first studied at Manigotagan village and at a number of places between the mouth of Manigotagan river and Poplar rapids, a distance of about 7 miles. In the Rice Lake map-area similar rocks outcrop in a narrow band from Charles falls on Manigotagan river eastward to Quesnel lake, where the band widens. These gneisses and schists are also well developed on Manigotagan lake. This band of schists dips 70 degrees or more to the south and between rhyolite and feldspar porphyry on the north and a large granite area to the south. Along the granite-schist contact there is a zone of banded gneiss, and many schist inclusions were noted in the granite over a mile south of the contact.

The biotite schists are fine to medium-grained, light grey to black, schistose rocks. The garnet gneisses are light grey, medium-grained, granitic rocks with gneissic structure poorly developed. Light red garnets—probably almandite—are very abundant in some beds, whereas in nearby beds garnets are absent. In the thin sections quartz and biotite are the most abundant minerals, the quartz forming from 30 to 60 per cent and the brown biotite from 15 to 35 per cent. The feldspars determined are orthoclase, microcline, albite, oligoclase-albite, and oligoclase and vary from 0 to 20 per cent. Most of the thin sections of these schists contain only a few crystals of microcline and albite in a mosaic of quartz and biotite. No hornblende and very little chlorite were noted. Specks of magnetite and small apatite crystals were noted in all thin sections, but only a few contain small pyrite and titanite crystals. Some of the quartz grains have a rounded outline, but most of the mineral grains are angular. Inclusions of quartz and biotite in feldspar and of feldspar in quartz are common. The biotite is in long threads and flakes with frayed ends, and is arranged in parallel lines in the more schistose varieties.

Origin of Biotite Schists and Garnet Gneiss. Moore describes these rocks as follows:[1] "Another very widely distributed rock is a mica schist or gneiss which consists largely of quartz and biotite, is grey to pepper-and-salt in appearance, and has probably originated in most cases from a sediment since it can be traced into a less altered phase of greywacke, arkose, or conglomerate, but in thin section some of it appears to be igneous."

[1]Geol. Surv., Can., Sum. Rept., 1912, p. 265.

Dresser[1] describes the schists along Manigotagan river and around Clearwater lake under the Wanipigow series as follows: "Lithologically the Wanipigow in the area described consists chiefly of quartz-feldspar schist or gneiss containing much biotite and a little sericite. Light-coloured garnets are found in it, and near intrusions of pegmatite tourmaline is common. It ranges in colour from light to dark grey, but no phases that could be called a conglomerate were found. It is a foliated arkose or greywacke." However, Cooke[2] mapped and described these rocks as contact metamorphosed Rice Lake lavas.

In the detailed mapping of Rice Lake map-area little positive evidence was found to prove the origin and structural relations of these mica schists and garnet gneisses. The contact between them and the acid lavas to the north is sharp and definite and similar to the contact between lava flows, but if these schists resulted from the contact metamorphism of lava flows there seems no good reason why, along the strike for about 20 miles, metamorphism should stop at so definite a line. Also, the absence of chlorite and the great abundance of brown biotite are hard to account for if these schists were originally lavas of basic or intermediate composition. They are not typical orthogneisses formed by the dynamic metamorphism of intrusive igneous rocks. Their texture and mineralogical composition are more similar to those gneisses and schists known to have resulted from the metamorphism of shale and shaly sandstone. Further detailed work to the east will undoubtedly give more information about the various problems relating to this thick and widespread series of rocks.

SEDIMENTARY SERIES

Conglomerate, Arkose, and Quartzite

The rocks of this group outcrop in a square area extending from Rice lake on the east to beyond Horseshoe lake on the west, and from the granite escarpment west of Red Rice lake north to Wanipigow river.

The quartzite and arkose are light grey, massive, dense, thick-bedded rocks of medium to coarse grain. Thin conglomerate beds alternating with quartzite outcrop at several places along the south slope of the hill west of Red Rice lake. The conglomerate consists of rounded boulders of granite, greenstone, chert, and quartzite ranging from 1 inch to 6 inches in diameter embedded in a dark, dense groundmass. To the north of these conglomerate lenses, quartzite beds from 1 foot to 10 feet in thickness alternate with thin slate beds. Both east and west of Horseshoe lake the rock is massive arkose. Thin sections of this quartzite and arkose consist of large, angular grains of quartz and oligoclase in a groundmass of small feldspar, quartz, and biotite grains with a great amount of calcite and sericite or paragonite and some chlorite. The arkose has more large grains and more plagioclase feldspar than the quartzite. The dip of these rocks is everywhere to the north. West of Red Rice lake the thick quartzite beds dip 30 degrees, whereas north of Horseshoe lake the dip is 60 degrees. The apparent exposed thickness of these sediments is about 10,000 feet. The succession from the base up is quartzite with thin beds of conglomerate, quartzite with thin slaty beds, thick-bedded quartzite, and massive arkose.

[1] Dresser, J., Geol. Surv., Can., Sum. Rept., 1916, p. 172.
[2] Geol. Surv., Can., Sum. Rept., 1921, pt. C, p. 24 C.

On one of the islands near the east end of Rice lake the arkose is cut by an agglomerate dyke from 2 to 4 feet in width. This dyke consists of angular blocks of greenstone, arkose, quartzite, and granite in a dark schistose groundmass and evidently represents a vertical fissure of eruption of a period of volcanism later than the arkose.

GRANITIC INTRUSIVES

Granitic intrusives occupy over one-half of Rice Lake map-area. The long, narrow belt of volcanic and sedimentary rocks already described lies between large granite masses to the north and south, and in the centre of the eastern and western part of the area mapped these sedimentary and volcanic rocks are divided into two bands by long, narrow granite masses, which are probably connected underground.

Massive granite is more characteristic of the Rice Lake map-area than the well-banded and foliated varieties common in other Precambrian areas. Light grey is the prevailing colour, although pink and dark grey varieties are found. In texture all gradations from coarse to fine grained were noted, and porphyritic granite occurs locally. In composition these intrusives vary from acid granite to granodiorite and syenite; pegmatite dykes are abundant south of Manigotagan lake, and the porphyry dykes described under dyke intrusives are probably differentiates of the granite magma.

The gold quartz deposits are closely associated with a light to dark grey, medium to coarse-grained or locally porphyritic variety, near granodiorite in composition, but with no known pegmatitic phases. This type of intrusive outcrops as long, tongue-shaped masses and the more important known gold quartz deposits are near the ends of these tongues in the intrusive itself or else in the volcanic schists a short distance from the contact. No gold-bearing quartz veins are known to be associated with the large areas of typical granite and granite gneiss south of Manigotagan river or north of Wanipigow river, but pegmatite and aplite dykes are abundant along the contacts of these areas.

Cooke described an older and younger granite in this general region. He mapped the granite east of the Gold Lake group of claims as the younger granite, and describes the granite north of Wanipigow river, and on the Luleo group of claims in particular, as the older granite.[1] He describes the earlier granite as being sheared and as being cut by diabase dykes, and the later granite as not being sheared and as cutting across the diabase dykes. Field work east of the Gold Lake group of claims shows that the granite there is sheared just as is the granite north of Wanipigow river. The shear on the Eldorado claims, just south of the southeast end of Halfway lake, is the strongest and most continuous shear seen in the whole district. It is exposed for over 2,800 feet along the strike and very probably continues for over 6,000 feet.

Though the granitic intrusives of Rice Lake map-area differ considerably in appearance, texture, and composition, there is no known decisive evidence that they are not all of the same general period of intrusion.

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[1]Geol. Surv., Can., Sum. Rept., 1921, pt. C. p. 12 C.

That an older granite did exist is shown by the large granite boulders in the andesite pillow lavas and conglomerate which are both intruded by the granite now exposed in the area, but it was impossible to locate any of these older granites in the area mapped.

In the areal mapping the granitic intrusives were divided into four main groups, each of which will be briefly described.

Granite and Granite Gneiss

In the southern and northern parts of Rice Lake map-area are large masses of granitic and granite gneiss which, as far as known, extend for considerable distances north and south of the map-area. These granites are light grey to slightly pinkish, medium to coarse grained, and fairly acid. Under the microscope they appear similar in mineralogical composition to the typical granite and granite gneiss already described in detail for so many Precambrian areas in Canada. Microcline is the most abundant feldspar and the plagioclase is albite-oligoclase. The quartz shows strain shadows, and it and the feldspar crystals are often granulated and cracked, though comparatively fresh. Brown biotite is always present and some thin sections contain a few hornblende crystals. Thin sections of the granite gneiss contain considerable muscovite. The ferromagnesian minerals are generally under 15 per cent and the quartz from 20 to 40 per cent.

Banded Gneisses

A belt of banded gneisses outcrops along and south of Manigotagan river from Turtle lake east to Manigotagan lake. These gneisses consist of black biotite schist and light-coloured granitic rocks in bands varying from a few inches to 20 or 50 feet in width, and of more common bands of black schist about 1 foot in width alternating with bands of light grey or slightly pinkish aplite, pegmatite, or granite. Often these bands can be traced 2,000 feet or more, but in most places they are short and discontinuous. Small drag folds are abundant and these rocks appear to be complexly folded. Everywhere the axial planes of the drag folds and the general dip of the bands are about 80 degrees to the south; in the vicinity of Clearwater lake the strike is north 70 degrees west, and on Manigotagan lake is north 40 degrees west. These rocks are typical lit-par-lit gneisses formed along the schist-granite contact by the granitic magma penetrating lines of weakness in the biotite schist and garnet gneiss described as a probable sedimentary group.

Granite, Granite Porphyry, Granodiorite, and Syenites

Coarse-grained, granitic rocks outcrop north and northwest of Turtle lake, east of Gold lake and Halfway lake, and north of Wanipigow lake and river as far east as the Luleo group of claims. These rocks are light grey to dark grey and, wherever observed, were always massive, except where metamorphosed to sericite schist along fracture zones. The acid varieties often contain a bluish glassy quartz and, locally, feldspar phenocrysts. In composition these rocks are similar to typical granites, but some sections contain a large proportion of oligoclase and slightly less quartz than typical granite and are thus granodiorite. Some thin sections contain little or no quartz and are typical syenites, but in the field it was impossible to differentiate these several varieties in areal mapping. Biotite and hornblende are generally both present, but in some sections biotite and, in others, hornblende, is the more abundant. The minerals are only slightly decomposed, but the feldspar phenocrysts of the porphyritic varieties contain numerous microlites. No pegmatite dykes or banded gneiss are known along the contacts of this type of granitic intrusives. However, the many schistose shear zones in the volcanic rocks near the intrusive contact, or in these intrusives themselves, are impregnated with quartz, which is often gold-bearing, and which is thought to represent the residual solutions from this granitic magma. Prospectors should search very carefully the country on the east side of this type of granitic intrusive.

Inclusions are abundant in the granitic rocks north of Wanipigow lake and east to the Luleo group of claims, whereas the granitic areas north of Turtle lake and east of Gold lake are not known to contain inclusions. These inclusions have the form of dykes, but consist of long, narrow bands of greenstone, biotite schist, slate, quartzite, and limestone. Under the microscope none of these rocks has the diabasic texture, but petrographically all except the limestone are similar to the groups of rocks already described under the volcanic and sedimentary group and into which the granite intruded. The inclusions on the Luleo group strike north 70 degrees west; north of Saxton lake the strike is north 70 degrees west and north 20 degrees west. Most of the schistose inclusions parallel the strike of the volcanic rocks. The impure limestone inclusion on the island in Saxton lake, which strikes north 20 degrees west, is a remnant of a limestone formation not yet recognized anywhere in this general region. The mineralized zones in the granite are parallel and closely associated with these inclusions.

Pink Hornblende Granite

Pink granite outcrops on Turtle lake, east of Clearwater lake, and in several large areas on Manigotagan lake. This is a medium-grained, massive granite and in many places is characterized by excellent horizontal joints. In thin sections quartz averages about 15 per cent. Microcline is more abundant than orthoclase. Green hornblende is abundant and is the characteristic ferromagnesian mineral, for biotite is only sparingly present. This granite is not known to be gneissic, and the minerals of the thin sections are only slightly granulated.

DYKE INTRUSIVES

Porphyry and Granite Dykes

Many porphyry dykes cut the volcanic rocks in the area between the granite north of Turtle lake and that east of Gold lake. The groundmass of these dyke rocks is dark grey to black, dense, or glassy. The most common type contains abundant white feldspar phenocrysts from one-tenth to one-fourth of an inch long and less common types contain biotite, hornblende, and quartz phenocrysts. These dykes vary from 2 feet to 250 feet in width and in a few cases were traced over 1,000 feet along the strike, but the average dyke can be traced only a few hundred feet. Small granite bosses or dykes outcrop near the northeast corner of Red Rice lake and in the Gold Pan Fractional claim, L 20-174. The brecciated character of the contact and the abundant small inclusions in the granite boss near Red Rice lake suggest that the present erosion surface is not far above the roof of this granite mass. Possibly if the lavas were eroded about another 100 feet many more bosses and dykes would be exposed in this general area.

Under the microscope the groundmass of the porphyry dykes consists of small plagioclase crystals, calcite, sericite, and chlorite. The feldspar phenocrysts are andesine and oligoclase, respectively, in the two specimens determined. In another dyke on the Nevada claim, L 27-174, the phenocrysts in order of abundance are andesine, biotite, and quartz and the rock is a feldspar-biotite-quartz porphyrite. A thin section of another dark, dyke rock contains long hornblende phenocrysts in a groundmass of small indeterminable plagioclase crystals and is, therefore, a hornblende porphyry. Many other types of dyke rocks would, probably, be found by detailed petrographic work.

Most of the porphyry dykes trend approximately east and west, or parallel to the strike of the lava flows, but a few cut across the volcanics. In a few cases the dykes cut the sheared volcanic rock, but in most cases the dykes are parallel to, and appear to have intruded along, fractured and sheared zones. Their relation to the granitic intrusives was not determined, but their distribution indicates that they are dykes from the granite which probably underlies the volcanic rocks in the area between the large granite mass north of Turtle lake and that east of Gold lake. The relation of these porphyry dykes to the diabase dykes was not noted in the area examined.

Diabase Dykes

Diabase dykes are not abundant in the Rice Lake map-area as a whole, but a number of narrow, discontinuous ones were noted between Clearwater lake and the Gold Pan claims. These dyke rocks are dense, fine grained, dark green to black, and weather reddish. In most cases the thin sections show the ferromagnesian minerals gone to chlorite and epidote and the feldspars to saussurite. These dykes cut the volcanic rocks and one diabase dyke cuts the granite on the Luleo No. 2 claim, L 42-174.

STRUCTURAL FEATURES OF RICE LAKE MAP-AREA

The area mapped in detail is not large enough to enable definite general conclusions to be drawn regarding all the structural features of the area. The following discussion, however, gives the important known facts bearing on the structure, and indicates some of the geological problems of this general region.

Stratigraphy. The following table shows three different classifications of the lavas and sediments of the Rice Lake mining district. Moore's classification is based upon a rapid reconnaissance survey of the whole Rice Lake mining district, whereas Cooke's classification is based upon detailed work in a very small area. The tentative classification adopted in this report is based upon the detailed mapping of about 300 square miles near the western end of the district, but owing to drift-covered areas along critical contacts, not enough information was obtained to confirm either of the two previous classifications. For the present no definite conclusion is drawn concerning the stratigraphic relations of the volcanic and sedimentary rocks of the area. However, the chief points ascertained may be summarized as follows:

Moore (1912)	Cooke (1921)		Present report (1922)
Wanipigow series	Rice Lake series	*Tuffaceous sediments*	*Sedimentary series*—Relations to probable sedimentary and volcanic series not known
Probable unconformity		Conformable contact	*Probable sedimentary series*—Apparently conformable above acidic volcanics
Rice Lake series		*Lavas and breccias*	*Volcanic series* with some interbedded sediments

As far as known the oldest rocks are a thick series of lavas, ranging from basic to acidic in composition, a part of which was probably extended on land and a part under water.

Interbedded with these lavas are thin beds of clastic sediments.

Apparently conformably above the acid lavas is a series of schists and gneisses, a large part of which is probably of sedimentary origin.

These lavas and sediments nearly everywhere stand vertically or at high angles.

East of Rice lake there is a thick series of clastic sediments, which in every noted case strikes about east and west and dips from 30 to 60 degrees to the north.

The relation of this series to either the lavas or probable sediments is not known, and it is probable that in the Rice Lake map-area this series is faulted into its present position and its true stratigraphic relations are not revealed, although one outcrop near the east end of Rice lake shows this sedimentary series to be conformably overlain by rhyolite and basalt described under the volcanic group.

The granitic intrusive, porphyry, and diabase dykes cut all three of the above groups of rocks.

Folding. Along the valley of Manigotagan river the lavas and sediments dip steeply to the south, whereas they dip to the north along Wanipigow valley. These two areas are separated by the granitic masses north of Turtle lake and east of Gold lake. Cooke, on the basis of a rapid change in texture near the bottom of lava flows, concluded that the lavas and sediments north of Rice lake were overturned.[1] Except for the central

[1]Geol. Surv., Can., Sum. Rept., 1921, pt. C, p. 7 C.

parts of the thick basalt flows, the lavas of Rice Lake map-area are so badly metamorphosed and, possibly, recrystallized that it is almost impossible to obtain detailed evidence about the original textures of the top and bottom of the different flows. Also, if overturned, the thick quartzite-arkose series east of Rice lake would have reversed dips as low as 30 degrees to the north, but the succession, from the present base upward, of quartzite and conglomerate, quartzite with slaty beds, followed by thick quartzite and arkose beds, is the normal sedimentary succession described for many similar Precambrian formations, and does not suggest that this series has been overturned. Everywhere north of the granitic masses north of Turtle lake and east of Gold lake the strike and dip of the lavas and sediments of the volcanic and interbedded sedimentary series are parallel to the contacts of the granitic masses, and this relationship indicates that the lavas and sediments were thrust up and squeezed aside by the granitic magma in making room for itself. The field evidence seems to indicate that there is no good reason to assume that the great thickness of lavas and sediments along Wanipigow valley have been overturned. They more probably represent the north limb of a broad anticline.

Faulting. No direct and definite evidence of faults with any great throw was noted in the Rice Lake map-area. The shape of the area of sediments east of Rice lake suggests that it is bounded by faults along its north and south contacts. The north-facing escarpment, west of Horseshoe lake, and the areal distribution of volcanic and sedimentary rocks suggest that the probable fault forming the north boundary of the sediments is a normal fault with the downthrow side to the north. There is no evidence of any great displacement along the fracture planes or shear zones so abundant in parts of the map-area.

Fracturing. Fracturing of the rocks in certain localities of the map-area has been carried to considerable lengths. At many places associated with this fracturing there has been intense metamorphism, and such zones have been called shear zones. The gold-bearing solutions circulated along these fractures and shear planes, and thus, from the economic point of view, they are important structural features.

The fracture and shear zones are generally parallel to, and a short distance from, the granite-lava contacts. As far as yet known the most extensive fracture zones, and hence the gold quartz deposits of greatest known size, are in the granitic intrusives north of Wanipigow and Long lakes. A number of fairly continuous shear zones are generally developed in the lavas or granite wherever the contact between the two takes a turn. The fracture zones cut the folded lavas. On the Iron Hat mineral claim about 2 miles east of Wanipigow lake a mineralized shear was traced from granite into schist and is younger than the granite north of Turtle lake and also younger than the folding of the lavas.

Some of the fracture zones can be traced for a considerable distance, but others are very short and irregular. Even in a uniform type of rock, such as granite, the fracturing and accompanying metamorphism vary greatly in intensity within short distances along the strike. At one place the fracture zone may be 30 or 40 feet wide, and the granite badly metamorphosed, whereas 200 to 300 feet along the strike the same fracture zone is represented by a single joint plane in massive granite, and 100 feet farther along the strike there may be no evidence of a fracture. These fracture zones are exceptionally irregular and lens-shaped where the rock types vary, and are of different degrees of competency, as is the case in the volcanic and interbedded sedimentary group. At some places the volcanic rocks seem to have fractured, but at other places along the same deformation zone apparently the same type of rock flowed, and now has slaty cleavage. In some places there are several parallel fracture zones, and when such is the case one of the group is generally better developed than the others. There is no evidence of any great amount of displacement along these zones.

The strike of the fracture zones varies in different parts of the area, but the dip is always about vertical. Their general strike north of Wanipigow river is north 50 degrees west, but less important fractures strike north 20 degrees west. In the Gold and Rice Lakes areas the fracture zones strike between north 45 degrees west and north 10 degrees west, but north of Turtle lake the strike is about east and west. This variation in strike suggests that the fracturing was not caused by widespread regional deformation, but, more likely, by local forces.

The inclusions of volcanic and sedimentary country rock, already described, are abundant along fracture zones in granite, and especially in the granite north of Wanipigow lake and river. Around the end of these inclusions the granite is badly fractured, metamorphosed, and impregnated with quartz. On the 125-foot level of the Selkirk mine, on Luleo mineral

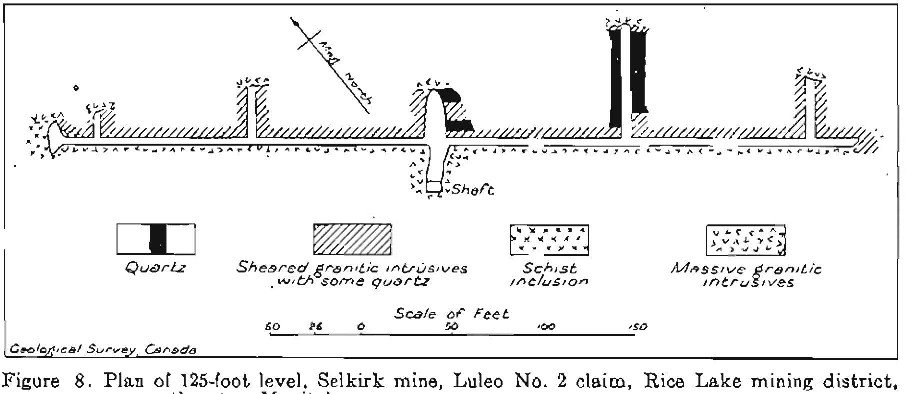


Figure 8. Plan of 125-foot level, Selkirk mine, Luleo No. 2 claim, Rice Lake mining district, southeastern Manitoba.

claim No. 2, L 174-42, very rich ore was found in such a mineralized zone near the east end of a quartz-sericite schist inclusion. The included rock generally is only slightly fractured and sheared a few inches from the contact, and contains little or no quartz, but in a few cases the whole inclusion is schistose, contains many small lenses of quartz, and is mineralized.

Thin sections of schistose granite from fracture zones, examined under the microscope, consist of large, irregular lenses of quartz in a microcrystalline aggregate of white mica, calcite, and quartz, with some epidote and chlorite. The long directions of the mica and calcite crystals are parallel, but the large quartz areas show no tendency towards parallel orientation. Thin sections from schists in fracture zones in volcanic rocks consist of a microcrystalline aggregate of quartz, white mica, chlorite, epidote, and some calcite. The thin sections of the rocks from these fracture zones are typical of rocks formed by dynamic metamorphism, and show no evidence of alteration by hydrothermal solutions.

It is believed that the fracture zones so abundant near the contacts of the large, sill-like masses of granite, granite porphyry, and granodiorite north and south of Wanipigow lake and river and east of Gold lake, were caused by the granitic magma, in the late stages of its intrusive history, making room for, and adjusting itself to, its new surroundings. The evidence for this belief may be summarized as follows:

The sharp definite contacts of the granite, granite porphyry, and granodiorite intrusives south of Turtle lake, the parallelism of these contacts to the dip and strike of the lavas and sediments, the absence of banded gneisses and evidence of assimilation along these contacts, indicate that this granitic magma made room for itself by shoving the country rock either aside or upwards. The badly sheared granitic rocks north of Wanipigow river contain abundant schist inclusions with sharp but slightly fractured contact zones, and indicate that this particular magma did not assimilate the country rocks at its present exposed level, but shoved them aside or upward, and in doing so incorporated long, narrow bands as roof pendants. Since these particular granitic magmas for some reason or another forced the country aside or upward they probably came fairly close to the surface, in the zone of fracture at least, in the final stages of their intrusive history. It is natural to suppose that adjustments by fracturing would have to take place along lines of weakness, both in the country rock and the nearly consolidated granitic masses themselves. The characteristics of the fracture zones already described in detail favour this origin, because they are parallel, or at a very slight angle, to the strike of the granitic contacts. They end suddenly along the strike, and are characteristically lens-shaped. They have no defined walls, but rather shatter walls infiltrated with quartz, and there is no evidence of any great displacement along any of the known fracture zones.

ECONOMIC GEOLOGY

GOLD QUARTZ DEPOSITS

Gold deposits are the only known deposits of possible economic value in Rice Lake mining district, though nickel-copper deposits occur, not far to the south, at Oiseau and Maskwa rivers. Gold claims have been staked since 1912, and each year some development work and prospecting are done, but up to the present only a few thousand dollars worth of bullion has been produced, though hundreds of thousands of dollars have been spent. In most cases the development work has not been systematic. Only shallow shafts have been sunk on a great many claims, so that there is little or no information about the extent and character underground of any of the deposits. The Selkirk Gold Mining Company, Inc., is making a systematic attempt to explore the deposits on the Luleo group of claims underground and the results are fairly encouraging. However, a number of the gold-bearing deposits are known to be large enough to encourage further development, if their average values were not so disappointingly small.

The gold quartz deposits outcrop as a series of lenses which partly replace the country rock and fill fracture planes in the volcanic and interbedded sedimentary group and in the granitic intrusives. These fracture or shear zones, as already described, are characterized by frequent pinches and swells along their entire length and are only partly replaced with quartz, various sulphides, and gold. The quartz and sulphides in some places display a banded or ribbon structure. In general character and mineralogy these deposits resemble gold quartz deposits formed under conditions of intermediate depth and temperature.

All the known deposits of the area have many features in common, and they will, therefore, be described in groups named after lakes or important mineral claims. De Lury used this system and has given much information concerning the various prospects. The following descriptions necessarily repeat many of the facts stated by De Lury, but all the information available since 1920 is added. No attempt is made to describe in detail the quartz leads on each claim, but rather to describe the important known deposits and general character of the whole group. The claims north of Wanipigow lake and river will be described first because developing and prospecting were active during the summer of 1922.

Luleo Group

This group is in the northwest corner of township 24, about 6 miles west of Wanipigow lake and 1½ miles north of Wanipigow river. The group covers about 2 square miles and includes thirty-five surveyed claims. The outcropping rocks are massive granite porphyry and granodiorite cut by diabase dykes, and contain many schist inclusions. The outcrops occur as low ridges and islands in the spruce swamps and muskegs which are abundant.

Prospectors have sunk many shallow pits along the shears and fractures on the various claims of this group. The Selkirk Gold Mining Company, Inc., have, at the Selkirk mine, sunk 325 feet near the footwall of the main shear of the Luleo No. 2 mineral claim, L 42-174. At the 125-foot level a crosscut was driven 50 feet to the north, 17 feet in granodiorite and 33 feet in sheared granodiorite and vein quartz. From where this crosscut intersects the footwall of the shear zone a drift was run along the vein 225 feet east and 250 feet west. At 125 feet east the vein was 62 feet wide, but was mineralized only 4 or 5 feet from the footwall. At 200 feet east the vein was almost entirely replaced by schist impregnated with quartz. At the east end of the drift there is very little quartz, but the granitic rocks are badly schisted. Along the west drift the quartz ends where a quartz-mica schist inclusion was encountered. Along the crosscut from the 325-foot level the fracture or shear zone is about 5 feet wide and contains little or no quartz, but along the east drift the sheared zone widens, and quartz is fairly abundant. The above description illustrates the irregular character both of the fracture zones and of the quartz.

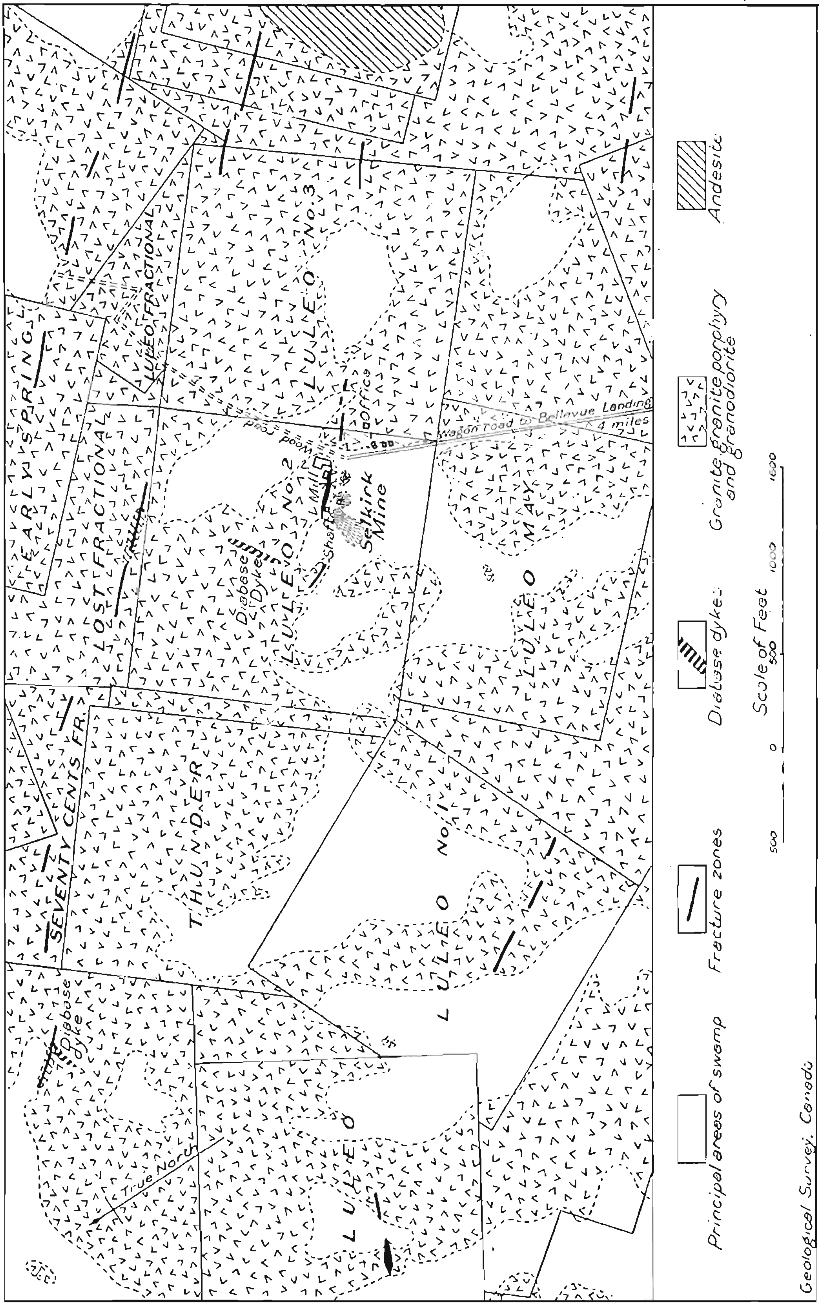


Figure 9. Diagram showing detailed geology of Luleo mineral claims, Rice Lake mining district, southeastern Manitoba.

In the workings of the Selkirk mine, described above, quartz is the principal gangue mineral and occurs as lenses of either a white, sugary, or a dark, glassy, variety. In places the schistose rock bends around the quartz lenses and was evidently squeezed aside by the quartz, which must have penetrated the fracture plane under great pressure. In other places quartz has replaced the metamorphosed country rock, and thin films and small inclusions of greenish schist are abundant in the quartz. Some of the quartz along the Selkirk mine workings contains no sulphides, but in a considerable part small grains of pyrite are distributed. In some parts of the vein, especially along the footwall, pyrite is abundant, and associated with it are small amounts of chalcopyrite, arsenopyrite, sphalerite, and galena. The quartz, pyrite, arsenopyrite, and chalcopyrite were evidently deposited contemporaneously, and later were badly fractured, for they are now veined with white mica, calcite, ankerite, quartz, and specks of gold. The granulated sulphides and quartz recrystallized, and in some polished surfaces quartz appears to replace pyrite and in others pyrite replaces quartz. Assays of sulphides with little quartz are reported to run from $150 to $200 a ton. The gold must be finely intergrown with the sulphide because no gold was seen in polished sections. However, specks of gold were noted in the vein material which cuts the sulphide, especially the arsenopyrite. This gold was probably liberated from the sulphide during crushing. Free gold also occurs throughout the white quartz or as thin films along cracks in this quartz. Molybdenite and mariposite (green chrome mica) were noted at one place along the workings. No tourmaline, pyrrhotite, specularite, or other high temperature minerals were noted in this mine or in any of the veins in the map-area. The mineralogy of the gold quartz veins of the Rice Lake mining district is similar to that of Kirkland Lake gold area, Ontario.[1]

There has been some movement along the plane of the Selkirk vein since it was formed because, as noted above, the quartz, pyrite, and arsenopyrite have been fractured and granulated. In places the vein also shows a pronounced sheeting parallel to the footwall which consists of alternating bands of successive sulphides and quartz separated by narrow bands of pulverized sulphide and quartz. This banding was probably caused by local concentration of these minerals in layers along which subsequent movements within the vein took place. The sulphides and quartz along the planes of movement would be granulated, fractured, and later recrystallized, producing the continuous and marked banding now observed. Mineral solutions may have accompanied or followed this movement, but no evidence of such solutions was noted in the few polished sections studied in detail.

All the shear zones of the Luleo group strike between north 45 degrees west and north 55 degrees west. However, those on the Pine Ridge claims near the north edge of the group are very irregular in direction, and their general strike is between north 20 degrees west and north 50 degrees west. The general dip of the fracture planes is between 80 and 90 degrees to the north. On the surface the shear and fracture zones are discontinuous along the strike, but along the same general strike a number of short lens-shaped sheared zones are often developed, which may or may not be con-

[1]Burrows, A. G., and Hopkins, P. E., "Kirkland Lake Gold Area," Ont. Dept. of Mines, vol. 29, pt. 4, p. 23, 1920.

nected underground. Quartz is not abundant in the outcrops of these sheared zones. Considerable pyrite, once chalcopyrite, and in many places free gold, were noted in the quartz. The sulphides are concentrated along the footwall in the Luleo shear zone, but in many of the surface outcrops they are concentrated in small lenses irregularly distributed throughout the quartz. Last year the Selkirk Gold Mining Company, Inc., blocked out a considerable tonnage of ore said to assay from $10 to $15 a ton. Beyond this there is little information about the tonnage and value of the ore in any of the claims of this group.

Saxton (Hay) Lake Group

This group of claims is in the southwest corner of township 25 and about 2 miles west of the Luleo group. It includes ten surveyed claims. About seventy other claims have been staked near Saxton lake. The country rock is well exposed and is massive granite and granite porphyry with many schist inclusions. About a dozen shallow pits have been sunk on the quartz veins and some of the sheared and fractured zones can be traced several hundred feet along the strike, in one case over 2,500 feet. The general strike of the most important exposed shear zones is north 50 degrees west, or parallel to the sheared zones on the Luleo group. Another group of parallel, small, but continuous, shear zones strike about north 10 degrees east, and a few other shear zones strike south 70 degrees east. Quartz is not abundant along any of the shear zones in this locality and the sheared and fractured zones average only about 2 feet in width. In some places the quartz is mineralized with pyrite, chalcopyrite, arseno-pyrite, galena, and sphalerite. Assays are reported to average about $17 in gold a ton across widths of 3 feet, but for only short distances along the strike. In September, 1922, there was no evidence of any considerable tonnage of ore on any of the claims visited, but systematic development may prove deposits large enough and rich enough to be payable.

Wanipigow Lake Group

The mineral claims in this group are in township 25 and are from 2 to 4 miles north of Wanipigow lake. Prospecting has been done mostly on the Huronic, Windsor, Bondholder, Rhoderick, Amisk, and Proctor claims, but consists only of a few trenches to prove the extent of the sheared zones along their strike, and a few shallow pits. The country rock of this whole area is coarse-grained, massive granite, granite porphyry, and granodiorite with many schist inclusions. A great part of the area is covered with post-glacial stratified clays and the granitic rocks outcrop as low, round knobs. There are a few small areas of excellent farming land north of Wanipigow lake.

The strongest shear zones strike north 60 degrees west parallel to the south contact of the granite area north of Wanipigow river and also nearly parallel to the general strike of the important shears on the Luleo and Saxton Lake groups. Other sheared zones were noted striking north 25 degrees west, north 15 degrees east, north 55 degrees east, and north 75 degrees east. In this particular part of the Rice Lake map-area the strike of the shear zones is not so regular and constant as in other localities. The shear zones are parallel to schist inclusions in the granite, the contacts of which evidently were lines of weakness and localized the fracturing shearing.

On the Huronic claim the shear zone averages about 4½ feet in width and the quartz 2 feet in width for about 200 feet along the strike. In the quartz there is some pyrite, considerable chalcopyrite, a little free gold, and a gold telluride. The sulphides are reported to assay as high as $120 a ton. The shear zones and quartz veins on the Bingo and Bondholder claims are narrow, but can be traced for several hundred feet on the surface and contain free gold. On the Rhoderick claim a quartz vein about 2 feet wide can be traced for over 100 feet along the contact between granite and a sheared and slightly mineralized schist inclusion. It was thought that this inclusion might contain values, but an assay of an average sample did not show even a trace of gold. The shears on the Proctor and Amisk claims averaging over 6 feet in width are continuous along the strike for 2,000 or 3,000 feet or more, and contain considerable quartz, but assays show low gold values.

In the Wanipigow area, as in many other parts of Rice Lake mining district, the prospecting and exploratory work are not sufficient, in most cases, to prove or disprove the value of the claims. However, the prospecting work, and the assays justify the conclusion that several of the very small deposits are rich, but that the known deposits that might be large enough to work economically are disappointingly low grade.

Rice Lake Group

This group is north of Rice lake and in the southeast corner of township 24. Over twenty claims have been surveyed and most of them are patented. The Gabrielle was the first claim staked. It lies along the north shore of Rice lake, north of which the rocks are diabase, andesite porphyry, pillow andesite, and rhyolite, whereas arkose of the sedimentary group outcrops on the islands in the lake. These rocks all strike east and west and dip from 45 to 60 degrees to the north. Along the shore of Rice lake on Gabrielle claim, L 5-124, the diabase is greatly fractured and impregnated with quartz, pyrite, and some siderite. A shaft was sunk, but no large body of workable quartz was found. About 1,200 feet almost northeast from this point another shaft was sunk along a crooked and irregular fracture zone striking about north 45 degrees west. The quartz is very irregular in distribution along this fracture zone and is exposed intermittently for a distance of 250 feet. No free gold was seen, but some pyrite and siderite were noted. The exposed outcrop of this deposit is irregular in shape and the assays of the quartz are low in gold. On the San Antonio mineral claim, L 46-124, an open-cut about 20 feet long and 12 feet deep exposed a quartz vein 3 feet wide. The diabase rock is badly fractured, and the quartz sulphide solutions replaced the country rock. The quartz can be traced only a few feet to the east, but may extend to the west. No free gold was seen and this deposit was not sampled. Considerable underground work has been done on a number of other claims to the east of the Gabrielle, but the workings were all full of water, and there is little or no quartz exposed at the surface.

Little Rice Lake Group

These claims are northeast and southwest of Little Rice lake and in the northeast corner of township 23. The country rock is andesitic lava intruded by porphyry and granite dykes. This lava is much fractured and metamorphosed with the result that there are numerous large quartz veins in these wide fracture zones of which the one on the Tine claim, southeast of Little Rice lake, is the largest and was being prospected last summer. This fracture and shear zone strikes east and is exposed for over 2,000 feet along the strike. About 100 feet to the north is another parallel, but not so well-developed, fracture zone, and these two probably meet a few hundred feet below the surface. The main fracture or shear zone averages about 6 feet in width. Quartz is abundant in it but is generally distributed in several narrow veins. The quartz is a white, sugary variety which at a few places contains free gold, and in places both the quartz and schist contain abundant sulphides. There is little information about the average gold content of this deposit, but the surface indications are favourable. On the Montcalm claim, which is a short distance north of the Tine claim, there is a large, irregular mass of quartz, patches of which are mineralized. The outcrops of these two deposits are large enough to warrant preliminary work and systematic sampling.

On the Wolf and adjoining claims northeast of Little Rice lake there are five or six fracture zones that contain a few large lenses of quartz. A few prospect pits and shallow trenches expose these quartz lenses, and prove that they are irregular in shape and discontinuous. A shipment of over a ton of ore from a pit near the northwest side of the Wolf claim sent to the Ore Testing Laboratory, Department of Mines, Ottawa, averaged as follows.[1]

Gold	1·07 oz.
Silver	1·50 oz.
Copper	1·43 per cent

An average sample of the large, dome-shaped mass of white quartz along the Manitoba Government road just east of the Wolf group of claims gave no trace of gold.

Gold Lake Group

This group of mineral claims is near the centre of the western part of township 23, and includes the claims between Gold and Big Clearwater lakes. In this area there are over fifty surveyed claims. Considerable development work has been done on ten of the claims, but in the summer of 1922 very little work was done on any of them, and little has been done since De Lury's visit in 1920. Of all the prospects in the Rice Lake map-area the Gold Pan is the best known, and has furnished very rich specimens.

[1]Information from De Lury's "Mineral Prospects in Southeastern Manitoba," Man. Bull., 1920, p. 29.

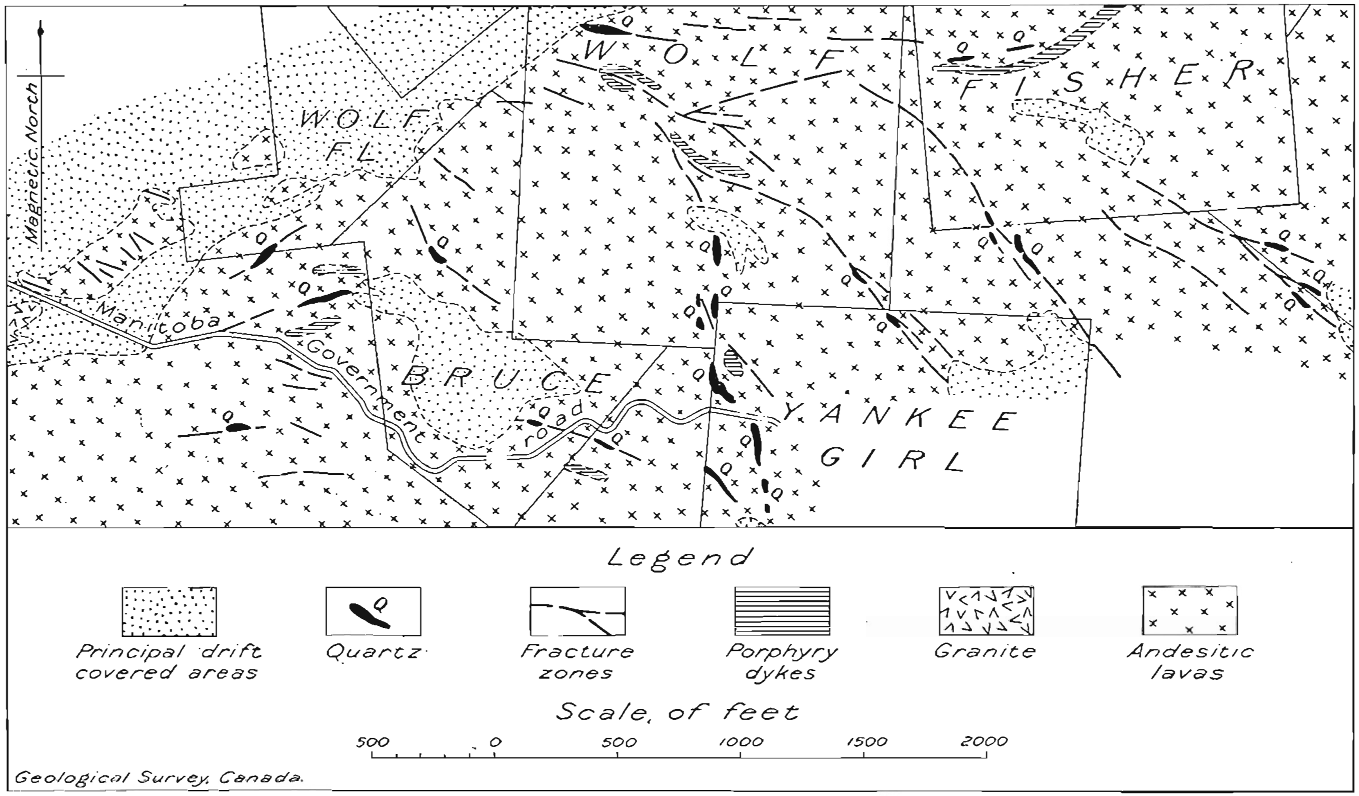


Figure 10. Diagram showing detailed geology of part of Red Rice Lake group of mineral claims, Rice Lake mining district, southeastern Manitoba.

The Gold Lake area is underlain by volcanic rocks, andesites, or slightly more acidic varieties, which are cut by various porphyry and granite dykes as well as by a few diabase dykes. The many large muskegs and swamps in the vicinity of Gold lake greatly handicap prospecting and detailed mapping. The volcanic rocks strike about northwest and are vertical, or dip slightly to the southwest. About 1 mile east of Gold lake the lavas are cut off by a large area of granite. For 2 or 3 miles west of this granite contact the lavas are badly fractured and metamorphosed, especially along the apparent contact between flows, or along the contacts of dykes. The diabase dykes must be older than the fracturing because the underground workings of the Gold Pan indicate that the diabase dyke crossing this fracture zone has been displaced about 20 feet, and quartz impregnates the fractured diabase.

The Gold Seal, Gold Pan, and Gold Pan Extension workings are along the same fracture zone. This zone strikes north 30 degrees west and was traced fairly continuously for 2,500 feet. It varies greatly in width, averaging possibly $2\frac{1}{2}$ feet for this distance. The quartz is very irregularly distributed, varying from 1 inch to 2 or 3 feet in width but averaging less than 1 foot. On the Gold Pan about 725 feet of underground work was done at various intervals between 1916 and 1920. The shaft was sunk where the fracture zone crossed the diabase dyke, and all the rich specimens were found along the western face of the dyke. The open spaces resulting from the fracturing of the competent and brittle diabase evidently made favourable conditions for the concentration and deposition of the gold quartz solutions. In September the Gold Pan workings were pumped out preliminary to stoping the remainder of the rich ore between the 100 and 200-foot levels. Several hundred feet of underground development has been done on the Gold Pan Extension and Gold Seal and the results, combined with the results of the Gold Pan work, show that these deposits underground are very similar in shape and mineral content to their surface outcrops.

The Moose claim and several other claims to the northwest are staked along well-developed fracture and shear zones. Along the strike of the Moose shear, southwest of the Moose shaft, the granite is fractured and impregnated with quartz for a short distance from the contact. In the volcanic rocks near the contact the shear zone is very irregular in shape and direction, but the general strike is north 25 degrees west, and the dip about 75 degrees to the southwest. On the Moose claim there are three lenses of quartz, up to 6 feet in width and over 100 feet long, which are fairly well mineralized with pyrite, chalcopyrite, and some free gold. This shear zone cannot be traced far west of the Moose workings because of muskegs, but probably continues to the northwest for some distance. Near the north side of the Nevada claim, L 27-174, and about 6,000 feet northwest of the Moose claim, there are two fracture zones about 50 feet apart, but little mineralized quartz was seen. Many claims have been staked on the numerous zones between the Moose claim and Rice lake, but northwest of the Nevada claim, L 27-174, quartz is absent or is in narrow stringers or small lenses, and most of the claims are of little value unless the schist rock along the fracture zone is mineralized. North of the Moose claim, along the andesite-granite contact, many other claims have been staked, but here the fracture zones are short and narrow, and the known deposits are far too small to be of economic importance.

To the southwest of the Gold Pan zone a well-developed and continuous shear zone crosses the Pilot, Smuggler, and Canadian Girl claims. It strikes north 15 degrees west and cuts slightly across the strike of the lavas. Where exposed on the Canadian Girl the quartz averages about 2 feet in width and the shear 6 or 8 feet. For 1,000 feet to the south the quartz is fairly continuous, but pinches and swells with a possible average width of about 4 feet. The shaft on the Pilot claim showed considerable pyrite in the quartz, and 45 feet from the surface and along the south wall of the shaft there is a band of solid pyrite a foot wide. The sheared zone is in places over 30 feet wide, but along the strike to the southeast the quartz is not so abundant, which is the reverse of conditions along the Moose shear zone. However, from surface showings this gold quartz deposit is the largest known in Rice Lake map-area and seems to warrant further development combined with systematic sampling and assaying to prove the value of the ore.

In this general area many other claims upon which some prospecting has been done were examined, but they are so similar to the claims already described as to need no additional description, and little is known about their available tonnage and values.

Turtle Lake Group

This group is in the northwest corner of township 23 and just north of Turtle lake. The rocks are lavas—quartz and feldspar porphyries—intruded by coarse-grained, massive granite. The granite is locally fractured and sheared, and these zones cross the granite contacts and run for some distances into the lavas. All the fracture and shear zones seen are small, and the quartz lenses are also small and discontinuous. Just north of Turtle lake some of these quartz lenses contain considerable free gold, but all the known deposits are too small to be worked economically. On the Eva claim, about 2½ miles northwest from Turtle lake, there is a well-defined shear zone in massive granite; it strikes north 70 degrees west and can be traced about 800 feet along the strike. The sheared granite varies in width from 1 foot to 6 or 8 feet, and the quartz, which is fairly continuous, is from 4 inches to 3½ feet. The walls of the shear zone are sharp and definite. At the bottom of a vertical shaft which has been sunk 100 feet on the vein the quartz is about 6 feet wide. The quartz is a black, vitreous variety and contains little or no sulphides. Average samples of the quartz from 50 and 75 feet gave no trace of gold.

SUMMARY

Distribution. The known gold quartz deposits of the Rice Lake map-area are in fractured and sheared zones cutting massive granite, granite porphyry, granodiorite, and the lavas near the contacts with these intrusives. Whether in the granitic intrusives or the lavas, the sheared zones are parallel to the contacts of these rocks, and where this contact bends there is a concentration of quartz deposits. The deposits of greatest known economic importance occur near or around the ends of wide, sill-shaped areas of granite porphyry or coarse-grained dioritic phases of the granitic intrusives. Prospectors should give particular attention to such areas.

Origin. It is thought that in their final stages of intrusion the wide, sill-shaped masses of granitic magma thrust and shoved aside the country rock, and caused the formation of openings or easily replaceable zones by intense fracturing both in the country rock and in the nearly consolidated intruding rocks. The residual solutions carrying quartz, pyrite, arsenopyrite, chalcopyrite, and gold from the granitic magma were concentrated along these zones. A similar connexion with granitic intrusives for the origin of the gold-bearing solutions of the gold quartz deposits of Precambrian age has been assumed for many deposits of this character in Canada, and both Moore and Cooke attribute the gold quartz deposits of Rice Lake map-area to the latest granite intrusion. However, the known mineral association of the deposits of Rice Lake map-area is not typical of the gold quartz deposits formed in close association with granitic intrusives, but is more typical of those deposits formed under conditions of intermediate temperature and pressure at some distance from the granitic intrusives. But since the deposits are in the granitic intrusives themselves, and the fracturing of the granitic rocks took place after they had consolidated, it is evident that these particular deposits, if they are associated with the granitic intrusives, must have been formed at a very late stage in the history of the intrusion.

Some of the quartz veins have been fractured and many of the fracture planes are slightly slickensided. The fracturing was followed by recrystallization of quartz and sulphides and the filling of the cracks in the sulphides with quartz, calcite, iron carbonate, and gold. All the gold seen in the polished sections was in this recrystallized quartz or in the gangue material filling the cracks in the sulphides. Not enough specimens have been examined to determine definitely whether the gold was introduced as free gold after the fracturing or resulted from the liberation of gold intergrown with the sulphides. In some of the apparently sulphide-free quartz the gold is distributed along very small fractures in the quartz, but may have been concentrated into thin films by the fracturing. Very often the gold is in fine grains irregularly distributed throughout the quartz and shows no evidence of having been deposited along fracture planes. It is very probable that all the gold was introduced with the quartz and sulphides before this later fracturing.

Extent and Value. Enough work has been done in Rice Lake map-area to prove that there are large tonnages of minable quartz along a few of the sheared zones, but the average value is too low to make these deposits of economic value under present conditions. Stripping on a large number of mineral claims proves that other quartz veins exposed are too small and irregular in shape to be worked economically, even though they be exceptionally rich. A very noticeable feature about deposits in the granitic intrusives is a marked concentration of high-grade gold ore around the ends of inclusions along the shear zones; as these inclusions evidently controlled the location and continuity of some of the shears in the granitic rocks, future mining will probably prove that the size of such deposits is largely controlled by the size of the inclusion. Underground development indicates that in some cases the outcrops give a fair indication of extent and values in depth. Since the outcrops of the sheared zones are lens-shaped, and the gold-bearing quartz in the shears is very irregular in shape and distribution, a great deal of expensive exploratory work, combined with systematic assaying, must be done to prove the shape, size, and value of each property.

COBALTITE PROSPECTS NORTH OF DEER LAKE ON ENGLISH RIVER, WESTERN ONTARIO

Location. In the spring of 1921, cobalt minerals were discovered about 15 miles north of Deer lake on English river. At that time, and in the autumn of the same year, several mineral claims were staked and some prospecting work was done. Mr. E. J. McMurray, of Winnipeg, sent samples of the cobalt minerals to the Mines Branch, Ottawa, for analysis and furnished the writer with information concerning the location of the claims. They are about 65 miles by canoe from Minaki which is a little over 100 miles east of Winnipeg, on the Canadian National railway. The route is down Winnipeg river from Minaki to the junction of English river, up English river to near the east end of Deer lake, then north across a series of five small lakes which are connected by a small river. There are six portages on the route, the longest of which is slightly over half a mile. With a good guide the canoe trip to the claims can be made easily in two days, and the return trip in 1½ days.

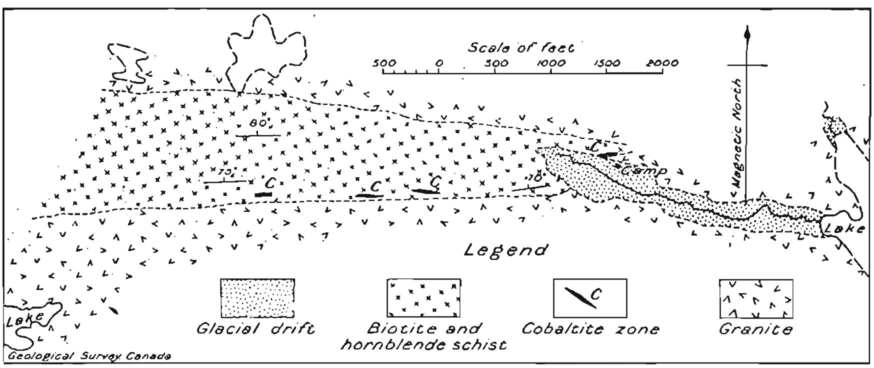


Figure 11. Cobaltite prospects north of Deer lake, English river, western Ontario.

General Geology. The country north of Deer lake is fairly rough, many of the hills rising over 500 feet above the lake. Some of the hills are heavily wooded with good timber, but in the vicinity of the cobalt claims all the timber has been burned and the rocks are exceptionally well exposed.

The rocks exposed along the route from Minaki to the cobalt claims are massive, pink granite and granite gneiss with many small schist inclusions and a few long, narrow bands of fairly basic schists. The rocks exposed on the cobalt claims are black or dark grey biotite schist and dioritic gneiss intruded by pink granite. Some of the biotite gneiss resembles gneisses in Rice Lake map-area thought to be of sedimentary origin, but the thin sections of this gneiss show abundant oligoclase-andesine, hornblende, and less amounts of quartz and biotite. The biotite schist is associated with hornblende or diorite gneiss of undoubted igneous origin, and it is very probable that these dark-coloured rocks represent metamorphosed igneous rock of basic or intermediate composition. These schists are cut by granite, aplite, and pegmatite dykes, and in places a typical lit-par-lit gneiss is developed. Massive, pink granite outcrops for considerable distances north and south of the claims.

Along the south contact of the basic schist, a garnet-rich band, about 8 feet wide, is impregnated with cobalt and copper minerals. In places this band consists of dark red garnets and quartz with a small amount of chalcopyrite. The workings along it show black garnet schist impregnated with small lenses and thin bands of cobaltite and chalcopyrite, with minor amounts of pyrite, pyrrhotite, magnetite, and covellite. No band or lens of garnetiferous rock is large enough to be a profitable source of abrasive. A specimen weighing 16 pounds, analysed by the Mines Branch, contained 18·56 per cent metallic cobalt and 30·01 per cent of insoluble rock material. Under the microscope, a thin section of lean sulphide ore shows the important gangue minerals to be quartz, garnet, feldspar, biotite, and hornblende. All these minerals are badly decomposed or fractured and the fracture planes are filled with chlorite, sericite, and sulphides. The relation of the sulphides to the gangue minerals, and the occurrence of the sulphides in lenses or thin tabular bands in the schists, suggest that the sulphides have been concentrated or introduced later, possibly by solutions from the pink granitic magma.

V. Dolmage, who examined polished sections of these ores, describes the minerals as follows:

"The cobaltite occurs in small crystals $\frac{1}{16}$ to $\frac{1}{4}$ of an inch in diameter thickly scattered throughout the gangue. The pyrite occurs partly in the same manner, but also as veinlets lying between the cobaltite grains and also in many cases cutting them, which show it to be in part later than the cobaltite. The pyrite is very impure, containing streaks that are very slightly darker than the pyrite, but, except for being slightly more easily attacked by acid, are similar to the pyrite in every other respect.

In the cobaltite and occasionally in the pyrite are small round and oval particles of a softer, dark grey mineral. The particles are so small as to be visible only under a medium high magnification. In many of them are minute blades of a mineral which is whiter than the cobaltite, and in several were seen a partly translucent mineral which transmits a greenish ray. On applying the usual etching reagents negative results were obtained with all but potassium cyanide and potassium hydroxide. With the former the mineral became quickly iridescent and remained a brown colour. With the potassium hydroxide it was quickly blackened and etched. The mineral which nearest answers this description is pyrargyrite, but as the assay shows no silver and as pyrargyite is the sulph-antimonide of silver it is not possible that this mineral is pyrargyite. The assays give traces of nickel which, together with the greenish transparent mineral seen in some of these particles, suggests that it is a nickel mineral. Its association with cobaltite would also suggest a nickel mineral, but its behaviour with etching reagents does not correspond with any of the nickel minerals listed in the tables."

Assays and partial analyses by the Mines Branch, of two average samples taken across 8 feet of the mineralized zone, gave the following results:

No. of sample	Oz. Troy per ton of 2,000 lbs.		Per cent		
	Gold	Silver	Cobalt	Nickel	Copper
340A............................	None	None	2·16	trace	0·10
340B............................	None	None	trace	trace	0·87

340A. From pit near camp and about halfway up hill.
340B. From pit one-quarter mile west of camp.

At a few places glacial erosion failed to remove all the weathered cobalt minerals, and small specks of cobalt bloom (erythrite) are abundant at some places along the garnet zone. Glacial erosion was evidently slight along the south side of the hill near the camp, for there is a big talus slope at the foot of this hill and at several places in the badly weathered sulphide zone along the face of the hill excellent specimens of erythrite, with some annabergite, are found. It was these minerals which first attracted the prospectors' attention. In prospecting the black and dark grey schists—especially garnetiferous zones near the pink granite contacts—should be examined carefully for small specks of cobalt bloom or for the fresh sulphides. The garnet zone along which the few pits have already been sunk should be prospected to the west for abundant sulphides. Prospecting is difficult because the weathered surfaces of the sulphides and the black schists are almost identical in colour, but the specks of cobalt bloom are a good indication.

CLAY DEPOSITS, DEER (PUNK) ISLAND, LAKE WINNIPEG

Large deposits of kaolin having been reported on Punk island, lake Winnipeg, Joseph Keele suggested a visit to this locality. None of the local residents knew much about the location of this reported deposit. The large island, named Punk island on the map, is locally known as Deer island, and the two small islands to the south, named Deer islands on the map, are locally known as Big Punk and Little Punk. The northwest shore of Deer island (Punk island on the map) and, in more detail, the area northeast for over 2 miles from the old sawmill, were examined. The deposits had evidently been examined before, as a number of small tunnels had been dug along the shore.

The water is shallow within several hundred feet of the shore, and a long wharf would have to be built to load the clay on barges to be towed to Selkirk, about 80 miles to the south. The waves are rapidly undercutting the soft sandstone and shale. The many red-stained sandstone boulders on the beach probably represent original hard lumps in the sandstone.

In places at the foot of the bluffs there is considerable talus. The best exposed section is about 2 miles northeast of the sawmill and is as follows, from the top downwards.

	Feet
Red sandstone and grey limestone	5
Light, greenish-yellow clay, with rusty spots and particles of white kaolin. Sample No. 281	5
Soft sandstone	$1\frac{1}{2}$
Grey shale, partly weathered. Sample No. 782	$2\frac{1}{2}$
Blue clay and white sand. Sample No. 783	6
Grey shale, partly weathered. Sample No. 783	10
White, friable sandstone in places slightly cemented	4
	34

These several beds vary greatly in thickness within short distances. About $1\frac{1}{2}$ miles southwest of the above section, where sample No. 784 was collected, there is only 6 or 8 feet of shale or sandy shale exposed, with white sandstone above and below. The beds are nearly horizontal or dip slightly to the southwest. They are coloured as Cambro-Silurian on the map of lake Winnipeg prepared by Tyrrell and Dowling and are described under the Winnipeg sandstone and shales belonging to the Trenton.[1] Fossils are scarce and poorly preserved and there is no definite evidence as to their age, but they are undoubtedly early Ordovician, possibly corresponding to the Potsdam sandstone of the St. Lawrence and Ottawa valleys.

Most of the sediments exposed along the northwest shore of Deer island are so badly weathered that they crumble in the hand and can readily be shovelled like unconsolidated clays. However, at many other places along lake Winnipeg the exposed sandstone and shale are firm and show no evidence of post-glacial weathering. The exposures on Deer island are of especial interest because they must be remnants of the preglacial regolith not destroyed by glacial erosion. The drumlins and glacial striæ on the islands in lake Winnipeg and on the mainland to the west indicate that the last ice-sheet moved south; east of lake Winnipeg the ice moved southwest and glacial erosion was very intense. Along the boundary between the large ice-sheet to the west and the southwest-moving ice-sheet to the east there would be a zone where glacial scour might not be intense and the location and the presence of preglacially weathered rocks on Deer island suggest that it lay in this zone, and thus escaped the intense glacial scour characteristic of the area to the east of lake Winnipeg.

Very little kaolin was seen in any part of the section examined. A few thin lenses of white, sticky clay, probably kaolin, were noted along the contacts between harder sandy and limy layers in the shales, or around what appeared to be concretions. None of the lenses or layers seen were large enough to be of economic importance. However, there is available a large tonnage of clay similar to the four samples which have been tested by Keele, who has furnished the following data about their physical properties and economic value.

---

[1]Dowling, D. B., "Geology of the West Shore and Islands of Lake Winnipeg," Geol. Surv. Can., vol. XI, pt. F, 1900, p. 60 F.

"Results of Physical Tests

"*Wet Moulded.* No. 781 required 21 per cent of water to make it workable in the plastic state. It is rather stiff when moist, and has a gritty texture, but would work well through a hollow die.

No. 782 was prepared by grinding to pass a 10-mesh screen. It required 24 per cent of water, and works rather stiff but has good plasticity.

No. 783 when ground required 20 per cent of water, and works up into a very stiff but plastic mass. Considerable power would be needed to push it through a hollow ware die, but it would work satisfactorily for making stiff mud brick.

No. 784 required 18 per cent of water and works easily into a plastic mass. It is very sandy but would flow readily through a hollow die.

The drying qualities of all the clays are good, and bricks made from them would probably stand fast drying in an artificially heated dryer.

The following results were obtained in burning:

No.	Per cent drying shrinkage	010		06		03		Colour
		Per cent fire shrinkage	Per cent absorpt-ion	Per cent fire shrinkage	Per cent absorpt-ion	Per cent fire shrinkage	Per cent absorpt-ion	
781	6	0	12	2	7	2·5	7	Strong red
782	6	2	12	4	7	5	6	Brownish buff
783	7	2	12	4	7	5	5	Light to dark red
784	5	0	11	0	9	0·5	8	Red to dark red

All the clays except 784 were overfired and vesicular when fired to cone 1, and all of them fused at cone 5.

Dry Press Test. Two of the samples, Nos. 782 and 783, were made up into semi-dry pressed bricklets and burned to cone 03. They showed a water absorption of 8 and 11 per cent respectively at that temperature. The red colours of the burned brick were fairly good, but white specks, due to the kaolin particles, appear on the faces. No. 782 made the best bricklet, but neither of the samples could be called good dry press brick. They were rather friable and crumbled at the edges, because there was not a good fused bond between the clay particles.

Hollow Building Block. Some small, hollow blocks were made up by the plastic process in a hand press, and burned to different temperatures, but only sample 783 from the 6 and 10-foot beds was tested. The burned specimens were very fair examples of hollow tile; even those burned at cone 010 were hard.

Summary of Tests. The above clays appear to be best suited to the manufacture of common building and face brick made by the stiff mud or wire-cut process. The bricks are hard and dense, and the burned colours are good. The best results would probably be obtained by a mixture of the clays, or shales, and the whole section, except the sandstone and thin limestone beds, could be worked together. The mixture of clays would also work well for the manufacture of building blocks and hard burned fireproofing. The clays have certain good qualities to recommend them, such as good working and drying properties, and low shrinkages; and are capable of being burned for hard structural wares at comparatively low temperatures. In this respect they are better than any of the clays known in the vicinity of Winnipeg.

They are not recommended for dry press face brick, but they will make good rough surface face brick by the plastic process.

They do not seem to be vitrifying clays, because on approaching the point at which vitrification ought to take place, the clays begin to bloat and become vesicular in structure. Hence they are not recommended for the manufacture of paving block or sewer pipe."

List of Surveyed Mineral Claims in Rice Lake Map-area, Shown on Map 1992 Accompanying This Report

Lot	Group	Township	Range	Name of claim
86	174	25	12	Adaline
41	124	23	13	Alice
39	174	24	13	Ali Baba
11	124	24	13	Annex
130	124	23	13	Arkley Fl
48	124	24	13	Augustina
33	174	24	13	Aunt Lizzie Fractional
38	174	24	13	Battery
36	174	24	13	Bayton Fractional
69	174	25	12	Bear
54	124	23	14	Bella
74	174	24	13	Bella
50	174	24	13	Bellevue Fractional
66	124	24	13	Big 4 Fractional
91	124	24	13	Big Rice Lake No. 1
91	174	24	12	Black Bear
37	124	23	14	Black Bess
28	124	23	13	Black Fox
9	174	23	14	Bluebell
64	174	25	12	Bonnet
213	124	23	14	Boulder
50	124	23	14	Brooklyn
56	124	23	14	Brooklyn Fractional
147	124	23	14	Bruce
149	124	23	14	Bruce Fractional
148	124	23	14	Bruce No. 2
31	124	23	14	Bull Moose
144	124	23	14	Canada
46	174	24	13	Captain
6	124	24	13	Cartwright
145	124	23	14	Casey No. 1
16	174	23	14	Chackawana Fractional
25	175	23	14	Chicamon

List of Surveyed Mineral Claims in Rice Lake Map-area, Shown on Map 1992 Accompanying This Report—Continued

Lot	Group	Township	Range	Name of claim
71	174	24	12	Clark
77	174	25	12	Clinton
81	174	25	12	Clinton Fractional
78	174	25	12	Clinton No. 1
83	174	25	12	Clinton No. 2
31	174	24	13	Colla Fractional
15	174	23	14	Columbia
20	124	24	13	Combine
142	124	23	14	Commonwealth
141	124	23	14	Commonwealth Fractional
26	174	23	14	Contact
54	174	24	13	Corbet
82	124	23	13	Crescent
51	124	23	14	Curtiss Fractional
135	....	24	13	Cypress
13	124	24	13	De Luxe
57	174	24	13	Devlin Fractional
56	174	24	13	Diana
59	174	24	12	Ditchling
37	174	24	13	Dorothy Fractional
93	124	23	13	Eagle
67	174	25	12	Early Fall
75	174	24	13	Early Spring
70	174	24	13	Electra
32	174	24	13	Elizabeth
198	124	23	13	Elizabeth
8	124	24	13	Emma
84	....	23	13	Fisher
84	174	25	12	Ford
5	124	24	13	Gabrielle
34	174	24	13	General Fractional
129	124	23	13	Gilbert
67	124	24	13	Gladonna Fractional
29	124	23	13	Glenroy
96	124	24	13	Gold Canyon
64	....	24	13	Gold Cup
65	....	23	13	Gold Cup No. 2 Fractional
132	124	23	13	Gold Dollar
72	124	24	14	Gold Dyke
44	124	24	13	Golden Gimli
87	124	23	13	Golden Rockett
23	124	23	13	Golden Rod
53	124	23	14	Golden Vein
7	124	24	13	Goldfield
195	124	24	13	Gold Link
18	174	23	14	Gold Pan
20	174	23	14	Gold Pan Fractional
89	124	23	13	Gold Pick
89	174	25	12	Gold Pin
14	174	23	14	Gold Plate
19	174	23	14	Gold Seal
55	124	23	14	Gold Seal Fractional
211	124	23	13	Gordie Fractional
82	174	25	12	Handsome
214	124	23	13	Hidal
29	174	24	13	Hidden Treasure
16	124	24	13	Hilma
17	124	24	13	Hilma No. 1
18	124	24	13	Hilma No. 2
33	124	23	14	Hudson
45	124	24	13	Island Fractional
57	124	23	14	J.N.D. Fractional
92	124	23	14	Johanna
36	124	23	14	Josephine

List of Surveyed Mineral Claims in Rice Lake Map-area, Shown on Map 1992 Accompanying This Report—Continued

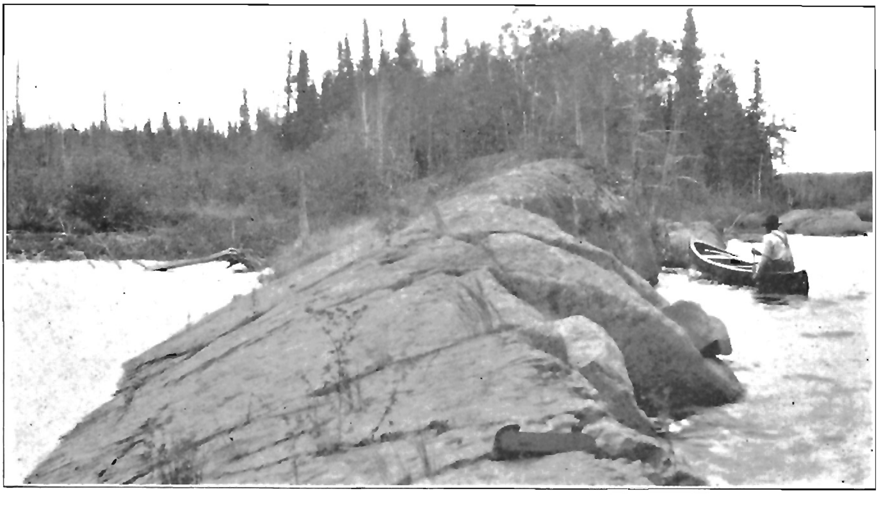
Lot	Group	Township	Range	Name of claim
24	124	23	14	Josephine Fractional
24	174	23	13	Jumbo
15	124	24	13	Jumping Cat
49	174	24	13	Katie Fractional
17	174	23	14	Kootenay
98	124	23	14	Lady Helen
97	124	23	14	Lady Jessie
99	124	23	14	Lady May
136	....	24	13	Lenora
62	174	25	12	Leo
28	174	24	13	Leopoldine Maria
128	124	23	13	Lexie
47	174	24	13	Little Jack
60	....	23	13	Little Jack Fractional
208	124	24	14	Lizzie
61	174	25	12	Lookout
210	124	24	14	Lost
35	174	24	13	Lost Fractional
52	124	23	14	Lucky Strike
41	174	24	13	Luleo
48	174	24	13	Luleo Annex
52	174	24	13	Luleo Fractional
72	174	24	13	Luleo May
44	174	24	13	Luleo No. 1
42	174	24	13	Luleo No. 2
43	174	24	13	Luleo No. 3
87	174	24	12	Madaline
215	124	23	13	Maria
197	124	23	13	Marshall
133	124	23	13	Martin
35	124	23	14	Mildred
85	174	25	12	Miller
14	124	24	13	Mite Fractional
139	124	23	14	Monarch
43	124	23	14	Moneta
199	124	23	13	Mons
10	174	23	14	Moose
100	124	23	14	Moose Fractional
12	174	23	14	Moose Horn
32	124	23	14	Morning
55	174	24	13	Nancy
27	174	23	14	Nevada
34	124	23	14	New York
21	124	23	14	Odelias
92	174	25	12	O.K.A.
27	124	23	13	Old Baldy
25	124	23	14	Olive Fractional
146	124	23	14	Ottawa
39	124	24	13	Outlook
75	....	23	13	Palm Beach
88	174	25	12	Panama
30	124	23	14	Pan Fractional
26	124	23	14	Pan Fractional No. 2
131	124	23	13	Paystreak
201	124	23	13	Pendennis
23	174	23	13	Pilot
51	174	24	13	Pine Ridge No. 2
127	124	23	13	Proctor
47	124	24	13	Rachel
63	....	23	14	Randall
22	124	23	14	Ranger
19	124	24	13	Rebecca
73	174	24	13	Revealed Treasure
38	124	23	14	Rex

List of Surveyed Mineral Claims in Rice Lake Map-area, Shown on Map 1992 Accompanying This Report—Concluded

Lot	Group	Township	Range	Name of claim
21	174	23	14	Roland
30	174	24	13	Rook Fractional
12A	124	24	13	Ross Fractional
12	124	24	13	Ross Fractional, north 200 feet of
137	....	24	13	Runa
46	124	24	13	San Antonio
88	124	23	13	Sandstone
42	124	24	14	Saxton
8	174	23	14	Saxton
9	124	24	13	Scarabe
143	124	23	14	September Morn
200	124	23	13	Sesame
58	174	24	13	Seventy Cents Fractional
45	174	24	13	Sinbad
59	....	24	13	Smyrna
62	....	23	14	Snowstorm
90	124	23	13	Snowstorm No. 2
164	124	23	13	Spruce
66	174	25	12	Stedfast
11	174	23	14	Sunbeam
22	174	23	14	Sunlight
13	174	23	14	Surprise
53	174	24	13	Sussex
207	124	24	14	Sybil
209	124	24	14	Tait
81	....	23	13	Talisman
202	124	23	13	Tar
74	124	23	14	Telena
49	124	23	14	Thistle
63	174	24	13	Thunder
95	124	24	13	Tiaris
76	....	23	13	Townsite No. 1
77	....	23	13	Townsite No. 2
78	....	23	13	Townsite No. 3
79	....	23	13	Townsite No. 4
68	174	25	12	Trail
40	174	25	11	Vanlor
65	174	25	12	Venture
76	174	24	13	Viceroy
165	124	24	13	Victoria
140	124	23	14	Washington
10	124	24	13	West Scarabe
80	174	25	12	Winsome
83	....	23	13	Wolf
85	124	23	13	Wolf Fractional
79	174	24	13	Wonderful
90	174	24	12	Wonderful Star
60	174	24	12	Woods Lake
86	124	23	13	Yankee Girl
194	124	24	13	Yuk

PLATE I

A. Acid bombs in pyroclastic rock, Ord claim. (Page 12.)

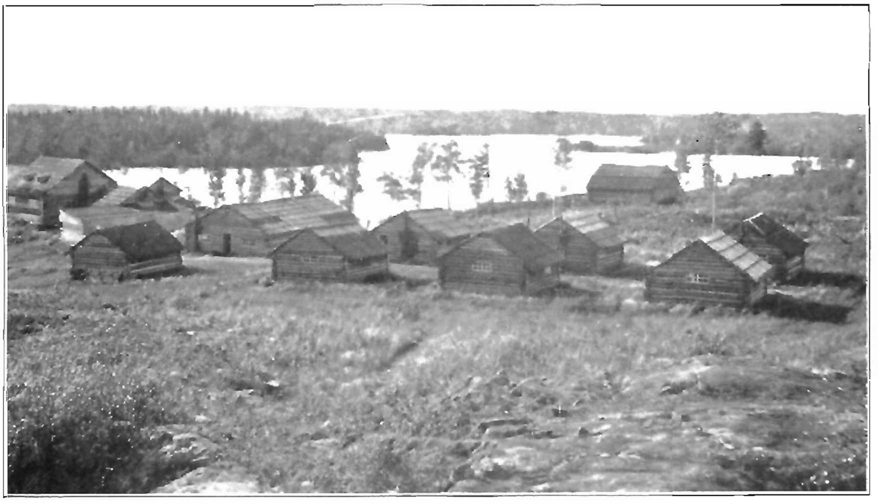


B. Missi conglomerate, Beaverdam lake, showing dip slope. (Page 14.)

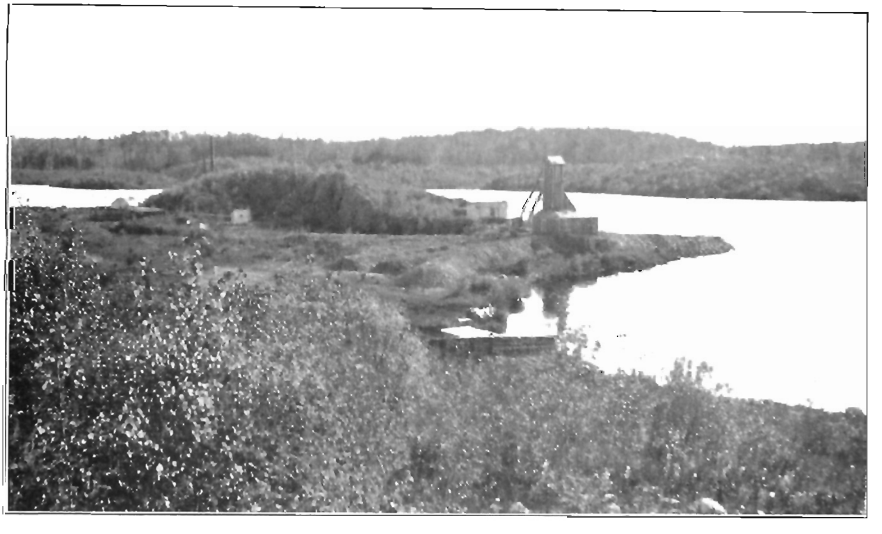
PLATE II

A. Mandy mine from across Schist lake. (Page 26.)

B. Barge with Mandy ore at Cumberland lake. (Page 27.)



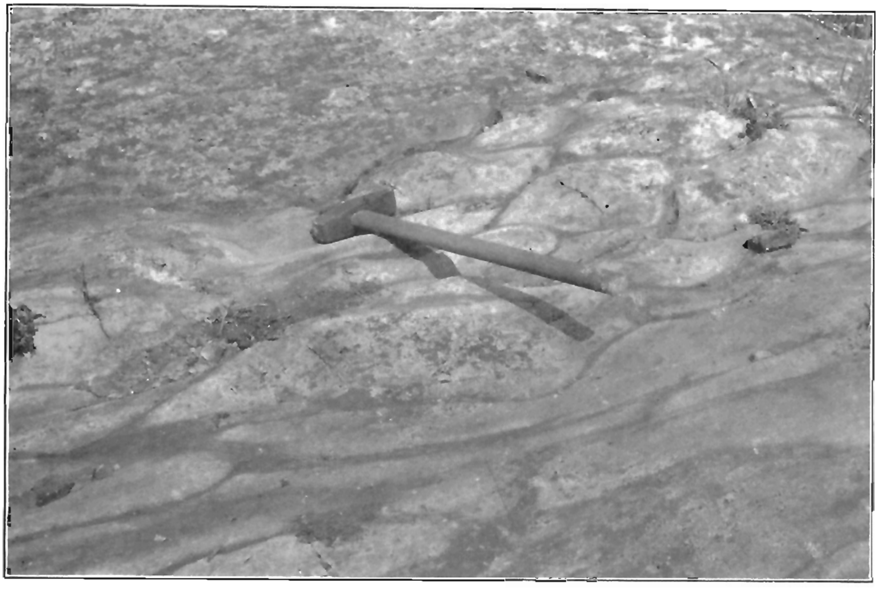
A. Flinflon camp, September, 1922. (Page 30.)



B. Flinflon, showing No. 2 shaft with horse of greenstone to the left. (Page 33.)

A. Selkirk mine from fire patrol tower about one-half mile northeast of the mill. This photograph shows the typical even skyline, the character of the woods, and the hummocky surface of areas underlain by granitic intrusives. (Page 48.)

B. Silver falls on Wanipigow river about 6 miles east of Wanipigow lake and 2 miles from Selkirk mine. Drop about 40 feet. Shows typical glaciated outcrop of andesitic lava dipping to the north. (Page 50.)



A. Pillow lava 1 mile east of the east end of Rice lake, and along the base of a thick basalt flow. (Pages 50, 51.)

B. Tuffaceous sediments about 1 mile east of the east end of Rice lake and 200 feet south of the pillow lava of Plate V A. Shows large bombs squeezed into lenses. (Page 53.)

A. A Large boulder of granite in a pillow lava flow along the face of the steep hill and about 1,000 feet north of the Manitoba Government cabin, Red Rice lake. (Page 51.)

B. Typical outcrop of biotite schist showing the penetration of granite along foliation planes, south shore of Big Clearwater lake. (Page 54.)

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