CANADA

DEPARTMENT OF MINES AND RESOURCES

MINES, FORESTS AND SCIENTIFIC SERVICES BRANCH

GEOLOGICAL SURVEY OF CANADA

PAPER 49-27

PINE CHANNEL AREA, LAKE ATHABASCA DISTRICT, SASKATCHEWAN

(REPORT AND MAP)

By

J. B. Mawdsley

OTTAWA

1949

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Illustration

PINE CHANNEL AREA

LAKE ATHABASCA DISTRICT, NORTHERN SASKATCHEWAN

INTRODUCTION

LOCATION AND MEANS OF ACCESS

The Pine Channel area (See accompanying map) comprises about 40 square miles of Precambrian terrain adjoining and north of Pine Channel, which connects Lake Athabasca with Fond du Lac. Pine Channel lies about 160 miles east of the Alberta border and 65 miles east of the mining camp of Goldfields on the north shore of Lake Athabasca. The Indian settlement of Fond du Lac is 20 miles west of the channel, and the settlement of Stony Rapids is 25 miles east of it.

The trading posts and settlements on Lake Athabasca are supplied during the summer months by 'stern wheelers' and other craft plying on Athabasca River and Lake Athabasca from the end of the railway at Waterways and McMurray, Alberta, 300 miles north of Edmonton. Normally, only about two trips are made to the east end of Lake Athabasca each season by the Hudson's Bay Company's boat; for short trips, or in instances when the heavy freight has been sent in by water, the district is reached more conveniently and economically by aircraft.

ACKNOWLEDGMENTS

The field work on which this report is based was done in the two months of July and August, 1946. Mapping was expedited by the efficient work of the student assistant, J. R. Smith.

Good topographic base maps supplied by the Topographical Survey, Ottawa, and vertical photographs, on a scale of about 1,400 feet to the inch, taken by the Royal Canadian Air Force, greatly facilitated the geological mapping.

The work was substantially aided by the co-operation of the Department of Natural Resources, Regina, who supplied some of the equipment and all the air transportation used. The Deputy Minister,

Mr. C. A. L. Hogg, and the Superintendent of Flying, Mr. Floyd Glass, of the Provincial Government air service in northern Saskatchewan, were particularly helpful.

Much of the detailed information with respect to the origin and nature of the gneisses in the area is taken from a study of this material made by C. Dahlstrom, in a Master of Science thesis entitled "Petrological Studies in the Tazin Group of Lake Athabasca". This thesis was accepted by the Graduate School of the University of Saskatchewan in May 1949.

PREVIOUS WORK

The Geological Survey of Canada did work in the Lake Athabasca area as far back as 1881, when A. S. Cochrane, one of its topographers, traversed the lake. In subsequent years, R. G. McConnell, J. B. Tyrrell, D. B. Dowling, Charles Camsell, and F. J. Alcock worked in the region. In 1935, Alcock[1] was in charge of a large party and completed reconnaissance mapping of more than 2,000 square miles of the region, as well as some detailed work. This reconnaissance included the area about Pine Channel. In his memoir, Alcock gives an interesting outline of the history, exploration, and topographic and geological work done in the region up to 1935, as well as a full bibliography.

[1] Alcock, F. J.: Geology of Lake Athabaska Region, Saskatchewan; Geol. Surv., Canada, Mem. 196, 1936.

GENERAL CHARACTER OF THE AREA

The country is well forested with the usual northern trees, Banksian or jack pine predominating on the sandy areas. However, the trees are relatively small, jack pine and white spruce with diameters at the butt of a foot or more being distinctly scarce. Only small burnt sections were observed within the Pine Channel area, but large ones are in the neighbourhood of it.

Game and fur-bearing animals are not plentiful except during the migrations of caribou in the late autumn and early spring. Their well-beaten trails thread the forest, and the narrows at Pine Channel is an important crossing for some of these herds. Many may die in the icy water before they make the south shore, and their skulls and horns are common along the beaches.

Fish is a stable diet of the natives and their dogs. The most valuable are lake trout and whitefish.

TOPOGRAPHY

NORTH OF PINE CHANNEL

North of Pine Channel the area is rocky, and this part of the shore of Lake Athabasca is deeply indented by fiords. The trend of these fiords and nearly all valleys is slightly north of east, and reflects that of the gneisses forming the bedrock. This section ic rugged, with relief at its greatest in the northeast part, where ridges and plateaux have elevations of perhaps 250 feet above Lake Athabasca. Towards the south and southwest, elevations are progressively lower to where the gneiss outcrops are awash on the north shores of the sandy islands bordering the west end of Pine Channel. The proportion of rock outcrop to drift is high, but valleys are narrow and usually drift filled. None of the small streams is navigable; generally they form a series of boulder rapids broken by a few quiet stretches and beaver ponds. Rocky-shored small lakes are dotted throughout the area, and their outlines reflect the easterly-trending structures of the bedrock. Lake Athabasca has an average elevation of 699 feet above sea-level, with a seasonal variation of as much as 10 feet. Its greatest known depth, 405 feet, is near the north shore towards its west end, half a mile west of the headland at the northwest extremity of Black Bay[1].

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[1] Professor R. S. Rawson, University of Saskatchewan, personal communication.

SOUTH OF PINE CHANNEL

Pine Channel has a minimum width of about 900 feet. Three soundings indicated a rocky bottom and a depth of 20 to 33 feet. The channel is bordered on the south by boulder and sand beaches; and back of them, within a distance of usually not more than 2,000 feet, the country rises to elevations of more than 400 feet, in places nearly 500 feet, above Lake Athabasca. This high, isolated area does not extend more than 5 miles west of Pine Channel, and slopes gradually towards the south. Its northern face, along the south shore of Lake Athabasca, is steep and even scarp-like in part. Bedrock is exposed only at rare intervals, and is flat-lying Athabaska sandstone. South of the east end of Pine Channel, from about 215 feet up to about 390 feet above Lake Athabasca, are numerous strongly developed cobble beaches. The uppermost, a beach ridge 2 to 3 feet high, forms an easterly pointing, sharply convex arc[1]. To the east, southeast, and south the country drops rapidly. To the north, across Pine Channel, is an uninterrupted view across relatively low, rocky country to high, rocky hills in the distance. Immediately to the west of the beach ridge, a small, higher tract, rough and rolling, is underlain by glacial till unworked by wave action. No lakes lie in this tract near Pine Channel, but they are numerous farther south.

[1] The results of hand levelling up to the highest beach showed its crest to vary in height from 390.7 to 392.4 feet above Lake Athabasca.

GENERAL GEOLOGY

INTRODUCTION

The bedrock of the Pine Channel area is all of Precambrian age. It is possible that the Athabaska series may be in part or entirely early Palaeozoic, but no evidence for this was found, and the series is here, as in earlier reports, regarded as probably late Proterozoic.

The gneisses and schists of the Tazin group are predominantly of sedimentary origin, are the oldest rocks in the area, and are of Archaean or early Proterozoic age.

All intrusive rocks in the area are younger than the Tazin group and older than the Athabaska series, but their relationships to one another are uncertain, and their sequence, as indicated in the following table, is questionable.

TABLE OF FORMATIONS

Cenozoic Quaternary	Recent	Lake beach deposits, sands, silts, muskeg
		Unconformity
	Pleistocene	Glacial till
		Unconformity
Proterozoic	Athabaska series	Conglomerates and sandstones
		Unconformity
Archaean or Proterozoic		Granite porphyry and rhyolite dykes
		Intrusive contact?
		Norite
		Intrusive contact?
		Pegmatite dykes

Intrusive contact	
	Granite and granite-gneiss
Intrusive contact	
Tazin group	Dark garnet-bearing gneisses, biotite gneisses, pock-marked gneisses, and garnet gneisses

TAZIN GROUP

The Tazin group is represented by a thick series of gneisses. Originally these were mainly arenaceous and argillaceous sediments, but interbedded with them are basic rocks, rich in dark minerals, which may represent metamorphosed flows or sills or, in some instances, dykes. These dark gneisses possibly form 5 to 10 per cent of the group mapped in the Pine Channel area. The Tazin gneisses are the result of granitic intrusion and related dynamo-thermal metamorphism on a regional scale. This metamorphism is believed to have reached the highest grade, and the rock types formed reflect their original composition; in part of the area, however, retrograde effects attended the subsequent slow cooling.

It is commonly difficult to distinguish between the intruded and intrusive rocks, but there is abundant evidence of the intrusion and at least partial assimilation of the invaded Tazin sediments by the granite. Lighter bands of granite-gneiss trend generally in the direction of the banding and gneissosity, but angular fragments may commonly be seen surrounded by intrusive rock. In some instances, small orientated fragments and flakes of the invaded rock appear to indicate a step in its absorption or replacement. Most of the granite, as well as the metamorphosed sediments and dark basic rocks, is strongly foliated or gneissic.

The granites occur in greatest amount in the northwestern part of the area, between Robillard and Sucker Bays. However, what now appears to be all granite may have been, in part, arenaceous and arkosic sediments.

The rocks of this closely associated and related metamorphic complex may be subdivided into the following four rock types: (1) garnet gneisses; (2) pock-marked gneisses; (3) biotite gneisses; and (4) garnet-diopside gneisses. The first three types constitute mappable belts (See map) in which each of the respective types predominates, but is not exclusive. The boundary between the belts can, therefore, be defined only arbitrarily. A fifth type is characterized by pronounced lineation or pencil structure. Its representatives, although chiefly in the younger granite, also occur in the metamorphic assemblage, with the possible exception of the biotite gneisses.

Garnet Gneisses

The garnet gneisses underlie about one-third of the area mapped, mainly to the south and east of a line extending easterly from Tyrrell Point between Norite and Dardier Bays to near the foot of the latter bay, and thence east and northeasterly from this bay.

Typically these gneisses are even-grained, medium- to fine-grained, light grey, light weathering rocks, in places somewhat darker than normal due to a high content of biotite and garnet. Gneissic structure is generally pronounced, and narrow, discontinuous, biotite-rich bands are separated by light quartz-feldspar bands. The orientation of the mica and the parallel elongation of the component grains in the quartz-feldspar bands give the gneissic and, commonly, rudely schistose structures present. Small, pink garnets, with a good rectangular parting, are most common in the dark bands.

Quartz probably averages 45 per cent by volume, but, in the eight specimens studied in thin section, varied from 15 to 65 per cent. It occurs as discontinuous stringers parallel with the gneissosity, and as grains interspersed with the other constituents. The stringers consist of three or four elongated grains placed end to end. They are traversed by hair-line cracks, either parallel with, or inclined at 20 or 30 degrees to, the normal to the schistosity, or by trains of fluid inclusions 10 or 15 degrees from the normal. One or two sets of the latter may be represented.

The feldspars vary greatly in amount and kind present. Some siliceous garnet gneisses carry as little as 2 per cent feldspar, but most have 35 to 50 per cent, and some approach 70 per cent. Of the eight specimens studied, one carries 2 per cent oligoclase only, and five others, 35 per cent. Two of these five contain some orthoclase as well, and one holds 30 per cent microcline and possibly some orthoclase. The remaining two specimens carry about 10 and 50 per cent orthoclase, respectively, and 5 per cent microcline each, but no oligoclase. The oligoclase in all these rocks carries 25 per cent of the anorthite molecule. Rod-like exsolution crystals of orthoclase were observed in some of the oligoclase, but are less common than perthitic rods or blobs in the microcline and orthoclase. The feldspars are very little altered; grains and flecks of epidote, zoisite, sericite, and calcite are in the oligoclase, and flecks of sericite in the potash feldspars.

Garnets comprise anywhere from 1 to 35 per cent or more of the garnet gneisses, but probably average about 5 per cent. In thin section, the garnets are pale pink or colourless. The larger grains contain numerous rounded inclusions of quartz, feldspar, or zircon, the first two of which are in some instances surrounded by narrow rims of pale green biotite. These inclusions have no special orientation, but were merely involved in the growth of the garnet.

The garnets are usually round, and the rectangular partings and other cracks in the garnets show no preferential orientation.

Spectrographic analyses of two garnet samples from this rock type show they contain iron, magnesium, and some titanium, but no calcium. Iron predominated in one and magnesium in the other. Aluminium is inferred to be present. Presumably in these as in most garnets[1] there are three molecules in mutual solution; the pyrope

[1] Winchell, A. N.: Elements of Mineralogy, Part II, 3d Ed., p. 174, New York, John Wiley and Sons, 1933.

($Mg_3Al_2Si_3O_{12}$) and almandite ($Fe_3Al_2Si_3O_{12}$) molecules are predominant and the titanium-bearing molecule incidental. This differs from the garnet analysis reported by F. J. Alcock[2], which showed "andradite"

[2] Alcock, F. J.: op. cit., p. 15.

garnet containing "iron and alumina with a small amount of calcium but no magnesium". As andradite ($Ca_3Fe_2Si_3O_{12}$) contains roughly equal amounts of iron and calcium, it would seem that this garnet was almandite with a small amount of andradite or grossularite ($Ca_3Al_2Si_3O_{12}$) in solution.

Brown and green biotite mica constitute from 1 to 15 per cent and, in some dark bands, as much as 40 per cent of the garnet gneiss. Brown biotite is always present, and, with a few exceptions, the green also, and the two occur in roughly equal amounts - the brown biotite as well-developed platy crystals, the green as irregular patches and segregations or as an incipient alteration product along fractures in the garnets. Commonly, concentrations of white, green, and brown micas have formed along the edges of quartz stringers.

The minor constituents, magnetite and zircon, are widely distributed; somewhat less so are zoisite or epidote, leucoxene or sphene, sericite, and calcite; less widely distributed are chlorite, apatite, and sillimanite. The zircons form very small, rounded grains. The calcite occurs as a secondary product and as narrow stringers parallel with, or perpendicular to, the gneissosity. In one of the eight slides studied, a little sillimanite was noted adjacent to garnet.

One of the slides studied displays a rather anomalous character. The chief minerals are microcline, oligoclase, hornblende, biotite, and garnet. The apatite shows good crystal form, and myrmekitic intergrowths of quartz and plagioclase occur along the boundaries of the feldspar grains. This suggests a granitic rock metamorphosed or intruded into a zone undergoing high metamorphism.

Pock-marked Gneisses

On weathered surfaces the pock-marked gneisses have a pitted appearance produced by the weathering out of altered garnets. The garnets on fresh surfaces are a lustrous black, and have a well-developed parting that simulates hornblende cleavage. In other respects, these gneisses are to ordinary observation similar to the garnet gneisses. However, the pronounced alteration suffered by the garnets deserves special mention.

The pock-marked gneisses occur along the northwest margin of the garnet gneiss zone, and the gradation from one type to the other is abrupt. With few exceptions, the pock-marked gneisses occur in a zone about half a mile wide bounded on the north by Norite Bay. A small part of this zone is composed of garnet gneiss. A little pock-marked gneiss is exposed on the south side of Robillard Point and at a few places along Algold Bay and the north shore of Sucker Bay; also, on the south side of the point at the east end of this latter bay.

The alteration of the garnet in the pock-marked gneisses is initiated by the formation of narrow stringers of pale green, slightly pleochroic biotite along fractures. Further alteration results in a widening of the biotite stringers, and at this stage either sericite or polysynthetically twinned clinochlore may appear as rod-like crystals in the biotite aggregate. In the closing stages, where the garnet occurs as relict grains within the biotite psuedomorph, sericite is common but clinochlore is not. Minute inclusions of zircon produce brown pleochroic haloes in the green biotite, and anomalous lavender haloes, under crossed nicols, in the clinochlore.

In the later stages, where the garnet has largely altered to green biotite, brown biotite commonly occurs as an alteration product in patchy areas along the edge of, or as a continuous rim around, the pseudomorphs. Grains of sphene are usually present, and leucoxene occasionally. 'Iron ore' grains form a trace to 2 per cent, and are presumably magnetite, probably titaniferous. Zircon occurs in half the slides studied, and in some of these the grains are very round. Apatite was seen in only one of the seven sections studied.

In general, the textures and structures of the pock-marked gneisses resemble closely those of the garnet gneisses. In some cases the garnets have been shattered and dragged out to produce smears of relict garnet, green and brown biotite, titanite, and interspersed quartz and feldspar. This brown biotite contains minute acicular inclusions of a dark mineral with a high refractive index (rutile?) and irregular inclusions of magnetite.

The quartz lenticles in the pock-marked gneisses wrap around or end abruptly against the garnets, a feature that seems to be more marked in these gneisses than in the garnet gneisses.

Biotite Gneisses

North of the area of pock-marked gneisses, the dominant rock types are biotite-bearing gneisses. They form the bulk of the rocks from Norite Bay to the north and northwest boundary of the map-area. However, garnet gneisses are not entirely lacking in this part of the area, and here and there a very few small garnets may be seen in the biotite gneisses. Pock-marked gneisses are also sparingly present, and dark, diopside-garnet and hornblendic gneisses also occur locally. In this general area, especially in the vicinity of Robillard Bay, are appreciable amounts of igneous gneisses, and in appearance many of them are difficult to distinguish from the biotite gneisses.

The biotite gneisses are also sparingly present in the other gneiss zones. One specimen containing a few garnets was obtained on Camille Bay, and another with many of the characteristics of the pock-marked gneisses from a mile east of Channel Point.

The biotite gneisses differ from the garnet gneisses or pock-marked gneisses only in their lack, or almost lack, of garnets; some of them contain much pronoucedly opalescent quartz. They occur in various shades of grey, and are medium-grained rocks with a pronounced foliated structure produced by alternating, discontinuous, quartz, quart-feldspar, or biotite-rich lenses, many of which may be $\frac{1}{8}$ to $\frac{1}{4}$ inch wide and 1, 2, 3, or more inches long.

In thin section the dark gneisses are seen to contain a smaller proportion of dark minerals than might be expected. Also, the biotite in the biotite-rich lenses is found to be only rudely alined, in contrast with what the hand specimen would suggest. Much of the biotite occurs in the groundmass of the gneiss, a fine mosaic of quartz and altered feldspar, which is generally liberally sprinkled with particles of biotite, sericite, chlorite, zoisite, and calcite. The particles of the groundmass have a grain size varying from about 0.02 to 0.2 mm.

Small garnet fragments, with a reaction rim of what appears to be green biotite, may occur in, or without, the biotite lenses.

The impression is given that the garnets and their alteration products have been 'smeared' out by movement.

Brown biotite forms, on the average, 15 to 20 per cent of the biotite gneisses. In the garnet or pock-marked gneiss affiliates, part of this mica is the green type and is commonly associated with altered garnet.

Quartz may form from 10 to 65 per cent of the biotite gneiss, and is commonly noticeably opalescent. The lenses of sutured and strained quartz parallel those of biotite.

Feldspar may form 15 to 70 per cent of the rock. Some of it is very fine grained, and is intimately associated with quartz; some of it is fairly clear, but much of it is altered. In some of these biotite gneisses only oligoclase (An_{25}) seems to be present, but orthoclase, with some microcline, forms the feldspar of one biotite gneiss body in the garnet gneiss zone.

Among the accessory minerals of the biotite gneisses, magnetite is always present, and may amount to as much as 1 per cent of the rock, and leucoxene, apatite, and zircon are occasionally seen. The last shows a pleochroic halo in biotite, and, where bordering feldspar, displays a reaction rim of pale, nearly isotropic material.

Garnet-Diopside Gneisses

Most of the dark, garnet-bearing gneisses are fine grained, and rarely exhibit a marked gneissoid structure. Where present, it is due to the segregation of garnet or feldspar. The garnets are generally small, and pink or orange in colour. In thin section, the gneissoid structure is rarely apparent, but a metamorphic texture is obvious; in decreasing order of idiomorphism are sphene, diopside, garnet, and feldspar. Hornblende, actinolite, and several accessory minerals are also present. The same mineral species occur in most of these gneisses, but in markedly varying proportions.

These dark gneisses occur at several places throughout the area, and the minerals of which they are composed could have formed from either ferruginous dolomitic arkoses or calcic gabbros or basalts. In view of the field evidence, it seems best to consider them as metamorphosed basic igneous rocks; some may have been lavas, others dykes or sills. Some occupy well-defined bands from a few feet to some hundreds of feet wide, usually conforming to the banding in the gneisses, but not traceable for long distances. They are probably of more than one age, but have all suffered pronounced metamorphism. They do not form more than a negligible proportion of the rocks of the area. In some places streaks of disseminated pyrite or pyrrhotite, or both, are found in them.

The garnet content of these rocks varies from 7 to 55 per cent. The garnets are irregular-shaped grains. Except for the occasional narrow reaction rim of actinolite at their contact with feldspars, the garnets show no alteration, even along the numerous fractures that traverse them. A spectrographic analysis detected iron as a principal constituent, with indications of magnesium, manganese, and titanium; no tests were made for aluminium and silicon. The variety is believed to be almandite.

Pyroxene occurs in half the specimens of dark garnet gneiss studied, and is the colourless variety of the clinoenstatite-diopside series. Although its composition varies to some extent, the pyroxene is normally 80 to 90 per cent diopside ($CaMgSi_2O_6$). Rod-like schiller inclusions, oblique to the cleavage, are common. Brown, pleochroic hornblende commonly occurs as an edging or as patches on the diopside, or it forms a groundmass within which irregular fragments of diopside and grains of quartz are scattered. This suggests a secondary origin, which is borne out by the retention of schiller inclusions in some hornblende grains.

The above hornblende was observed in several thin sections, and in some occupies nearly 50 per cent of the slide. Actinolite is about as generally distributed, but rarely exceeds 10 per cent; however, in one slide where diopside is lacking, it forms 65 per cent of the section. The actinolite is secondary after diopside or hornblende, as shown along calcite-filled fractures from which actinolite extends for 1 or 2 mm. The actinolite formed from hornblende contains numerous fine inclusions of what might be either albite or quartz. Garnet is traversed by these fractures but is unaltered along them.

Brown and green biotite, presumably secondary, were observed in some sections, and may form as much as 15 per cent of the slide.

The plagioclase feldspar is generally fresh and unaltered, and may occupy a little, or as much as 50 per cent, of a thin section. It varies in composition from calcic oligoclase to sodic labradorite. No zoning or antiperthite rods were noted.

In three actinolite-bearing thin sections, devoid of diopside and hornblende, quartz forms 3 to 15 per cent, mostly in the form of elongated grains or rods, producing a marked lineation.

The iron oxides are represented by small amounts to as much as 5 per cent of disseminated grains or minute stringers of hematite or magnetite. What was taken to be ilmenite replaces the margins of grains of sphene in a vermicular or polka dot pattern. Completely replaced and unaltered sphene may occur within the same thin section, and may amount to as much as 3 per cent of the section.

Here and there, in minor amounts, are grains and veinlets of calcite and antigorite and grains of zoisite, leucoxene, and zircon. Apatite is almost always present. The antigorite (or chlorite) veinlets may or may not contain grains of iron oxide.

On Dardier Bay, a garnet-free type of basic gneiss is composed of about 90 per cent diopside, 8 per cent plagioclase, and minor amounts of hornblende, biotite, apatite, and iron oxide. It occurs in the garnet gneiss zone, and was considered to be a greenstone band or dyke enveloped in the gneiss. On an island in Sucker Bay is a garnet-rich type of these dark gneisses, which on strike is seen to lose the garnets and appears to be hornblendic.

GRANITE AND GRANITE-GNEISS

Granite-gneiss and some massive granite form at least half of the bedrock between Robillard and Sucker Bays. In appearance and mineralogically they closely resemble one another as well as phases of the biotite and garnet gneisses that underlie most of the rest of the area. Some of the latter have clearly observable intrusive relationships, but their mineralogical peculiarities resemble those of the rocks they intrude.

Although features such as inclusions or angling apophyses were observed, crosscutting relationships are not in evidence; the igneous rocks conform to the general trend of the gneissoid or banded structures of the associated metamorphic strata. Further, as no evidence to the contrary has been found, it seems best at present to regard these granite intrusions as all of the same age.

Most of these granitic rocks are medium to coarse grained, but some carry augen of feldspar in a fine-grained groundmass. They range from rocks with typical, massive, granitoid textures through others that are faintly to strongly gneissoid; some display an augen structure and some others are pencil-gneisses. In colour, they are generally pink to reddish, but some are grey.

The dark mineral constituents form from 10 to 20 per cent of the volume of the granitic rocks and are mainly biotite, either brown or green or both. In one place, muscovite was also observed.

Feldspars form from 50 to more than 80 per cent of the rocks, with oligoclase and potash feldspar commonly in about equal amounts. The latter is usually orthoclase, but microcline may also be present or may be present to the exclusion of orthoclase. Exsolution phenomena are generally recognizable, but are confined to one type of feldspar in each case noted. In a quartzose specimen from just east of Dardier Islands in Pine Channel, only oligoclase is present; this rock intrudes garnet gneiss and contains about 1 per cent of garnet. Quartz forms from 10 to nearly 50 per cent of the rocks. Minor amounts of several accessory minerals and alteration products include apatite, chlorite, zircon, and epidote, and less commonly zoisite, sericite, garnet, magnetite, leucoxene, and calcite. Feldspars are more altered in the pencil-gneisses than in the massive granite-gneiss.

A massive, granitoid gneiss from Robillard Bay contains large oligoclase crystals containing exsolution rods of potash feldspar. Mica and orthoclase are interstitial, and the latter is slightly altered to sericite. Along crystal boundaries is an intergrowth of altered plagioclase and orthoclase, probably produced by late magmatic vapours.

The gneissoid or foliated structure observed in some specimens is due chiefly to the orientation of the biotite. The augen-gneiss studied shows a wavy foliation of the biotite, which wraps equidimensional, but not rounded, augen of plagioclase. Microcline and orthoclase are both present but not as augen.

The granite pencil-gneiss studied carries long rods of quartz, and the quartz and feldspar grains have interlocking contacts typical of recrystallized rocks. Biotite is segregated into lenticles.

PEGMATITE DYKES

Along the east shore of Robillard Bay some coarse phases of the granite and granite-gneiss approach pegmatites in nature.

Mineralogically, they resemble the granites, and they conform to, and strike with, the gneiss.

Ten pegmatite dykes were seen cutting across the gneisses. The largest is 2 feet wide; the others are 8 inches or less, the smallest being 2 inches wide.

Pale pink to dark brown feldspar is the most abundant mineral constituent. All the dykes contain potash feldspar, mainly microcline, and altered plagioclase was identified in one. Quartz is present in all dykes, and in two it had an opalescent appearance. Biotite was noted in one dyke.

All the pegmatite dykes seem to have suffered pronounced crushing, and the alteration of some of the feldspar is probably related to this deformation.

NORITE

About 2,000 feet southeast of the extreme east end of Norite Bay, just east of the creek draining the $1\frac{1}{2}$-mile-long lake north of Camille Bay, work has been done on a pyrrhotite deposit containing nickel. It occurs in a small body of norite that intrudes quartzite and pock-marked and garnet gneisses. The norite body has a width of about 30 feet and is traceable westerly for about 300 feet. It is the only body of norite found in the Pine Channel area.

Most of the norite is a coarse gabbroic rock with a bronze cast; but some is fine grained and, in this, a faint banding conforms to that in the neighbouring gneisses, which dip south at 65 degrees. Disseminated sulphides, chiefly pyrrhotite, result in rusty outcrops and a pronounced gossan across the 2- to 3-foot band, rich in pyrrhotite, centrally located in the norite mass.

In thin section the norite is a fresh aggregate of about 75 per cent, almost colourless hypersthene, near to enstatite in composition. Some of the hypersthene crystals are more than 10 mm. in diameter, but most of them are about 1 mm., with fine grains bordering the larger crystals and enveloped in a mosaic of fine-grained plagioclase. Plagioclase occupies about 23 per cent of the rock, and has the composition of andesine (An_{35}); rods of orthoclase are locally concentrated in it. About 2 per cent of brown mica neighbours the margins of the hypersthene masses, and is mostly in well-formed crystals that appear to be primary and earlier than most of the feldspar but later than the bulk of the hypersthene. A few grains of pyrrhotite were seen; these have straight boundaries with the biotite, and the sulphide is apparently one of the last minerals to crystallize.

The mineral constituents of the norite, although fresh, show pronounced strain. The millimetre grains of hypersthene forming the large aggregates, together with closely associated finer grains, are presumably the result of crushing. However, the bordering finer grains associated with larger feldspar grains are due to earlier, partly contemporaneous crystallization with the feldspar.

The freshness and mineralogical character of the norite suggest that it was intruded after the period of pronounced metamorphism when the neighbouring garnet gneisses were formed, and later than the period of retrograde metamorphism during which the garnet gneisses were changed to pock-marked gneisses. However, the crushed, gneissic structure of the rock indicates that it suffered considerable stress after its formation.

It is not known which is the older, the pegmatite dykes or the norite; on the supposition, however, that the pegmatite dykes are related to the granite and granite-gneisses, the norite is regarded as younger than the pegmatite dykes.

GRANITE PORPHYRY AND RHYOLITE DYKES

A single granite porphyry dyke was observed cutting across the gneisses, and is, presumably, much younger than the quartzose, biotite gneiss and granite-gneiss that it intrudes. It crosses Algold Bay 2,000 feet from its mouth, and was traced from a point on the north shore of Sucker Bay, an overall distance of nearly ½ mile. The dyke has a general strike of north 30 degrees west and a vertical dip. It varies in width from 5 to 25 feet, and occupies a clean-cut fracture along which the west wall has moved south with respect to the east wall. The dyke intersects quartz-feldspar stringers that trend northeast and dip southerly, conforming to the structure of the enclosing gneiss.

The porphyry is light grey and massive. Euhedral phenocrysts of feldspar and quartz 1 mm. in diameter lie in an aphanitic groundmass. The feldspar crystals are plagioclase and are zoned, the external shells being composed of oligoclase, and the central parts largely altered to sericite and epidote or zoisite. Wisps of brown biotite show haloes around zircon inclusions, and together with the phenocrysts are set in a fine-grained groundmass of quartz and feldspar, the latter believed to be sodic plagioclase. A little magnetite, apatite, and calcite occur in minute cracks.

On Camille Bay, at the east end of the largest island, are two joints, 2 feet apart, striking north 30 degrees west and dipping vertically, along which are two rhyolite dykelets ¼ and ¾ inch wide, respectively. There seems little doubt that these dykelets are of the same composition and age as the granite porphyry on Sucker and Algold Bays.

ATHABASKA SERIES

Sandstone of the Athabaska series was studied on the south shore of Lake Athabasca 2 miles southwest of the west end of Pine Channel, where cliffs rise from a short distance back of, and 15 feet above, the lake to at least 250 feet above it. A series of widely spaced outcrops is also exposed from $\frac{2}{3}$ mile to 2 miles south of the east end of the channel. The northernmost of these exposures is at an elevation of about 282 to 298 feet above Lake Athabasca, and the highest outcrops lie a little more than a mile south of the channel at an elevation of about 400 feet above the lake. Six miles east of the map-area, on the south shore of Fond du Lac, other outcrops were investigated a few tens of feet above lake level.

Nothing that is not already known about the Athabaska series was noted. It is essentially flat-lying, although crossbedded layers are common between flat-lying beds. Most of the sandstone is a white, well-cemented to slightly friable rock composed of quartz sand. Some pebbly layers were seen, and in them the pebbles are of white vein quartz. The outcrops seen are white or grey, and weather buff. In the westernmost occurrence, the bedding is in one place crossed by narrow, brown bands.

Considerable care was exercised in the search for any fossil remains or markings in these outcrops and in the numerous sandstone boulders along the south shore of Pine Channel, but none was seen. Certain of the local trapper-prospectors were asked if they had ever seen any such markings, and such occurrences would very probably attract the eyes of these observant people. However, they had neither seen any fossils nor heard of any.

The remarkable lack of accessory minerals in the rocks of the Athabaska series is borne out by the pureness of the sand forming the beaches along the north shore of Pine Channel. It is an excellent glass sand, but far from any market.

Two sets of near-vertical joints are characteristic of the Athabaska sandstone at the localities studied and, apparently, along the whole south shore of Lake Athabasca, at least. The most noticeable is an east-west, or slightly south of west, jointing. Along scarps, ice wedging had opened this jointing into cracks as much as 2 feet or more in width. The other direction is not as marked, and strikes about south 10 to 25 degrees east.

In the vicinity of Pine Channel the Athabaska series has a thickness of at least 400 feet. It rests, with profound unconformity, on a surface of ancient, probably Archaean rocks. Its singular purity of composition indicates that it is the result of sorting of a thoroughly weathered erosional product, or, perhaps, of resorting of previously deposited material. The wide extent of the series and its many features of shallow-water depositional environment indicate the featureless surface upon which it was laid down. Unfortunately, no additional information as to its age was gathered; but the series is generally regarded as late Proterozoic.

STRUCTURAL GEOLOGY

GNEISSOSITY

The gneisses of the map-area trend, in general, a few degrees on either side of north 70 degrees east. Near Robillard Bay and Tyrrell Point, they may strike as much as 20 degrees more to the north; near the east end of Algold Bay, they strike east; and ½ mile south, along the north shore of Sucker Bay, the gneisses are much contorted and strikes and dips vary markedly within short distances. Elsewhere there are local divergences from the general straight or gently sinuous trend of these banded and foliated rocks, probably in most places due to dragging along the numerous faults that cross them. In the southeastern part of the area the gneisses dip vertically to steeply northerly or southerly; elsewhere they generally dip southerly at angles of from 45 to 65 degrees.

The gneissoid structure is pronounced, due to the arrangement of the different minerals, particularly biotite and quartz, in bands and lenticles. The boundaries between the different gneisses seem everywhere to parallel the direction of foliation. Differences in composition are believed to be due, in the main, to variations in the original composition of this assemblage, which is largely composed of metamorphosed bedded sediments.

LINEATION AND PENCIL STRUCTURE

Pencil structure is common to all five of the gneiss types represented: garnet, pock-marked, biotite, garnet-diopside, and granite-gneisses. The structure, however, is only well developed locally. No example of it was seen along the north shore and north of Sucker Bay, and it can, therefore, be said that it is rare in the typical biotite gneiss zone, though biotite pencil-gneisses were encountered.

Many outcrops in the southern and eastern part of the map-area exhibit marked to faint lineation in the planes of foliation or gneissosity. The lineation generally plunges westerly at from 5 to 25 degrees from the horizontal, the steeper dips being most common in the southwestern part of the area. In a few places the structure was observed to be horizontal, and in the extreme northeastern part of the area one determination showed an eastward plunge of 5 degrees.

The linear characteristic of the pencil-gneisses is due to rods of quartz or pencil-like groups of feldspar crystals, and a thin section cut parallel with the axis of the rods looks much the same as a section from a specimen of any one of the ordinary gneisses. The rods of quartz, 1 or 2 mm. in cross-section, are composed of intricately locked sutured quartz grains or crystals commonly exhibiting a preferred orientation of the crystallographic C-axis in the direction of elongation. The straightness and length of some of these rods are remarkable. In one specimen the rods abut abruptly against a large 'eye' or auge of feldspar. As in the other gneisses, the quartz rods or lenses cut sharply across the groundmass mosaic of feldspar grains and other minerals. In one section the straight rods were seen to pass along the border of embayed garnets, the bays filled with the groundmass minerals. The garnets appear to have been there before the formation of the quartz.

Hair-line cracks normal to the elongation of the quartz rods were seen, and some of these coincide with tiny gash veinlets in the matrix material. Trains of secondary inclusions, probably mostly fluid inclusions, cross the quartz grains at angles of 15 to 20 degrees on either side of a normal to the elongation. Not all of these have a constant direction, but deflect in passing from one quartz grain to another, or within a single grain that is near a garnet. Commonly there are mica concentrations along the edges of the quartz rods.

STRUCTURES IN INTRUSIVE ROCKS

The dark, garnet-diopside gneisses and other dark types probably represent highly metamorphosed extrusive and intrusive rocks. The intrusions are probably of different ages, but those bearing garnet definitely pre-date the period of intense metamorphism. The biotite-rich gneisses probably also pre-date this period, but some of the hornblende-rich types may be younger.

The granite and granite-gneiss are apparently closely related to the period of folding and metamorphism. They conform with the gneisses, and although crosscutting relationships were observed they were only seen locally and on a minor scale at a pronounced angle to the foliation.

Of the ten small pegmatite dykes encountered, all cross the direction of gneissosity; six strike between north 15 and 30 degrees west; two a little west of north; one, north 60 degrees west; and one, north 85 degrees east. Their dips are all vertical or steep, with the exception of one of the six, which dips 55 degrees northeasterly. The dykes were evidently emplaced in tension fractures during the cooling and shrinking of the gneisses. All show crushing and strain effects due to stress applied long after the primary folding and metamorphism of the Tazin sediments.

The one norite body seen shows a faintly gneissoid crush structure. It was intruded in about the direction of foliation of the gneisses, and in this way resembles the older metamorphosed, garnet-bearing intrusions. However, it shows little alteration, and is presumed to be younger than the pegmatite dykes, though perhaps deformed at the same time.

The youngest intrusive rocks in the area, the one granite porphyry dyke, and the two rhyolite dykelets seen, occupy joints or fractures striking north 30 degrees west and dipping vertically. The west wall of the fracture containing the granite porphyry dyke has moved south with respect to the east wall. The same dyke is crossed by a vertical slip striking north 15 degrees west, along which the west side has moved south; and by another that strikes south 80 degrees east, along which the north side has moved east.

FAULTS AND SHEARS

The formations of the map-area exhibit numerous faults, shears, and joints, and their varied trends indicate a complex structural history. With few exceptions, the direction of movement noted on faults and shears was for any one system in the same direction. For the structures trending north-south or north-northwest, this direction of movement was 'left-hand'; remaining structures all have 'right-hand' displacements. Vertical components of movement in most instances were probably of less magnitude than the horizontal components.

Veins would be emplaced in fractures opened under tensional stress. The chief directions in which they occur are north-south, north-northwest, east-west, and closely conforming to the attitude of the gneisses.

North-south Structures

These are not numerous, but some are important. Faults and shears striking within a few degrees of north have steep to vertical dips and displacements along them are 'left-hand'. Two strong fault zones of this nature cross Channel Island and are associated with mineralized quartz veins of interest.

A strong fault crosses Robillard Bay, passing just west of the mouth of Algold Bay; it forms a prominent west-facing scarp. At the foot of this scarp face is a slice of drag-folded biotite schist paralleling the fault. I does not resemble the biotite gneisses the fault cuts, but it could be a metamorphosed fault gouge. If so, the fault has antiquity. The present scarp is due to recent movement with a vertical component.

A north-south fault, on the north shore of Algold Bay a mile from its mouth, displays features indicating successive movements in both 'right-hand' and 'left-hand' directions, with a resultant 'right-hand' horizontal displacement of 15 feet.

North-northwest Structures

These have strikes of from 15 to 30 degrees west of north, and generally vertical dips. As in the north-south faults and shears, the displacement along these is 'left-hand', and possibly the two groups should be considered as one. One fault, with 25 feet lateral displacement, crosses the two islands southeast of Channel Point. Each of the two islands in the eastern part of Sucker Bay is crossed by one of these faults, one of which contains a lensy quartz vein.

Most of the pegmatite dykes strike north-northwest. The granite porphyry dyke crossing from Sucker Bay to Algold Bay also falls in this group, and is emplaced in a fracture along which the same 'left-hand' movement has occurred. The rhyolite dykes on Camille Bay follow joint fractures with the same strike.

Some of the larger mineralized quartz veins fall in this group, such as the 3-foot vein 1½ miles east of Channel Point, and several small tension cracks filled with quartz.

Northwest to West-northwest Structures

These comprise the most numerous faults and shears. Displacements along them are 'right-hand'. Their strikes mostly lie between 30 and 40 degrees west of north, with dips vertical to steeply northeast; less common strikes range from 50 to 65 degrees west of north, with dips to the northeast. One fault, with a known 40-foot horizontal displacement, crosses islands southeast of Channel Point, and another with a 50-foot horizontal displacement is on the western entrance to Camille Bay. The hanging-wall of the latter apparently moved southeast and down a fault plane dipping 75 degrees northeast.

An occasional veinlet, and some carbonate, chlorite, and a little pyrite were seen along these fractures, but no evidence of significant mineralization.

East-West Structures

These are most numerous in the southwestern part of the area, where several faults and slips strike within a few degrees of east and generally dip about 75 degrees north across the dip of the gneisses. The movement on them is 'right-hand'. At the east end of Dardier Bay, a comparatively strong, mineralized quartz vein has this attitude.

Northeast Structures

These are not common. One with 'right-hand' displacement crosses the east end of the second island off the point at the east end of Sucker Bay. It may be related to a fault crossing the west end of the peninsula between Norite and Sucker Bays, and it may conceivably turn more easterly along the narrow eastern part of the latter bay.

At the northeast end of the large island in the south part of Camille Bay, what appears to be a sinuous thrust fault strikes 5 to 20 degrees east of north and dips easterly at 25 to 40 degrees. Chloritization is marked along it, and the fissure is mineralized with pyrite.

Structures Conforming with the Gneisses

Few faults or shears conform even approximately with the gneisses. A little displacement has occurred on a slip paralleling the gneisses $\frac{3}{4}$ mile northeast of Tyrrell Point. Other similar slips were observed on outcrops in Camille Bay.

A jamesonite-bearing auriferous quartz vein on Channel Island and the mineralized fissure on the point at the east end of Sucker Bay angle slightly across the banding of the enclosing gneiss.

Though there is no proof, it is possible that faults of magnitude strike along such pronounced bays as Algold and Sucker. If there is one along Algold Bay, it must have formed prior to the emplacement of the northwesterly-striking granite porphyry dyke, which, apparently, is not displaced. The evidence of gold mineralization of interest in the vicinity of Sucker Bay suggests the attractive speculation that the physiographically pronounced eastern part of this bay, with its south shore much higher than its north, is the locus of a pronounced strike fault.

Flat Joints

Flat joints and a few flat-dipping veins of no consequence were observed. On the east side of Robillard Bay, flat and vertical joints bound blocks of pink granite-gneiss 40 feet high. The joints are exceptionally far apart, and the blocks unusually large for this district.

PLEISTOCENE AND RECENT

PLEISTOCENE GLACIATION AND WEATHERING

The shoreline of Lake Athabasca north of Pine Channel is an excellent example of a fiord coast line. Long narrow bays, with steep, commonly parallel, rocky shores have lengths up to 5 miles. Algold Bay, with a width rarely varying far from 350 feet, has a length of $1\frac{3}{4}$ miles. These bays follow closely the trend of the gneisses and in many places their courses are pronouncedly arcuate.

Since the disappearance of the last ice-sheet weathering has had little or no effect, as can be seen by the many glacially smoothed and polished rock surfaces. On these surfaces even the more susceptible rocks only show weathering to depths of a small fraction of an inch.

However, weathering strongly affected all rock surfaces exposed prior to the advance of the last ice-sheet. On the north shore of Sucker Bay, $1\frac{1}{2}$ miles east of the west end, are prominent west-facing and southerly facing cliffs of southeasterly dipping banded gneiss, which are weathered to depths of as much as 3 or 4 feet. On top and back of these cliffs, this same gneiss is polished and scoured smooth by the action of the last glaciation. At places along all the bays, and on most of the islands in the section of the area north of the Athabaska series, are outcrops that show the effect of this ancient period of weathering. In many places the granite-gneisses are deeply pock-marked, where the biotite mica and other susceptible minerals have weathered out. On other surfaces it is obvious that the last glaciation has only partly scoured off the weathered material. At some places, as on the south shore of Algold Bay, highly polished, deep, rounded grooves, parallel with the banding of differentially weathered gneiss, can be seen to be due to moving, scouring ice. None of these deeply grooved or rough surfaces contains rusty material, having evidently been thoroughly scoured by the aid of wave and current action since their formation. However, inland, especially in the northeast section of the map-area, rusty outcrops were seen.

The southernmost outcrops that show this ancient weathering are along the south shore of Dardier Bay and the north side of the sandy islands bordering Pine Channel on its north, a short distance north of the south shore of Lake Athabasca. Other rock surfaces, so weathered, are probably farther south beneath the sand of the above-mentioned islands bordering Pine Channel. They would indicate that the high ground now forming the south shore of Lake Athabasca, within this map-area, was at most a short distance north of its present position during the last interglacial period, and that the last ice-sheet did little to pluck back and steepen this prominent north-facing scarp.

The southward-sloping surface of gneiss on which the Athabaska sandstone once rested north of Pine Channel was a hard, southward-tilted surface on which an easterly, or westerly, flowing stream or river would tend to move laterally southward, undercutting the friable Athabaska sandstone, and forming a steep south bank composed of this sandstone and its debris.

The scarcity of boulders of rock types composing the bedrock north of the channel is a notable characteristic of the till or the elevated beaches south of Pine Channel. Athabaska sandstone boulders, too, are essentially lacking north of the channel, and abundant evidence in the form of striated surfaces indicates that the last ice moved in a direction slightly south of west; the striae noted are nearly all within 3 degrees or so of south 67 degrees west, closely paralleling the trend of the gneisses in most of the area.

ECONOMIC GEOLOGY

HISTORY OF PROSPECTING

On the north shore of Lake Athabasca, west of Robillard Bay and 18 miles east of Fond du Lac, a prospector named Piche staked a claim in 1910; and in 1912 and 1913 he and others staked several claims farther east at the Narrows. In 1914, this activity continued eastward, and most of the older claims were re-examined. The presence of sulphides, some associated with norite and containing nickel and copper, were the main attractions. Arsenopyrite was noted, but apparently the gold occurrences in some of the quartz veins at the Narrows were not found until much later, in the autumn of 1935.

In 1915, a large, unsuccessful prospecting rush took place to the east end of Lake Athabasca, following a much publicized account of the reported presence of rich silver ore. The report was evidently false, and no such ore has yet been found.

The best-known name in connection with activity of 1914 and subsequent years is H. V. Dardier. Dardier was financed by English capital, had prospected in British Columbia, and on hearing of the copper-nickel showings on Lake Athabasca, entered the district in 1914 with a prospector named Dalton who had staked claims there. After a summer in the field, he returned to England to raise more funds. In the spring of 1915, he set out again for Lake Athabasca with a considerable crew and two Calyx shot drills. A hole was put down a half mile east of Channel Point, in gneiss on the north side of a large island. As it required nearly a year to complete this hole to a depth of 425 feet it was decided to bring in a diamond drill from Edmonton, and several holes were drilled 12 miles to the northwest of Channel Point and 12 miles east of the point. Only a few sulphide stringers were encountered; the work was abandoned.

It is surprising that the easily discoverable veins on Channel Island, immediately to the north of the site of the shot drilling, were not recognized to be gold bearing by some of the men involved at that time in this futile work. Obviously they had no knowledge of the techniques of prospecting.

In 1929, prospectors of Dominion Explorers, Limited, staked a nickel-copper deposit on Axis Lake, 8 miles northwest of the settlement of Stony Rapids and 15 miles northeast of Camille Bay. The deposit was explored and trenched, but the ground was finally dropped. The recent activity in Manitoba on the nickel-copper occurrences at Lynn Lake have again attracted attention to Axis Lake, and the old ground is once more staked.

A little desultory prospecting was done in 1946, and some of the veins discovered in 1935 and 1936 were staked, but nothing of note was uncovered.

NATURE OF MINERAL DEPOSITS

The deposits of interest now known in the Pine Channel area fall into two general types: nickel-bearing and gold-bearing.

Only one nickel-bearing deposit of interest has so far been discovered. It is in a small body of norite 2,000 feet southeast of the east end of Norite Bay. This was the only body of norite found in the area during the course of the mapping done in 1946. The nickel is associated with pyrrhotite. Bands more or less rich in disseminated pyrrhotite occur in some of the gneisses elsewhere in the area, especially in the dark gneisses, but this sulphide is evidently different in origin from that in the norite and is entirely, or almost entirely, devoid of nickel.

Quartz veins of appreciable size are confined to the northwest part of the area. Minor veinlets and some sulphide occurrences, in part associated with quartz, were seen in the Camille Bay section, but none is of workable size. With the exception of the vein at the east end of Algold Bay, which is reported to carry gold, the known gold-bearing veins are all in the vicinity of Sucker Bay. Those of principal interest are in four general localities, namely: on the north shore of Sucker Bay, 1½ miles east of the west end of this shore; on the point at the east end of Sucker Bay, from $\frac{1}{2}$ to 1 mile east of Sucker Bay; Channel Island; and $1\frac{1}{2}$ miles east of Channel Point, on the north side of Norite Bay.

The most interesting of these gold-bearing veins are probably those on Channel Island. The quartz in these veins is generally white and commonly greasy looking. Arsenopyrite and pyrite are generally present, and pyrrhotite and jamesonite ($Pb_4FeSb_6S_{14}$) in some veins. Tourmaline may also be present. Native gold is visible in some of the vein quartz. There seems to be no particular mineral indicator of the presence of gold, and veins of diverse strike contain it.

In general, the gold is in that part of the area where igneous intrusions are most numerous - this part corresponding to the area of pock-marked and biotite gneisses where retrograde metamorphism of the gneisses is marked. It is also tempting to consider the possibility that Sucker Bay and Valley to the east are the loci of important faults, which have had a bearing on mineralization of interest.

Although prospecting has been aided by the rocky nature of this country, it must be appreciated that shattered and mineralized zones are subject to easy erosion, and are, in part, now in the low and covered ground, as the pre-Glacial erosion surface of this area has definitely not all been scoured by the last ice-sheet.

A geiger-müller counter was carried during the mapping, but no indication of radioactive minerals was noted in the area.

DESCRIPTION OF DEPOSITS

Robillard Point and Algold Bay

On Robillard Point and adjacent islands, as far as the mouth of Algold Bay, several narrow quartz veins were noted, most of which carry some tourmaline. Some contain vugs. The veins cut either northwesterly or northerly, across massive gneiss, and most of them dip vertically; two dip westerly at 75 and 50 degrees, respectively, and one is flat.

Along the north shore of Algold Bay are narrow veins at relatively widely separate localities; none was noted along the south shore. At a point 3,500 feet east of the mouth of the bay, some rock trenching in massive, dark, micaceous gneiss discloses several quartz veins 2 to 8 inches wide. These veins strike easterly and dip 30 degrees north. The quartz is glassy, carries some biotite and tourmaline, and vugs are lined with quartz crystals and filled with fine- to medium-grained pyrite. At this locality, another glassy quartz vein, 6 inches wide, strikes northeast and dips 55 degrees northwest. To the east, 150 feet, are two milky white quartz veins with vertical dips striking north 10 degrees west. At 3,500 feet farther east, a 2 inch vein of glassy quartz dips flatly north.

On the north side of the east end of Algold Bay, cross-trenching and stripping have been done at irregular intervals along a vein-bearing zone for a distance of about 1,000 feet, in a general direction of north 55 degrees west. The zone angles across light and dark gneisses. The exposures disclose shattering, in places approaching shearing in intensity, across widths of rarely more than 3 feet, and generally less than half this width.

The chief vein material is white quartz. It does not occur as a continuous body, but is in lenses or in closely spaced parallel discontinuous veins. Towards the south end of the zone, the quartz has widths of up to 3 feet. In a central pit, 1½ feet of quartz is exposed. In the northernmost pit, the shatter zone is from 6 to 12 inches wide, with quartz occupying 2 to 6 inches of it. A few feet north of this pit the shattering is even less, and mineralization is represented by a little pyrite and arsenopyrite, with no quartz. Coarse arsenopyrite is found in places in the vein quartz or in the adjacent wall-rock. Some of the vein quartz is much fractured, and slips that formed later than the quartz follow or parallel the vein walls.

No visible gold was seen, but it is reported that some assays showing gold have been obtained from samples from this otherwise not particularly attractive or heavily mineralized zone.

North Shore of Sucker Bay

Along the western 3 miles of the irregular north shore of Sucker Bay are three general localities where veins have been investigated.

Three-fifths of a mile from the west end of this shore is a vein of white sugary quartz, 3 to 8 inches wide, that carries no other mineral. It strikes northwest and dips vertically.

On the east side of the point $1\frac{1}{2}$ miles east of the west end of this shore, within a belt 40 feet wide, are eight quartz veins having widths up to 1 foot. Seven of them strike between north 43 and 65 degrees west, and one north 5 degrees west; they all have vertical dips. The wall-rock is a dark, micaceous band or inclusion in the lighter coloured gneiss. The quartz is fractured and well mineralized with pyrite, arsenopyrite, and a little tourmaline and pyrrhotite. A sample assayed by the Bureau of Mines, Ottawa, gave 0.045 ounce gold and 0.18 ounce silver a ton. Two hundred feet farther east is a 6-foot zone striking north, cutting across the gneiss. The west wall is a vertical slip, and east of it are irregular lenses of quartz striking along the zone, making up to 50 per cent of its width. The quartz is white and somewhat sugary. In the quartz is pyrite in the form of coarse grains and fine veins. Some chlorite and a little pyrrhotite were also noted.

The same zone may outcrop on the small island 1,400 feet to the south. There, a pit has been sunk, and the zone, which has a width of more than 60 feet, somewhat resembles a breccia healed with short, vein-like masses and lenses of quartz striking north. The quartz is white, and contains pyrite and a little pyrrhotite and tourmaline. The adjacent gneiss is reddish.

A mile and a half farther east, on the west side of a small bay, is a sinuous, barren, white quartz vein, 2 inches wide, with an average strike of north 85 degrees west and dipping 45 degrees north. Seven hundred feet farther east are a couple of quartz veins of like width and colour, which contain vugs and some chlorite; they strike south 40 degrees east and dip 80 degrees northeast. The first vein is in an opalescent, quartz-rich gneiss, and the last two are in a dark, hornblende- and garnet-rich inclusion in the gneiss.

Point and Two Islands at East End of Sucker Bay

The east end of Sucker Bay is divided into two bays by a prominent point. About 150 feet east of the west end of this point, and on its north side, is a mineralized zone on which some work has been done. It lies in dark, pock-marked gneiss and dark granite-gneiss, in which the foliation strikes north 80 degrees east and dips southerly at 50 degrees. The quartz stringers and silicified bands have a like attitude, and form 30 per cent of a zone 6 feet wide. For another 6 feet in the hanging-wall are other occasional stringers. Thirty feet south of the zone is the contact with a dark, fine-grained, garnetiferous meta-gabbro, which conforms with the gneiss and forms the south part of the point for some distance. This latter rock is cut by a pegmatite dyke 6 inches wide. In the mineralized zone, near the water's edge, are lenses, 8 to 18 inches wide, of what appear to be altered syenite in the altered and mineralized schist. The schist contains much graphite. The only recognizable sulphide is pyrite, some of which is also found in patches in the neighbouring gneiss. The long, thin, but lensy veins of quartz are crossed by a few fractures striking east of north and dipping vertically, and a few slips parallel the quartz veins. A grab sample from a section reported to have assayed $\frac{1}{2}$ ounce gold to the ton was assayed by the Bureau of Mines, Ottawa, and yielded a trace in gold and 0.05 ounce of silver to the ton.

Nearly a mile east of the west end of the point, and 200 feet from its south shore, a vein zone has been trenched at intervals for more than 100 feet. The zone strikes north 55 degrees west and is confined to a dark, contorted, hornblendic gneiss cutting light, fine-grained, banded gneiss. In the central trench, the quartz veins and lenses occur across a width of 20 feet. Although this width is maintained in the other trenches, the amounts of quartz present are much less. The quartz is white, glassy to sugary; is much fractured; and is barren looking. A little pyrrhotite occurs in the schist, and veins silicified bands; and a few grains are in the quartz. Slips along the zone are common, and the wall-rock contains white mica.

A thousand feet west of the last zone is one of like strike, north 52 degrees west, with a northeast dip of 80 degrees. It is 1 to 3 feet wide, and contains quartz lenses en échelon up to 6 feet long and $1\frac{1}{2}$ feet wide, striking north 30 degrees west. It is mineralized with some pyrrhotite, as in the last described zone. The wall-rock is fine-grained, dark, garnet-hornblende gneiss containing a little pyrite.

A few narrow quartz veins of differing attitudes were also noted at other points along the south side of this point.

Seven hundred feet west of the point is an island 200 feet long composed of gneiss and dark, fine-grained meta-gabbro. The rocks are somewhat contorted, and minor faults and slips were observed. At the crest of a small anticlinal structure are fragments enveloped in quartz. A few quartz veins, up to 6 inches wide, with vertical dips and striking from north 7 to 27 degrees west outcrop along the southeast shore; some fine pyrite occurs along their walls.

A second island, 1,100 feet west of the last one, is 1,400 feet long. It is composed of dark, garnetiferous and hornblendic gneisses and lighter, pock-marked and micaceous gneisses with opalescent quartz; banding is generally pronounced. At most places the gneisses strike between 60 and 72 degrees east of north and dip from 40 to 60 degrees southeast. Minor faults and slips were observed.

Near the west end of the island, some trenching discloses flat-lying opalescent quartz, pyrite, and gossan. The quartz conforms to the gneissic structure. It is crossed by a zone up to 3 feet wide, composed of 50 per cent quartz containing glassy white quartz veins striking north 32 to 48 degrees west and dipping vertically. The quartz contains vugs. Pyrite forms veinlets in the quartz and films on neighbouring fracture planes.

On the south side of the island, one-third of the distance from its east end, is a vein zone up to 6 feet wide, striking north 22 degrees west and dipping vertically. In it are veins *en échelon* up to 1 foot wide, composed of glassy quartz with spots of gossan. In the vein zone the garnets of the gneiss have disappeared, and hornblende and chlorite are prominent, together with grains of a mineral that is probably ilmenite. Movement along this zone is left hand.

East of Sucker Bay

Two-thirds of a mile east-southeast of the extreme east end of Sucker Bay is the westernmost of a series of five veins and shatter zones containing veins of gold-bearing, greasy white quartz, as well as minor zones and areas of gossan. The veins and vein zones cut granitic to micaceous gneiss, which is more or less banded; they strike either northerly or northwesterly and dip vertically or steeply. The wall-rock is not noticeably altered. The veins were staked in 1935 by J. G. Hebden and P. Daigle. The group was optioned and investigated by Ceres Explorations, Limited, in the spring of 1936, but as the veins are small and values erratic the option was dropped, and no further work has been done on these showings.

The westernment is a vein zone cross-trenched for 100 feet. It strikes north 5 degrees east, and contains stringers and lenses of quartz with some tourmaline. In the south trench the zone strikes north 25 degrees west and dips 65 degrees northeast. It carries fine pyrite and coarse arsenopyrite. The pyrite is associated with quartz, but the arsenopyrite is not. In one of the other trenches, specks of what is probably jamesonite occur in the quartz, and films of pyrite along fractures.

Four hundred feet east of the above vein zone is exposed a short section of a vein 8 inches wide containing arsenopyrite. It strikes north 5 degrees west and dips vertically. On strike is an occasional lens of quartz.

A thousand feet to the northeast of the last are three pits on a quartz vein up to 14 inches wide, which strikes north 55 degrees west and dips steeply northeast. The vein contains no tourmaline, but holds considerable arsenopyrite, which also veins the adjacent gneiss.

Two hundred feet farther east, a pit discloses an 8-inch fracture zone containing 4 inches of arsenopyrite, quartz, and a little pyrite. The arsenopyrite veins the quartz. The zone strikes north 55 degrees west and dips vertically.

A little more than 200 feet east of the last occurrence, six trenches at intervals for a distance of 250 feet disclose a narrow shear or shatter zone trending northwest and dipping steeply northeast. On the foot-wall are 4 inches of solid arsenopyrite, in places with or without quartz. A sample of the arsenopyrite assayed by the Bureau of Mines, Ottawa, gave 0.36 ounce of gold and 0.16 ounce of silver to the ton.

South Shore of Sucker Bay.

On the south shore of Sucker Bay, 3 miles east of Channel Point, is a small bay across which trends a pronounced fault striking south 75 degrees east and dipping vertically. From evidence of contortion in the gneiss, it is probable that the northeast side of the fault moved southeast a distance of about 500 feet. If so, this displacement occurred prior to that of a small pegmatite dyke in the same direction, but for a distance of only 3 feet. Quartz occurs in the narrow fault zone and is sliced by it. The quartz is veined by pyrite, and pyrite and pyrrhotite occur in the schist along the fault together with a little calcite. The deposit has structural relationships of interest, but is not of economic value.

Channel Island

Channel Island lies at the west end of the south side of Sucker Bay. It is $1\frac{1}{4}$ miles long, about 800 feet broad, and its western tip is known as Channel Point. The island trends slightly north of east parallel with the banded, grey, biotite gneisses that compose it. The dip of these gneisses is generally southerly at 40 to 60 degrees.

Just south of the west end of Channel Island is a low rocky island 800 feet long. Crossing it are a few, greasy white quartz veins 3 to 8 inches wide, dipping steeply and striking north 30 to 35 degrees west. They are mineralized with fine pyrite. A little pyrrhotite and chalcopyrite were seen in one.

About 1,300 feet east of Channel Point, crossing Channel Island, is a depression, 10 feet wide and about as deep, striking north 10 degrees west. The strike of the southerly dipping, grey, biotite gneisses adjacent to this depression diverges from the normal and indicates a fault along which the west side has moved south. Near this depression there is evidence of mineralization associated with at least three diverse structures, which will be described.

Two hundred feet north of the south shore of the island is an arsenopyrite-rich vein traceable for more than 80 feet west of the depression. On it two pits have been sunk. The vein strikes north

50 degrees east, dips 45 degrees northwest, mostly, but in part flatly, and then feathers out within a few feet on the dip. It is as much as 12 inches wide, but in most places its width is not more than 6 inches. Besides arsenopyrite, it contains fine tourmaline needles and pyrite. In the easternmost pit, 2 feet above the main vein and an equal distance below it, are parallel stringers 1 inch to 2 inches wide, rich in tourmaline. A well-mineralized sample, assayed by the Bureau of Mines, Ottawa, gave 3.36 ounces gold and 17.12 ounces silver a ton.

About 100 feet south of the above vein, a short distance west of the linear depression, is a small exposure of a 6-inch vein of quartz and tourmaline containing no sulphides. It strikes northwest and has a vertical dip. On a small island 250 feet southeast of the south end of the linear depression are a couple of white quartz veins containing fine pyrite and a very little pyrrhotite and chalcopyrite.

A third type of mineral deposit is illustrated at a locality a little north of the first-described vein and a few feet east of the depression. Here, a pit discloses a 3-foot zone of sugary quartz and schist, in which quartz forms 50 per cent of the zone. The quartz appears crushed and chlorite has formed along slips. This zone contains no visible metallic mineral.

These three structures may be related, the fault depression being the main direction of shear, and the 45-degree to flatly northerly dipping vein due to tension failure. If this is so, the west side of the main fault moved both south and down with respect to the east side.

A half mile east of the linear depression referred to above is another narrow fault, shatter, and shear zone, crossing the island in a north-south direction. It intersects finely banded, grey, biotite gneiss and a meta-greenstone extending half way along this break to near the south shore of the island. Towards the north, along this zone, quartz appears to within a short distance of the shore, and forms as much as 50 per cent of the 2-foot width of the zone. In the cliff overlooking the lake, the zone is 10 feet wide, and is bounded on both sides by strong, north-trending shears. The gneiss between is sliced and traversed by cherty to greasy white quartz. The main quartz-bearing zone, about 2 feet wide, is next to the main east shear. It enters the lake striking north 10 degrees east with a steep easterly dip. Some discontinuous stringers nearly parallel the main vein near the west boundary of the zone, and this slight divergence in strike is evident in lenses farther south. The quartz in the cliff is generally well fractured and contains some chlorite masses, and both the quartz and the wall-rock contain some fine pyrite and arsenopyrite. The extreme northern section is obviously the most favourable part of the zone, particularly as it contains some visible free gold. It is unfortunate that the lake precludes an adequate study of the zone farther north.

As its north end, the above zone of shearing and mineralization cuts across the gneiss and what appears to be a younger, green amphibolite dyke, 3 feet wide, that parallels the gneiss structure and ends against the west side of the 10-foot zone. Parallel with the gneiss, just about lake level, approaching the zone from the west, is a narrow, pyrite-bearing stringer or stringer zone that probably antedates the mineralization along the main zone.

About 350 feet west of the north end of the main zone is a north-south slip dipping 62 degrees east; along it, the west side has moved south for 9 feet relative to the east side. To the west of it, five rock trenches cross a vein traceable for nearly 100 feet. The vein strikes north 73 degrees east and dips 45 degrees southeast; it angles slightly across the gneisses, which strike north 78 degrees east and dip 45 degrees southeast. Near the slip the vein breaks up into narrow stringers with a northeast strike. The vein has a width of 2 to 8 inches, and is composed of greasy white quartz in lenses, broken and bounded by slips. Vugs present are lined with quartz crystals, and the quartz carries fine needles of tourmaline. Irregularly distributed in the vein are jamesonite, arsenopyrite, and fine-grained pyrite.

A selected sample, assayed by the Bureau of Mines, Ottawa, yielded 0.395 ounce gold and 0.54 ounce silver to the ton.

Islands South of Channel Island

South of Channel Island is a large island with a small bay on its north shore near its west end. On the east shore of this bay is a gossan zone 2 feet wide striking northeasterly parallel with the shore and with the enclosing gneiss and dipping southeasterly at 50 degrees. Two zones 8 feet apart outcrop 200 feet farther east. The zones contain 10 to 30 per cent fine-grained pyrrhotite in irregular ramifying veinlets carrying a little fine-grained pyrite. An assay of this material by the Bureau of Mines, Ottawa, gave 0.015 per cent copper, 0.03 per cent nickel, and 0.005 ounce gold and 0.045 ounce silver to the ton. Apparently it was this deposit that was investigated in 1914 by means of the shot drill brought in by H. V. Dardier.

A few hundred feet west of the above island is a small island on which are two gossan zones similar to the one referred to above and exposed for 150 feet from its east shore. The northern band is 5 feet wide, and 20 feet to the south is the second about half as wide. Crossing the centre of this small island is a boulder-filled depression 30 feet wide; this is evidently the site of a fault trending north 20 degrees west, along which the west side has moved south 60 feet relative to the east side.

North Shore of Norite Bay

A mile east of Channel Point, in the centre of the north shore of an island 1,000 feet long, is a white milky quartz vein striking north 15 degrees west and dipping easterly at 85 degrees.

Although $1\frac{1}{2}$ feet wide, it contains no visible mineral of interest.

About 1,000 feet east of the last island, and on the north side of Norite Bay, is an 80-foot cliff of light-coloured, fine-grained, micaceous gneiss intersected by a vertical vein zone striking north 20 degrees west. The zone is 3 feet wide and contains a branching and interlacing system of white quartz veins, each of which is 1 to 3 inches wide. Associated with the quartz are arsenopyrite, a little tourmaline in the form of fine needles, a little chlorite, and later calcite veinlets. Apparently this mineralized zone disappears near the top of the cliff, 80 feet from the bay. Half-ounce gold assays are reported to have been obtained from this zone, but a well-mineralized grab sample assayed by the Bureau of Mines, Ottawa, gave gold, 0.02 ounce, and silver, 0.07 ounce, a ton.

Eastward from the above point, for a distance of about 4,000 feet, dark meta-gabbro, containing a few garnets, is exposed at intervals along the north shore of Norite Bay. In some of these outcrops are rusty gossan bands up to a few feet wide and parallel with the gneiss, which carry pyrrhotite and pyrite. Some 7,000 feet farther east, just beyond the prominent southeasterly trending fault that crosses the peninsula between Norite and Sucker Bays, is another and similar gossan zone 12 to 15 feet wide.

About 2,000 feet west of the above-mentioned fault, some blasting has been done on a mineralized zone in fine-grained micaceous gneiss. Striking with the gneiss, north 65 degrees east, and dipping 45 degrees southeast is a 6-foot zone composed of 50 per cent opalescent quartz in veins and lenses $\frac{1}{16}$ inch to 3 inches thick, and containing a little pyrrhotite. Cutting this zone is a 2-inch, white quartz vein striking north 40 degrees west, dipping 80 degrees northeast, and containing some arsenopyrite and biotite. Fine quartz stringers striking north 15 degrees west and dipping westerly at 80 degrees are also prominent.

Tyrrell Point and the Peninsula East of It

The two small islands just off Tyrrell Point are composed mainly of garnet and 'pock-marked' gneiss. A small, dark inclusion was observed on the more westerly of these islands. In this inclusion are quartz-filled tension cracks striking north 50 degrees west and dipping 60 degrees northeast. Cutting the gneiss on both islands are a few quartz veins striking northwest and dipping vertically, some of them composed of lenses en échelon, up to 6 inches wide. The quartz is glassy white, and contains tourmaline and some chlorite, or these two minerals occur along the margin of the quartz. Pyrite is in the quartz or intimately associated with the tourmaline.

East of Tyrrell Point, at 4,000 and 7,500 feet respectively, along the north shore of the peninsula, are single narrow quartz veins; and at 3,200 feet east of the point, along the south shore, are six narrow quartz veins within a distance of 12 feet striking northwesterly and dipping vertically or steeply east. These veins resemble those on the islands, but no tourmaline was noticed and pyrite was seen to vein the quartz in some of them.

The small island in Norite Bay, 2,000 feet northeast of Tyrrell Point, is composed of banded, light-coloured, fine-grained, micaceous gneiss containing opalescent quartz; the gneiss strikes north 60 degrees east and dips 57 degrees southeast. Along this direction of strike is a rusty, silicified zone, 8 inches wide, containing 5 to 10 per cent pyrite.

Dardier Bay

At the east end of Dardier Bay, 4,000 feet north of Pine Channel, on the north side of a narrow bay more than 2,000 feet long, a quartz vein up to 10 inches wide is exposed for more than 150 feet. Its strike, north 80 degrees east, is nearly that of the massive, banded, pock-marked gneiss in which it occurs, and it dips northerly across the gneisses at 50 to 80 degrees. The vein contains nests of pyrite and arsenopyrite, and is veined by fine-grained pyrite.

Two other quartz veins of like attitude were noted in the southern part of this section. Both are quite narrow; the widest, 3 inches, occurs on the small island in the channel entering the east end of Dardier Bay from Pine Channel. It contains aggregates of fine pyrite and some graphite.

Nickel-bearing Deposit Southeast of Norite Bay

A nickel-bearing deposit occurs 2,000 feet southeast of the east end of Norite Bay, about 1,000 feet northwest of the west end of the lake, 1½ miles long, north of Camille Bay, and just to the east of the stream that drains this lake. The mineralized zone has been cross-trenched for a length of 300 feet in a direction a little north of east. The centre trench crosses a width of about 30 feet of coarse- and fine-grained norite. The norite is seen to narrow eastward, and is replaced by garnet and pock-marked gneiss in both directions, and also is flanked by this rock type. The coarse norite has a grain size of 10 mm. or more, and is composed of about 75 per cent light-coloured hypersthene, 23 per cent andesine, with local concentrations of exsolution rods of orthoclase, 2 per cent brown mica, and a few grains of pyrrhotite. Some of the norite is fine grained and faintly gneissic, presumably due to crushing.

The disseminated pyrrhotite has weathered and has produced a pronounced gossan along a central zone. In the central trench, a band 2 to 3 feet wide contains about 25 per cent pyrrhotite. A polished section of a specimen of this sulphide shows a few, disseminated, semi-euhedral grains of pyrite. In part, the pyrrhotite appears to be interstitial and to have crystallized late; but some of it also seems to vein the neighbouring minerals. In contact with the sulphide, these minerals have smoothly rounded mutual boundaries as if partly resorbed.

A selected grab sample, rich in pyrrhotite, assayed by the Bureau of Mines, Ottawa, gave: nickel, 1.09 per cent; copper, 0.14 per cent; and gold, a trace.