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ONTARIO DEPARTMENT OF MINES

Geological Report No. 42

Geology of Pashkokogan Lake - Eastern Lake St. Joseph Area

By

A. M. GOODWIN

1965

ONTARIO
DEPARTMENT OF MINES

HON. G. C. WARDROPE, *Minister* D. P. DOUGLASS, *Deputy Minister*
M. E. HURST, *Director, Geological Branch*

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ABSTRACT

The map-area, between Lat. 50°55′ and 51°12′30″N. and Long. 90°10′ and 90°42′30″W. in the Districts of Thunder Bay and Kenora, is 23 miles long and 16 miles wide, and comprises about 350 square miles. The centre lies 60 miles north of Savant Lake station on the Canadian National railway.

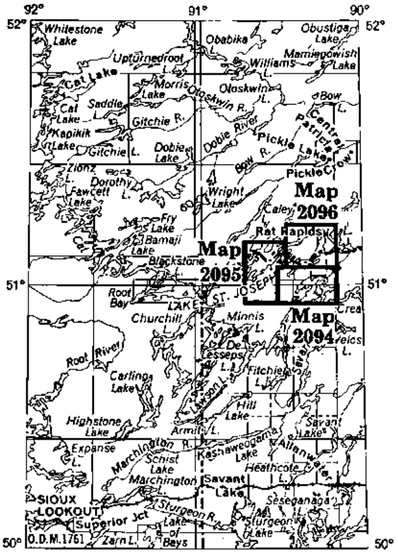

Figure 1 — Key map showing location of map-area. Scale, 1 inch to 50 miles.

The bedrock, of Precambrian age, contains an older assemblage of: metasediments and metavolcanics and associated basic intrusions; younger acid intrusions; and diabase. The unconsolidated till, sand, gravel, and clay are mainly of Pleistocene age.

The older assemblage comprises interzoned metasediments and metavolcanics. Metasediments, mainly quartz-mica schist, arkose, greywacke, and banded iron formation, form the lower part of the sequence. They are conformably overlain by a substantial thickness of assorted acid to basic volcanic tuffs, flows, and breccias. Occasional dikes, sills, and larger irregular masses of metadiorite and metagabbro are present.

Granitic intrusions, ranging from narrow dikes up to large stocks 6 miles in diameter, are present. In addition, granite gneiss and migmatite, part of a large regional mass, underlie the south margin of the area. A single dike of fresh diabase was observed.

Metavolcanics and metasediments have been folded about east-trending east-plunging axes. A principal anticline, isoclinally overturned to the north, follows the south shore of Lake St. Joseph. Other parallel folds are indicated to be present. Although local transverse faults are common, no evidence of significant faulting was observed.

The map-area contains two large deposits of low-grade concentrating-type magnetite iron formation. The Sanjo Iron Mines Limited property at Lake St. Joseph is reported to contain 618,000,000 tons of open-pit magnetite iron formation averaging 23.1 percent soluble iron, and yielding a concentrate averaging 67.6 percent soluble iron at a concentration ratio of 3.5 to 1. The Belcher-Doran property at Doran Lake is reported to contain 376,000,000 tons of magnetite iron formation averaging 19.2 percent magnetic iron, and yielding a concentrate averaging 68.1 percent soluble iron at a ratio of concentration of 4.52 to 1.

A chip sample across a spodumene-bearing pegmatite zone, approximately 50 by 100 feet long at East Pashkokogan Lake, assayed 1.25 percent Li_2O. Other zones may be present nearby. Of the numerous small local, conformable disseminated sulphide zones present in the volcanic rocks, sixteen were sampled and assayed and showed traces of copper, nickel, and gold. Minor disseminated pyrite, present in highly sheared rock near the south shore of Doran Lake, is considered to warrant further investigation.

Geology of
Pashkokogan Lake–Eastern Lake St. Joseph Area

Districts of Thunder Bay and Kenora

By

A. M. Goodwin[1]

Introduction

Following the discovery and exploration of large low-grade iron deposits in the Lake St. Joseph area by mining companies in the late 1950s, the Ontario Department of Mines began a systematic geological survey of the large belt of Precambrian volcanic, sedimentary, and igneous rocks that underlies the general Lake St. Joseph region. The initial phase of this survey, commenced in 1962 with the mapping of the Pashkokogan–East Lake St. Joseph area, is dealt with in this report.

Location

The map-area is between Lat. 50°55′ and 51°12′30″N. and Long. 90°10′ and 90°42′30″W. in the Districts of Thunder Bay and Kenora. It is 23 miles long and 16 miles wide, or 350 square miles in area, with its centre 60 miles north of Savant Lake station on the Canadian National railway. The area includes all of Pashkokogan Lake, the east half of Lake St. Joseph, and Doran Lake.

Access

Provincial Highway 599, from Savant Lake to Pickle Crow, passes through the eastern part of the map-area. The highway approaches the northwest corner of Pashkokogan Lake and passes around the east end of Lake St. Joseph, which provides ready access by water to most parts of the area. In addition, numerous smaller lakes and streams facilitate access to more remote parts. Soules Bay, on the south shore of Lake St. Joseph in the centre of the map-area, provides direct access to iron deposits in the immediate vicinity and indirect access by way of Thelma Lake to iron deposits at Doran Lake.

Mapping Method and Rock Exposure

Field mapping was conducted by pace-and-compass traverses at intervals of ¼ mile. Results were plotted at a scale of 1 inch to ¼ mile on basemaps (Cronaflex) provided by the Cartographic Unit of the Ontario Department of Mines. Because the drift-cover was known to be extensive, air photographs were examined in detail for potential outcrop areas before the start of the field season. Field experience quickly demonstrated the efficiency of this method of eliminating heavily drift-covered zones, which then received only minimum attention.

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[1] Geologist, Ontario Department of Mines, Toronto.

Outcrops are very scarce in the vicinity of numerous thick morainal zones and eskers that trend in a generally southwest direction across the area. Between these belts, however, and along the shores of lakes and streams, rock exposures are fairly plentiful.

Until the middle of August 1962, the level of Lake St. Joseph was 6 to 10 feet below normal. This condition afforded unusually fine shoreline exposure. Later in the field season, heavy rains had partly restored normal lake level, which substantially reduced the number of rock exposures. For this reason, many shoreline and island outcrops shown on the accompanying geological maps (Nos. 2094, 2095, 2096) may now be inundated.

Previous Work

The east half of Lake St. Joseph was mapped by E. L. Bruce in 1922 (Bruce 1922). The entire map-area was included in a larger area subsequently mapped by W. S. Dyer on reconnaissance scale in 1933 (Dyer 1933). The map-area forms part of the regional airborne magnetometer survey and mapping program conducted jointly by the Ontario Department of Mines and the Geological Survey of Canada, 1959–1960.

In addition, Sanjo Iron Mines Limited and Little Long Lac Gold Mines Limited have carried out extensive exploration work, including geological mapping and diamond-drilling, on their iron properties located, respectively, at Soules Bay of Lake St. Joseph and at Doran Lake.

Acknowledgments

The field party is indebted to members of the Ontario Department of Lands and Forests stationed at Pickle Lake, particularly Mr. Gordon Fenelon and Mr. David Croal, for their assistance during the field season. Sanjo Iron Mines Limited and Little Long Lac Gold Mines Limited kindly provided detailed information on their respective iron properties.

Field assistants were R. O. Rye, R. H. Ridler, R. J. Griffis, and L. E. Stephens. Mr. Rye, as senior assistant, conducted independent mapping. Mr. Ridler prepared the pre-season air photo outcrop survey.

The author gratefully acknowledges the value of and has drawn freely upon a comprehensive company report written by A. T. Avison, geologist with Steep Rock Iron Mines Limited.

Topography and Drainage

The topography of the map-area is typical of that of much of northwestern Ontario. A generally flat surface, with local relief of several hundred feet, has a southwesterly grain due to the passage of the ice-sheet, and supports a large number of lakes, swamps, and marshes. The larger lakes include Pashkokogan Lake in the southeastern part, Lake St. Joseph in the centre-northwestern part, and Doran Lake in the southwestern part.

Pashkokogan Lake drains to the northeast by way of the Albany River to Hudson Bay. The natural drainage of Lake St. Joseph is northeastward by the same route. However, the lake has been diverted from its natural drainage course by a dam erected at the northeast outlet of the lake. As a result, the lake is drained to the southwest, via Root River and Lac Seul, to the English River. The other smaller lakes of the area flow by way of short streams into one or other of

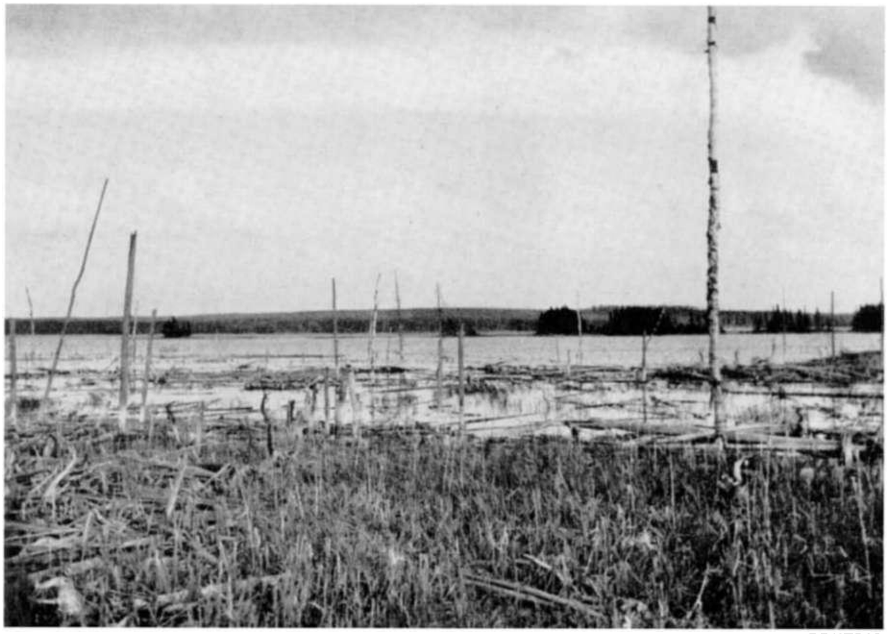

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Photo 1 — Lake St. Joseph showing flat topography and drowned land.

the larger lakes. For example, Medcalf Lake in the southwest drains northeast into Pashkokogan Lake; and Doran Lake in the southwest drains northward to Lake St. Joseph.

Inhabitants

The Osnaburgh Indian Reserve, situated in the northeast part of the area, is inhabited by several hundred members of the Ojibway tribe. The community centre is at Doghole Bay on the east shore of the northeast arm of Lake St. Joseph. A small commercial fishery is located at Pashkokogan Lake. Tourist camps are operated at Pashkokogan Lake and Medcalf Lake. The Hudson's Bay Company operates a post at Osnaburgh House. This post was located on the west shore of the northeast arm of Lake St. Joseph for many years, but has recently been transferred across the lake to Highway 599, about three-quarters of a mile east of Doghole Bay.

General Geology

The bedrock of the area is of Precambrian age. It comprises: an older assemblage of metasediments and metavolcanics and associated basic intrusions; younger acid intrusions; and diabase. The unconsolidated till, sand, gravel, and clay are chiefly of Pleistocene age.

The older assemblage comprises interzoned metasediments and metavolcanics. Metasediments form the lower part of the sequence. They are conformably overlain by a substantial thickness of assorted acid to basic volcanic rocks with which several thinner zones of metasediments are associated.

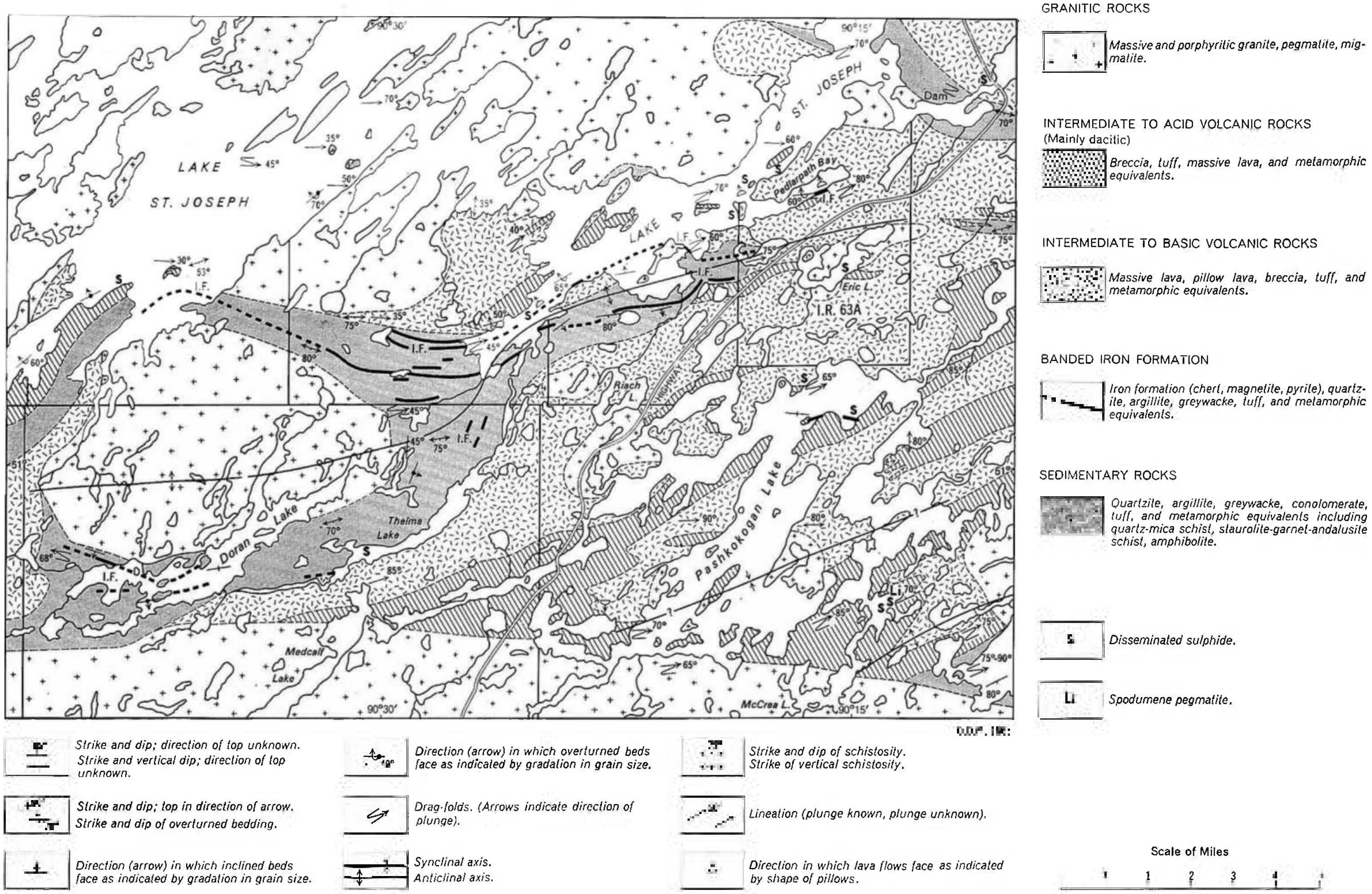

Figure 2 — Geological sketch map of Pashkokogan Lake and eastern Lake St. Joseph area.

Metasediments consist mainly of quartz-mica schist, arkose, greywacke, staurolite-garnet-andalusite schist, pebble conglomerate, and banded iron formation. All iron formation of economic interest is contained in the main sedimentary zone that lies in the lower part of the rock sequence.

Metavolcanics consist predominantly of acid to basic tuffs, flows, and breccias, and metamorphic equivalents. Occasional dikes, sills, and larger irregular masses of metadiorite and metagabbro are present.

Granitic stocks up to 6 miles in diameter are present in the older rocks. In addition, the south border of the area is underlain by younger granite gneiss and migmatite.

A single dike of fresh diabase was found to intrude into metavolcanics.

TABLE OF FORMATIONS

CENOZOIC	
Recent	Peat, river deposits.
Pleistocene	Boulder till, gravel, sand, clay.
	Unconformity
PRECAMBRIAN	
Late Basic Intrusions	Diabase (dikes).
	Intrusive Contact
Acid Intrusions[1]	Granite, granodiorite, porphyry, pegmatite, aplite. Granite gneiss, migmatite, granodiorite, pegmatite.
	Intrusive Contact
Early Basic Intrusions	Metagabbro, amphibolite, lamprophyre.
	Intrusive Contact
Metavolcanics[2]	Basic to acid lavas, tuffs, breccias and metamorphic equivalents; iron formation; greywacke, shale and metamorphic equivalents.
Metasediments	Impure quartzite, arkose, argillite, greywacke, pebble conglomerate and metamorphic equivalents including quartz-mica schist, garnet-staurolite-quartz-feldspar schist, quartz-feldspar-andalusite schist; banded quartz-magnetite iron formation; basic volcanic tuff and metamorphic equivalents including amphibole schist and feldspar-amphibole schist.

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[1] Age relationships between the two groups of acid intrusions are not known.

[2] The metavolcanics generally overlie but also include some metasediments.

Metasediments

Metasediments of the area comprise pebble conglomerates, impure quartzite, arkose, greywacke, argillite and their derived schists, together with banded iron formation. In addition banded tuff, massive amphibolite and amphibole schist, all of probable volcanic derivation, are present.

The most common rock type in the assemblage is quartz-biotite-feldspar schist. Arkose and greywacke are widespread. Conglomerate is present near Soules Bay and Doran Lake. Argillaceous schists characterized by abundant aluminium-rich metacrysts, particularly staurolite, andalusite, and garnet are present at Soules Bay and vicinity. Banded iron formations, composed of interbanded siliceous magnetite, quartz, and schist, form an integral part of the metasediments at Soules Bay and Doran Lake.

Figure 3 — Location map of Sanjo Iron Mines Ltd. property, Lake St. Joseph.

DISTRIBUTION AND THICKNESS

The main band of metasediments lies in the west-central part of the area. It extends continuously from Ace Lake on the east along the south shore of Lake St. Joseph for 8 miles to the head of Soules Bay, where it divides into two arms that together embrace the Doran Lake stock (Figure 2). Within this total distance of 12 miles the band of metasediments is up to 12,000 feet wide. The true thickness of sediments represented, though highly variable, averages 5,000 feet; the maximum thickness is about 8,000 feet.

Thinner bands of metasediments are present in the northwest, northeast, and southeast corners of the area (*see* Figure 2). The northwest band is restricted in exposure to a group of small islands in the main part of Lake St. Joseph. The northeast band, about 5,000 to 7,000 feet wide and at least 5 miles long, extends southeast from the former site of the Hudson's Bay Company Post on the west shore of the northeast arm of Lake St. Joseph to the east boundary of the map-area. The southeast metasedimentary band, of similar dimensions, is restricted to the vicinity of Greenbush Lake in the extreme southeast corner of the area.

In addition, highly folded metasediments are present at the east boundary of the area at a point 2 miles east of Eric Lake, and a thin discontinuous metasedimentary band is exposed intermittently along the south shore of the north part of Pashkokogan Lake.

Banded iron formations form a significant part of the main metasedimentary band in the west-central part of the area. Iron deposits of economic significance are present at Soules Bay and Doran Lake.

Two main iron-bearing sedimentary zones are present at Soules Bay and vicinity; they are referred to as the North Zone and the South Zone, respectively (*see* Figure 3). The North Zone is about 19,000 feet long; it extends from the head of Soules Bay on the east to the southeast shore of a small lake on the west. Within this interval, the North Zone ranges in width from 100 to 1,000 feet. The South Zone is offset 6,000 feet to the southwest with respect to the North Zone. The South Zone extends for at least 18,000 feet along-strike from the head of Soules Bay on the east to the west edge of the Sanjo Iron Mines Limited property on the west; it also ranges in width from 100 to 1,000 feet.

Two smaller iron-bearing zones are present in the same vicinity, as follows: to the northeast, a zone at least 7,000 feet long and between 100 and 400 feet wide extends along the length of Soules Bay; and a small zone lying between the North Zone and the South Zone (Figure 3) is approximately 3,500 feet long and 150 to 700 feet wide.

At Doran Lake to the southwest, two main iron-bearing zones again are present (*see* Figure 6). The North Zone, the smaller of the two and situated at the northwest corner of Doran Lake, is 2,600 feet long and up to 500 feet wide. The South Zone is at least 16,000 feet long and ranges from 100 to 1,000 feet wide.

DESCRIPTION

In brief, the metasedimentary assemblage comprises a well-bedded arenaceous sequence of varied facies construction that includes local argillaceous, ferruginous, and conglomeratic phases. The 5 main lithologic types are as follows: impure quartzite and arkose; pebble conglomerate; staurolite-garnet-quartz schist and staurolite-andalusite-quartz schist; metagreywacke; banded iron formation. A significant amount of banded-to-massive amphibolite of apparent volcanic derivation is associated with the metasediments.

In summary, the main sedimentary band in the west-central part of the map-area includes all the rock types listed above. Quartz-mica schist is by far the most common; conglomerate and arkose are present in the interval between Doran Lake and Soules Bay; staurolite-andalusite-garnet-quartz schist is present at Soules Bay and vicinity; and banded iron formation is a significant component at and near Soules Bay, and again at Doran Lake.

Considering the other metasedimentary bands in turn: the northeast band, exposed at the original site of Osnaburgh House on the west shore of the northeast arm of Lake St. Joseph, comprises mainly quartz-mica schist with local andalusite-garnet-quartz schist; the northwest sedimentary band is composed of quartz-mica schist, phyllite, pebble conglomerate and amphibolite; the southeast, or Greenbush band, which is formed mainly of quartz-mica-garnet schist and quartz-feldspar schist, is associated with significant amounts of migmatite and pegmatite.

Pebble Conglomerate

Pebble conglomerate is exposed intermittently for 7 miles between the south shore of Doran Lake and the vicinity of Soules Bay. The main exposures are found near a group of small lakes located 2 miles southwest of Soules Bay. The conglomerate is not restricted to the stratigraphic base of the sedimentary sequence but occurs as lenses throughout it.

The pebble-bearing layers range from 2 to 10 feet thick, and are separated by equivalent thicknesses of quartzite and arkosic grit. Some pebble layers are uniform in thickness for considerable distances along-strike, others are lenticular (Photo 2). The contacts of the pebble layers and the quartzite interbands are typically abrupt. The oval to tabular fragments are commonly 1 to 4 inches long, but are up to 14 inches long and 6 inches wide. Most fragments are angular to subrounded. Evidence of fragment sorting is negligible, although occasional layers display crude size gradation. Matrix material to the fragments is generally grey, fine- to medium-grained, quartz-mica-feldspar quartzite and arkosic schist.

The pebbles and cobbles are composed of grey quartzite, grey to black cherty iron formation, white vein quartz, grey granite, greenstone, and occasional grey schist in that general order of abundance. The great majority of fragments are

Table 1 *Lithologic analysis, pebble conglomerate, Doran Lake*

	NUMBER OF FRAGMENTS IN SIZE RANGES					
LITHOLOGY	0–1 INCH	1–2 INCHES	2–3 INCHES	3–4 INCHES	TOTAL FRAGMENTS	PERCENT OF WHOLE
Iron formation	32	21	2	3	58	43
Quartzite	40	30	3	1	74	54
Vein quartz	....	3	....	....	3	2
Granite	....	1	....	....	1	1
Totals	72	55	5	4	136	

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Photo 2 — Pebble conglomerate, Doran Lake, showing nature of pebble beds and intervening quartzite bands.

composed of the first three. Table 1, based on a pebble count of a square foot area of typical conglomerate at the southeast shore of Doran Lake, illustrates the size range and lithologic proportions. Fragment composition varies considerably from layer to layer. In this manner, cherty iron formation predominates in some layers but is absent in adjacent layers; similarly, granite is locally abundant though generally a rare component.

The proportion of fragments to matrix in individual conglomerate layers ranges from 25 to 80 percent. The proportion of fragments to matrix generally varies widely in adjacent conglomerate layers.

Quartzite interbands separating the conglomerate layers range from 2 to 6 feet thick. They are composed of grey, quartz-biotite and quartz-feldspar-mica schist. Some beds are graded. Pebbles and small cobbles are locally present.

The conglomerate was apparently formed by rapid accumulation of detritus derived from arenaceous and cherty iron formation-bearing source areas. Local variations in pebble composition from layer to layer suggests intermittent contributions from several local sources. The presence of angular fragments and absence of sorting suggest rapid transportation by flood streams in a hilly terrain.

A prominent feature of the conglomerate layers is the alignment of tabular and oval fragments in the plane of schistosity regardless of bedding attitude. In folded strata where the schistosity is locally at a high angle to the direction of bedding the contrast between the original sedimentary element (bedding) and the superimposed structural element (schistosity) is strikingly accentuated (*see* Photo 2).

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Photo 3 — Banded metasediments; Soules Bay, Lake St. Joseph. Light-coloured layers are biotite quartzite; darker layers are studded with staurolite and occasional white andalusite metacrysts.

Quartzite, Arkose, Argillite, Arenaceous and Argillaceous Schist

Impure quartzites range from grey to black in colour on the fresh surface and weather medium brown. The common variety is banded in light and dark shades reflecting relative proportions of quartz and biotite. Individual bands are generally 2 to 6 inches thick and locally 24 inches thick. Local pebble zones up to 50 feet long and 6 feet thick, containing small fragments of quartzite, quartz, and iron formation, are present. They represent infilling of scour channels, and indicate substantial current action during sedimentary accumulation. Many of the quartzitic beds are graded; large-scale cross-laminations were noted locally.

Purer phases of the quartzite contain up to 80 percent fine-grained suture-bonded, almost turbid, quartz together with fresh fine-grained crystalline biotite, accessory plagioclase (albite-oligoclase), and epidote. Arkosic phases contain approximately equal parts of suture-bonded quartz and feldspar (albite-oligoclase)

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Photo 4 — Broad-banded metasediments at Soules Bay, Lake St. Joseph. Clustering of andalusite metacrysts are shown in upper argillaceous portion of sedimentary bands.

together with 10 to 20 percent each of fresh crystalline biotite and white mica plus accessory epidote. Coarser-grained arkose, in addition, contains larger considerably altered grains of oligoclase and K-feldspar. In the quartzite-bearing conglomerate, fragment quartz is finer-grained than the matrix quartz.

Meta-argillite is a common component of the sedimentary assemblage at Soules Bay and vicinity. Although locally present in relatively pure layers, argillaceous material is typically intermixed with more or less arenaceous material. Considering the sedimentary assemblage at large, the argillaceous material is present near the stratigraphic top of the sequence, where it is closely associated with banded iron formation.

Argillaceous bands range from 2 to 30 inches thick; they are commonly 12 to 24 inches thick (Photo 3). Interbanded arenaceous layers normally range from 2 to 6 inches thick. Common metamorphic assemblages present, characterized by prominent aluminous metacrysts, include garnet-staurolite-quartz, staurolite-andalusite-quartz, andalusite-quartz, and staurolite-biotite-quartz. Such assemblages generally are found interbanded with prevailing quartz-biotite schist and banded iron formation. The exact mineral assemblage present in a particular layer reflects the proportions of arenaceous, argillaceous, and ferruginous components in the original sediment. Metacrysts typically stand out on the weathered surface, thereby accentuating the sedimentary layering (Photo 4).

At the head of Soules Bay the sedimentary beds commonly comprise a graded arenaceous lower part and an argillaceous upper part, the latter containing andalusite and staurolite metacrysts of spectacular size and distribution (Photo 5). Metacryst development has locally resulted in reversed grain gradation.

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Photo 5—Broad-banded metasediments; Soules Bay, Lake St. Joseph. Note gradation in a single bed from basal coarse-grained quartzite at left (hand lens) through finer-grained quartzite to andalusite-studded meta-argillite forming top of bed (pocket knife). Coarse-grained quartzite at base of overlying bed is visible to the right.

Generally the sedimentary assemblage at Soules Bay and vicinity points to accumulation of intercalated sands and muds in a deltaic or estuarine environment. The water was sufficiently deep and quiet to permit development of graded bedding including differential settling of early arenaceous and later argillaceous fractions. Intermittent turbulence attributable to offshore wave and current action was sufficient to scour out substantial channels and transport pebbly material to the site. The source area had undergone sufficient weathering and chemical leaching to have provided large quantities of arenaceous and argillaceous fractions that were transported in suspension by slow sluggish streams to the broad estuarine site of deposition.

At Doran Lake to the southwest, relatively thin-bedded fine-grained impure quartzite and greywacke are associated with a substantial amount of banded iron formation. Arkose and pebble conglomerate are also present. Typical grey to green fine-grained schist is composed of quartz-biotite-feldspar, amphibole-quartz-feldspar, and amphibole-garnet-quartz assemblages. At the southwest shore of Doran Lake, considerable chlorite-sericite schist is present. Sedimentary bands are normally less than 1 inch thick and rarely exceed 2 inches thick. Much of the banding is vague and indistinct; this reflects gradational contacts between adjacent layers. Many beds display faintly visible grain gradation. Small-scale scour structures are also present. The rocks contain a higher proportion of mafic components than do those at Soules Bay; this has resulted in prevailing grey to green colours. Generally, the sedimentary assemblage at Doran Lake indicates that clastic accumulation proceeded in quiet deep water. The thin fine-grained nature of the beds suggests that reduced loads of fine-grained clastic detritus only were transported to the site of deposition. The relatively high mafic content may reflect a source area of basic volcanic composition, or, alternatively, direct addition to the accumulating sediments of fine-grained volcanic ash of basic composition.

Dark grey fine-grained banded greywacke is intermittently exposed along the south shore of the main peninsula of Pashkokogan Lake. Thin gritty layers, generally less than 1 inch but also up to 12 inches thick, are composed of hornblende-biotite-quartz-feldspar-epidote assemblages. Small red garnets are locally present. Minor disseminated pyrite is common. The greywacke, which is closely associated with acid volcanic rocks, may represent local sedimentary accumulations of fine-grained tuff.

At Greenbush Lake to the southeast, highly contorted dark grey well-banded quartz-biotite schist, locally rich in garnet, is associated with about 40 percent pegmatite and granite. White quartz-feldspar-muscovite-tourmaline pegmatite sills and dikes, up to 6 feet thick, are distributed randomly throughout the metasediments. Thick massive quartz-biotite schist is locally interbanded with a "pebbly" phase containing numerous lenticular fragments, each ½ to 1 inch thick and 1 to 2 inches long, composed of mosaic quartz with minor interstitial biotite. This rock probably represents recrystallized pebble conglomerate.

At the original Hudson's Bay Company post on the west shore of the northeast arm of Lake St. Joseph, biotite quartzite, phyllite, and minor meta-argillite are closely interbanded with volcanic tuff-breccia and lava flows of basic to intermediate composition. The contacts between adjoining bands of metasediments and metavolcanics are abrupt; they lack evidence of contemporary erosion or of faulting. The relations thereby indicate that arenaceous clastic and volcanic materials, each derived from separate sources, were added alternately to a common subaqueous site.

On several small islands in the main part of Lake St. Joseph at the northwest corner of the map-area, pale brown finely banded highly folded and crenulated phyllite, containing thin rusty-weathering pyritic layers at 4 to 10 foot intervals across the strike, is associated with pale grey fine- to medium-grained impure arkose and gritty quartzite. Thick-banded (20 to 40 feet thick) conspicuously graded impure quartzite contains basal pebble zones. Also, at the south point of one small island, two spheroidal subrounded boulders, each 12 to 24 inches long and composed of dark green schistose amphibolite of probable volcanic origin, are enclosed in banded quartz-biotite schist. The metasediments in this vicinity are associated with an equal amount of banded to massive amphibolite. The two rock types are closely intercalated, the individual bands ranging from 2 to 20 feet thick. The amphibolite bands locally contain highly deformed pillow-like structures that indicate direct volcanic derivation. Thus, the evidence points to the mutual contributions of volcanic and sedimentary materials.

Banded Iron Formation

Banded iron formations of economic interest are present at Soules Bay and vicinity and also at Doran Lake. At both localities the iron formations represent integral parts of the main sedimentary assemblage of the map-area. In addition, thin, lean, irregular zones of iron formation, associated with volcanic flows and pyroclastic rocks, are present at Pedlarpath Bay at the southeast end of Lake St. Joseph, and along the shoreline and islands of the north part of Pashkokogan Lake.

The main iron formations are composed of interbanded quartz, siliceous magnetite, and clastic sedimentary rocks. All proportions of iron-silica layers to barren schist layers are present, ranging from predominant schist with occasional iron-silica layers to substantial thicknesses of closely interbanded quartz and magnetite with rare schist layers. In this manner, the main iron-bearing zones of the area, which represent those parts of the sedimentary assemblage that contain considerable banded iron formation, grade imperceptibly along and across the sedimentary strike to nonferruginous clastic sedimentary rocks.

The on-strike gradational character of the banded iron formation between leaner and richer phases is illustrated by 3 detailed measured sections (*see* Table 2 and Figure 5) taken across the formation at intervals along a strike-length of 8 miles at the south shore of Lake St. Joseph. The east section is 3 miles east of Soules Bay; the centre section is on the southeast shore of Soules Bay; the west section is through the North Zone and South Zone iron deposits, which lie immediately west of Soules Bay. It is seen that the iron-bearing bands comprise 33 percent of the east section, 57 percent of the centre section, and up to 87 percent of individual parts of the west section. It is noted that the approximate economic cut-off point is 50 percent iron-bearing bands; that is to say, to be economic, the iron-bearing zone must contain at least equal parts of iron bands to waste bands.

Table 2 *Measurements across iron formation*

	SOUTH SHORE OF LAKE ST. JOSEPH (3 miles east of Soules Bay.)	SOUTHEAST SHORE OF SOULES BAY
Total thickness of measured section	30.8 feet	55.3 feet
Number of individual iron-bearing bands	66 bands	102 bands
Number of intervening schist bands	64 bands	97 bands
Total combined thickness of iron-bearing bands	10.2 feet	31.8 feet
Total combined thickness of schist bands	20.6 feet	23.5 feet
Range in thickness of iron-bearing bands	⅛ to 7 inches	½ to 14 inches
Range in thickness of schist bands	½ to 30 inches	¼ to 12 inches
Average thickness of individual iron-bearing bands	1.9 inches	3.8 inches
Average thickness of individual schist bands	3.8 inches	3.6 inches
Proportion composed of iron-bearing bands	33 percent	57 percent
Proportion composed of schist bands	67 percent	43 percent

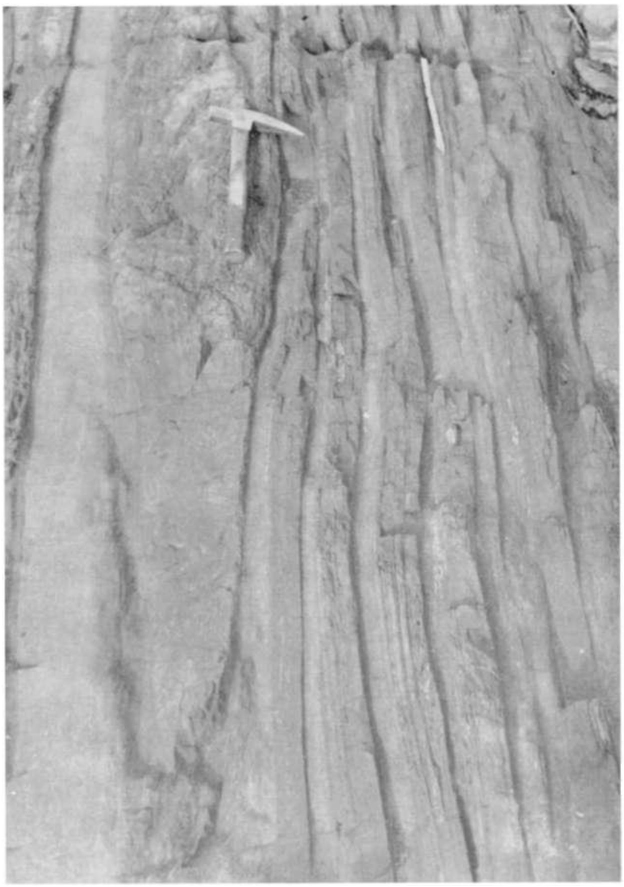

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Photo 6 — Banded iron formation; southeast shore of Soules Bay, Lake St. Joseph. Internally banded quartz-magnetite layers (ribs) and intervening schist layers (depressions) are shown. Thick quartz-magnetite band, on which hammer rests, is complexly folded, but adjacent bands are not deformed.

Similar gradational changes across the sedimentary strike are present. For example, in both the North and South iron deposits that are situated immediately west of Soules Bay, the proportion of iron-bearing bands is highest at, or close to, the north or structural footwall contact, which is abrupt; in contrast, the proportion of iron-bearing bands at the south or structural hanging-wall contact is low, and the transition to barren schist relatively gradual. These gradations along and across strike are attributed to original sedimentary facies changes.

At Soules Bay and vicinity, iron formation is closely associated with arenaceous, argillaceous, and tuffaceous schist. The typical iron formation is composed of alternating iron-rich and silica-rich layers and schist layers (Photo 6). Individual iron-silica layers range from ¼ to 14 inches thick; they extend discontinuously along strike, pinching, swelling, and bifurcating in an irregular manner. Intervening schist layers, up to 12 inches thick, have a correspondingly irregular

ODM7066

Photo 7 — Banded iron formation; south shore of Lake St. Joseph, 3 miles east of Soules Bay. Interbanding of quartz-magnetite layers and intervening quartzite layers are shown, with ribbon of white quartz at upper contact (toward hammerhead) of each quartz-magnetite layer. Note complex folding.

pattern. Descriptive data on typical iron-bearing bands and intervening schist bands are presented in Table 2.

In richer phases of iron formation, such as those that constitute the main iron zones near Soules Bay, the percentage of iron-silica layers relative to schist layers range from 62 to 87. The richest phase, locally called "zebra iron formation", is composed of closely interbanded white quartz and black siliceous magnetite layers, each ¼ to 3 inches thick.

At Soules Bay and vicinity, the iron formation is composed of fine-grained quartz, magnetite, and variable amounts of secondary silicate minerals, mainly biotite, garnet, and staurolite, but including muscovite and andalusite. Dark grey to black siliceous magnetite layers are composed of fine- to medium-grained quartz grains in typical suture-bonded pattern. This quartz has the characteristic features of recrystallized chert. The margins of the iron-silica bearing layers and the schist layers are normally lined with secondary silicate minerals, particularly amphibole and garnet.

Iron formation exposed on the south shore of Lake St. Joseph and 3 miles east of Soules Bay (*see* Photo 7) contains internally banded iron-silica layers associated with graded clastic layers. Because of potential stratigraphic significance outside the immediate area, this rock type is described in detail in the following paragraph.

The iron-silica layers range from 1 to 6 inches thick, but associated schist layers are 6 to 14 inches thick. In detail, the iron-silica layer is divided into an upper white quartz lamina and a lower dark grey to black siliceous magnetite lamina. Commonly, the white quartz lamina is itself finely laminated in shades of white to grey, and up to 20 laminae per inch are present. The relative widths of the upper

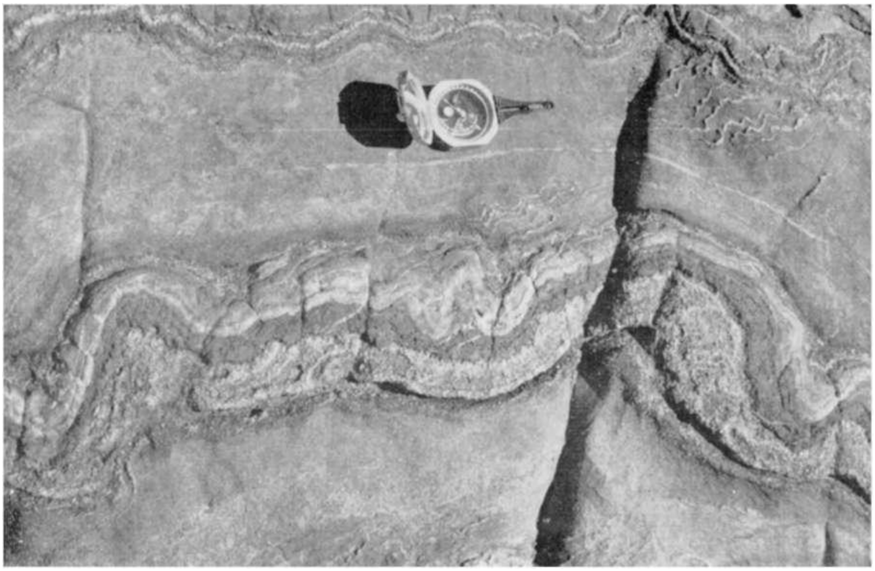

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Photo 8 — Detail of banded iron formation in Photo 7, south shore of Lake St. Joseph, 3 miles east of Soules Bay. Nature of interbanding of quartz-magnetite layer and intervening quartzite layer is shown. Quartz-magnetite layer comprises upper quartz lamina (light) and lower magnetite-bearing lamina (black). Garnet metacrysts are prominently developed at contact between magnetite-bearing lamina and underlying quartzite layer.

quartz lamina and the underlying magnetite-bearing lamina, which together form the iron-silica layer, are highly variable. Normally, the magnetite-bearing lamina is equal to or thicker than the quartz lamina that ranges in width from a thin ribbon ⅛ to ¼ inch thick (Photo 7) to 2 inches thick (*see* Photo 8). This iron-silica layer of twin-lamina construction overlies a graded clastic layer up to 14 inches thick, which displays grain gradation. Thus, where fully developed, the complete sedimentary band comprises in descending order: white quartz lamina; black magnetite-bearing lamina; and brown clastic layer. Graded beds were sufficiently widespread to establish the regularity of the colour sequence; namely, brown, black, and white in ascending stratigraphic order. This threefold association provides an indication of stratigraphic tops whether or not graded bedding is present. It is to be stressed, however, that the method has local application only even within the present map-area. Its usefulness has yet to be demonstrated elsewhere.

In interpretation of the above, the sedimentary sequence of events resulting in development of the threefold layering appears to have proceeded in the following 4 stages: (1) coarse clastic deposition grading to, (2) finer clastic deposition, followed by (3) iron-silica precipitation, and, finally, (4) pure silica precipitation. The relations suggest that all three components of a particular band (the iron, the silica, and the clastics) were transported in suspension and(or) solution and were contributed simultaneously to the subaqueous site; here differential settling of clastic material was followed stage by stage by precipitation of iron-silica components and, finally, by silica alone. This sequence of events, repeated many times, would lead to rhythmic accumulations of the type present in the map-area.

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Photo 9 — Core A: Cut-and-fill structure in banded iron formation. Core B: Graded bedding in quartzite. Both structures appear useful as top indicators. (Diam. of core is 1 ¼ in.).

ODM7069

Photo 10 — Banded iron formation; Doran Lake; showing narrow quartz-magnetite ribs and intervening schist bands. Note thin irregular, discontinuous nature of banding. Individual quartz-magnetite ribs bifurcate and terminate abruptly.

It is reasonable to assume that only under particularly favourable sedimentary conditions would this threefold sedimentary sequence be developed to a significant extent. Interference in the form of erratic surges of suspended and dissolved material, sudden change in water depth, undue agitation, and disturbance of the proper chemical environment would inhibit development of the threefold layering. In its place would be developed irregular non-rhythmic mutually gradational associations of clastic, iron, and silica layers as, indeed, is common in the Lake St. Joseph iron formations. However, this does not lessen the potential stratigraphic significance of the threefold sedimentary sequence where developed.

Locally at Soules Bay and Doran Lake, the iron-silica layers have been scoured and infilled with fine-grained sandy material. This relation indicates that iron-silica layers were sufficiently consolidated prior to deposition of overlying material to permit scouring by sand-laden currents (*see* Photo 9A).

At Doran Lake iron-silica layers are generally thinner and more discontinuous than are those at Soules Bay. Individual layers thicken and thin abruptly, bifurcate commonly, and terminate abruptly (Photo 10). Internal lamination, though present, is not developed to the same extent. Individual iron-silica layers, generally less than 4 inches thick are commonly separated by 3 to 6 inches of biotite-quartz schist. The intervening schist bands are considerably finer-grained than is the case near Soules Bay to the northeast. However, graded bedding and scouring (*see* Photo 10), although on a reduced scale, are not uncommon. These sedimentary features suggest that Doran Lake iron formation was deposited in an equally deep and quiet water environment, to which relatively light clastic loads were transported compared to Soules Bay.

Thin bands of iron formation are present in 3 other localities: at Pedlarpath Bay on the southeast shore of Lake St. Joseph; on the southeast shore of Lake St. Joseph at the west boundary of the map-area; and along the north shore of the main peninsula separating Pashkokogan Lake from East Pashkokogan Lake. In all three localities, thin banded iron formation, generally less than 2 feet thick, is composed of coarsely granular banded chert, magnetite, and pyrite and pyrrhotite interlayered with, and gradational to, mafic lava flows and acid to basic tuff.

The banded iron formations of the map-area are clearly sedimentary deposits. The iron and silica components, in all likelihood, represent chemical precipitates. The quartz layers were probably originally chert layers. The nature of the primitive iron precipitate is unknown. Possibly, it was originally in the form of siderite as is present in non-metamorphosed phases of banded iron formation at Pickle Crow, 40 miles north.

The source of the chemical components present in the iron formation is uncertain. The mutual association of iron-rich and aluminium-rich sedimentary beds at Soules Bay suggests a common source of these constituents, possibly by extensive weathering or chemical alteration of a nearby land mass. Alternatively the source of the iron and silica may be directly related to a phase of the volcanism.

Metavolcanics

Metavolcanics predominate in the eastern and northwestern parts of the map-area. They range from basalt to rhyodacite in composition. The 3 common varieties present are: basalt flows, tuffs, and breccias; dacite to rhyodacite tuffs and breccias; and mixed breccias composed of acid fragments in a basic matrix.

The three main volcanic types listed above are closely associated and alternate rapidly along and across strike. However, considering the area at large, basic volcanic rocks predominate in the lower stratigraphic part of the assemblage particularly north of Pashkokogan Lake and along the south shore of Lake St. Joseph, and acid pyroclastic rocks predominate in the upper stratigraphic part as at the southern part of Pashkokogan Lake. The relationships indicate that the early volcanic history was dominated by rapid effusion of basalt flows and fragmental rocks with intermittent extrusion of dacitic pyroclastic rocks. Acid extrusion gradually increased to the predominant position during the later volcanic history.

DISTRIBUTION

A wedge-shaped belt of metavolcanics underlies the southeast half of the map-area. The thin edge of the wedge projects from south of Thelma Lake as far west as Doran Lake; the thick edge incorporates almost the entire east boundary of the map-area. In addition, a thinner belt of metavolcanics extends along the south shore of Lake St. Joseph (*see* Figure 2).

Within the main wedge-shaped metavolcanic belt referred to above, basic volcanic rocks predominate to the northwest, specifically near the northern part of Pashkokogan Lake, and acid pyroclastic rocks predominate to the southeast. The thinner volcanic band referred to above, which extends along the south shore of Lake St. Joseph, contains a rapid alternation of basic, acid, and mixed breccia components.

DESCRIPTION

Basic Metavolcanics

Volcanic rocks of basic composition are present in the form of closely intercalated lava flows, breccias, and tuffs. They occur both as thick massive accumulations of uniform composition and as units closely intercalated with prevailing acid volcanic rocks.

Individual lava flows are generally 10 to 30 feet thick, and rarely exceed 50 feet thick. Some flows contain both pillow and massive phases; others are pillowed throughout; however, many do not contain pillows. Where present, pillow structures are generally small, seldom exceeding 3 feet by 1 foot wide. Most pillows are uniformly lenticular in plan view (*see* Photo 11); some display rounded tops and downward projections of stratigraphic value particularly at Pedlarpath Bay, Soules Bay, and along the southeast shore of Lake St. Joseph near the west boundary of the map-area. Occasional pillows are rimmed with quartz-filled amygdules up to ½-inch diameter. At Pedlarpath Bay and Soules Bay, in particular, pillowed lava flows, each 2 to 22 feet thick, are interlayered with predominant mixed volcanic breccia that is composed of acid volcanic fragments in basic volcanic matrix.

Many massive to pillowed basic lava flows are interzoned with flow breccias typically composed of numerous angular basic lava fragments, 2 to 6 inches long, in a subordinate matrix of similar basic composition. In some flows, pillow zones and breccia zones are mutually transitional. On the east shore of Pashkokogan Lake, flow breccia composed of medium grey lenticular volcanic fragments, up to 12 inches long, in a noticeably darker grey subordinate matrix is attributed to engulfment of surface-flow fragments in still-mobile lava of more basic composition.

Thick zones of massive amphibolite are present in the mafic volcanic sequences, particularly north and west of Pashkokogan Lake and again on the small islands in Lake St. Joseph at the northwest corner of the map-area. Within such zones, round to lenticular clusters of dark green amphibole crystals, up to 1 inch in diameter and together forming more than 50 percent of the rock, commonly present a decidedly irregular knotted appearance. Regarding the origin, close examination usually reveals vague pillow outlines either within or marginal to the massive amphibolite; this suggests that much of the massive amphibolite represents metamorphosed basic lava flows and associated basic intrusions.

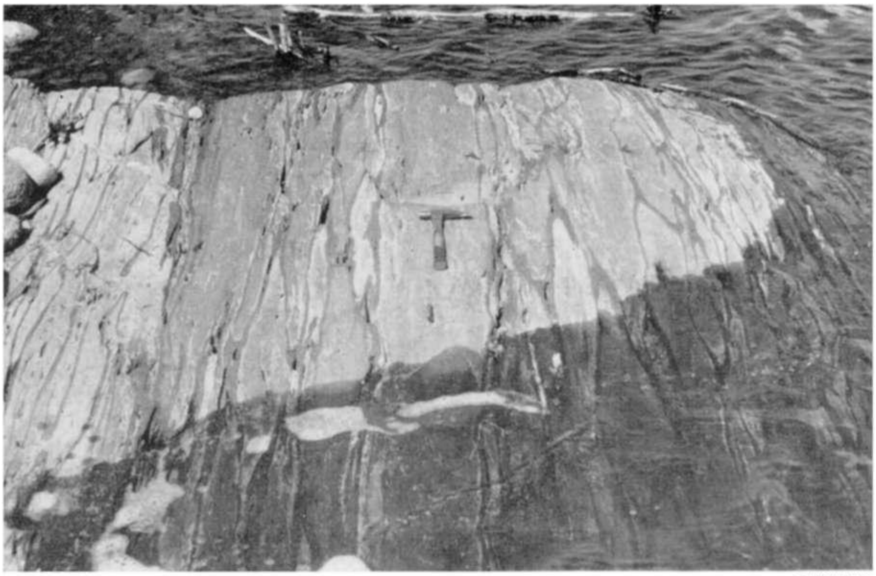

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Photo 11 — Pillow basalt. North shore of island, 1 mile west of Pedlarpath Bay, Lake St. Joseph.

ODM7071

Photo 12 — Volcanic breccia composed of andesite fragments and matrix; former site of Osnaburgh House, west shore of northeast arm of Lake St. Joseph.

ODM7072

Photo 13 — Intraformational conglomerate exposed on southeast shore of Soules Bay, Lake St. Joseph. Pebbles are mainly amphibolite; matrix is quartz-biotite schist.

Epidote is commonly present in the massive amphibolite. It occurs as small irregular disseminations, as veinlets, and as irregular lenticular aggregates several inches long. On the east shore of the narrow exit at the north end of East Pashkokogan Lake, coarse amygdaloidal-like segregations of epidote in basic volcanic rock range from 1 to 2 inches in diameter. Small clusters of disseminated magnetite commonly accompany the epidote.

At the original site of the Hudson's Bay post on the west shore of the northeast arm of Lake St. Joseph, andesitic volcanic breccia contains abundant unsorted angular to subrounded amygdaloidal fragments that are up to 8 inches in diameter (*see* Photo 12). The high proportion of amygdaloidal fragments suggests the presence of nearby source vents or fissures.

Numerous gabbroic-dioritic dikes and sills, commonly 2 to 24 inches thick, are present in the volcanic sequence. For the most part, they are of similar mineralogical composition as their volcanic host, having undergone the same metamorphic alterations. Conspicuous crosscutting relationships (*see* Photo 16) in many cases leave no doubt as to the intrusive relationship. Many sills are faithfully concordant over considerable distances. Some of the dikes and sills may be contemporaneous in age and origin with the volcanic rocks representing mantle sills, feeder dikes, and associated intrusive units. Others may represent distinctly separate post-volcanic intrusions.

Substantial thicknesses of basic tuff, now recrystallized to amphibole-feldspar aggregates and generally referred to as amphibolite, are widespread. Some tuff units are massive throughout, but most are closely banded in shades of grey and green. The tuff units, ranging from a few inches to 50 feet thick, are present in both the sedimentary and volcanic sequences. For example, in the North and South iron deposits on the property of Sanjo Iron Mines Limited at Soules Bay, metamorphosed volcanic tuff forms up to 37 percent of the total rock sequence present. Indeed, the main sedimentary assemblages of the area grade along and across strike to volcanic assemblages by gradual increase in tuff content. The banded and massive tuff units appear to represent either freshly-deposited volcanic ash or clastic detritus derived by transport of previously-deposited unconsolidated volcanic material.

On the southeast shore of Soules Bay, at a location 1 mile southwest of the entrance, grey banded tuff is discordantly overlain by clastic metasediments. An apparent angular discordance of 70° is accentuated by the presence of conglomerate composed of subrounded fragments of grey to green volcanic rock, grey granite, chert, and grey schist in a quartzitic matrix (Photo 13). This disconformity appears to be a local feature only, possibly related to local slumping and erosion. Similar discordant zones are probably present elsewhere in the rock assemblage.

Acid Metavolcanics

Dacitic to rhyodacitic metavolcanics form numerous tuff-breccia zones of substantial thickness. Although interspersed throughout the entire volcanic assemblage of the map-area, these acid volcanic rocks predominate in the southeastern part of the area. Also, well-defined acid volcanic zones are present at Soules Bay and along the south shore of Lake St. Joseph to the west. In addition to pure acid pyroclastic rocks in which fragments and matrix are of similar composition (*see* Photo 14), mixed breccias composed of fragments in a basic matrix are common (*see* Photo 17).

Acid volcanic breccia, typically present in irregular zones 3 to 50 feet thick, is composed of angular fragments in a fine-grained matrix of similar composition. The breccia is generally completely unsorted, adjacent fragments ranging from pea-size to large angular blocks 18 inches in diameter. The proportion of fragments to matrix is highly variable, ranging from 10 to 80 percent in adjacent layers. Crude layering is locally marked by abrupt changes in fragment size in adjacent layers. Generally each breccia layer probably represents the depositional product of either specific volcanic outburst or of mud flows derived by slumping of previously accumulated volcanic material. As previously stated, the acid pyroclastic zones occur both as major components of thick volcanic sequences and as subordinate units in predominantly basic sequences. The relationship indicates that predominant basic effusion was interrupted repeatedly by local small-scale acid extrusion and occasionally by major eruptions of acid material.

On the south bank of Pashkokogan River, 2 miles from the east boundary of the map-area, unsorted lenticular pale grey dacite porphyry fragments, commonly 4 inches long and ½ inch wide but up to 18 inches long and 3 inches wide, are dispersed in a fine-grained matrix so similar in composition that the fragmental nature of the rock is obscure. Similar dacite breccia, containing pale grey lenticular fragments up to 2 feet long in a fine-grained dacitic matrix, is exposed on the southeast shore of Lake St. Joseph near the west boundary of the map-area.

Local conformable rusty-weathering zones, each 1 to 5 feet thick and 10 to 100 feet long, are present in the dacite pyroclastic rocks. The zones contain disseminated pyrite, pyrrhotite, and, locally, magnetite. They may represent products of local fumarolic action that operated during accumulation of the volcanic material.

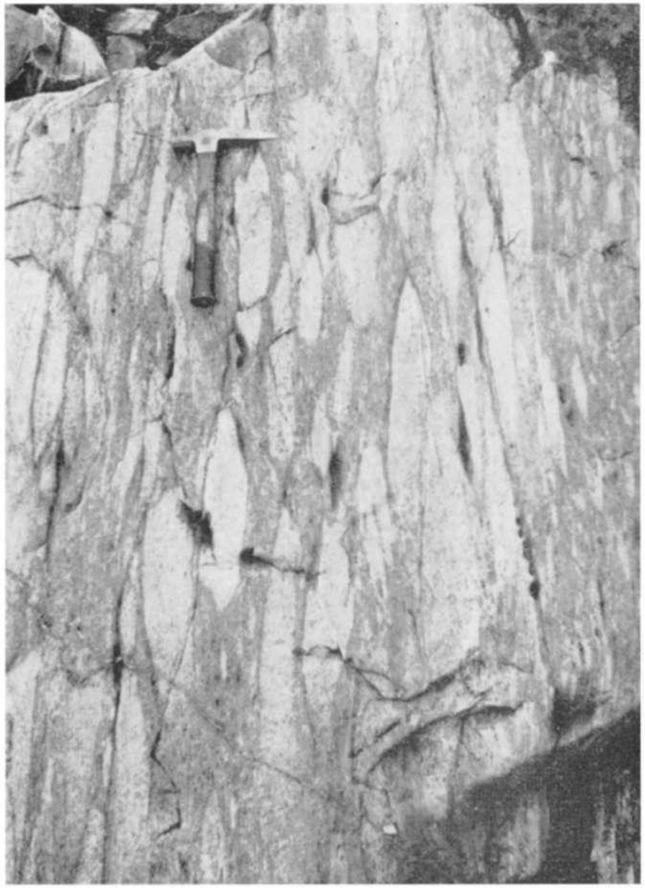

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Photo 14 — Volcanic breccia with rhyodacite fragments and matrix; 2 miles west of Pedlarpath Bay, east part of Lake St. Joseph.

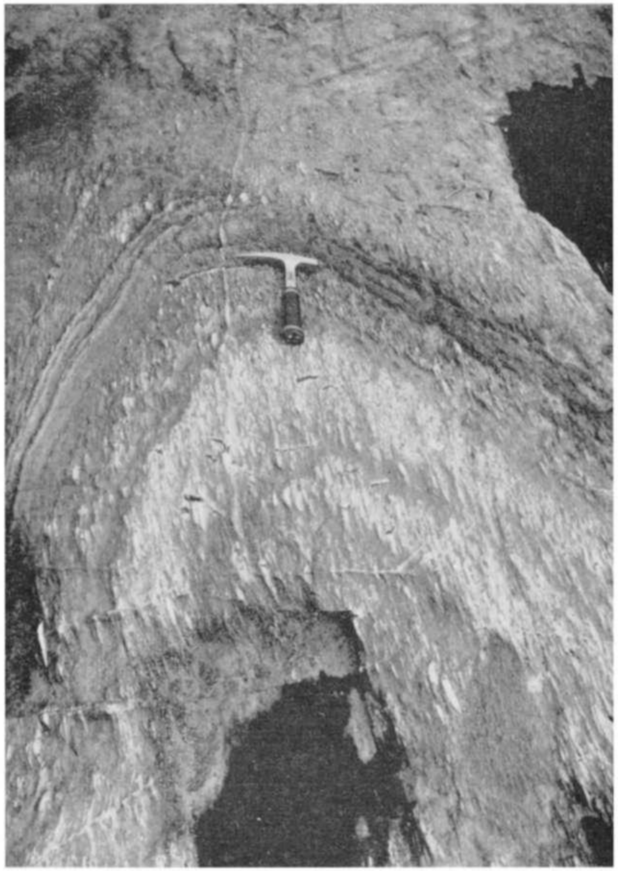

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Photo 15 — Dacite tuff-breccia; south shore of Lake St. Joseph, 2 miles east of west boundary of map-area. Note alignment of fragments in plane of schistosity.

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Photo 16 — Volcanic breccia, 2 miles east of Pedlarpath Bay, Lake St. Joseph. Note structurally deformed fragments and crosscutting metabasalt dike.

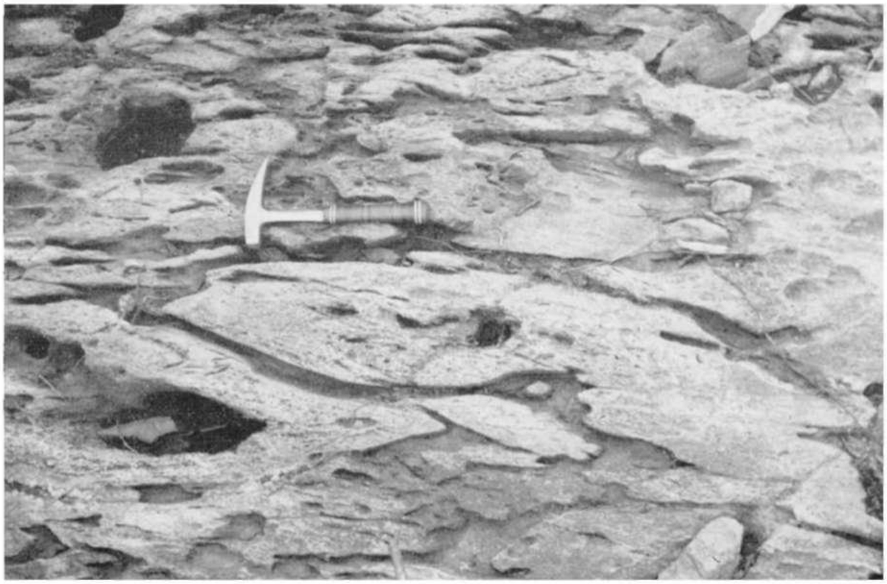

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Photo 17 — Volcanic breccia. Dacite fragments in basaltic matrix; northwest shore of Soules Bay, Lake St. Joseph. Note structurally deformed fragments.

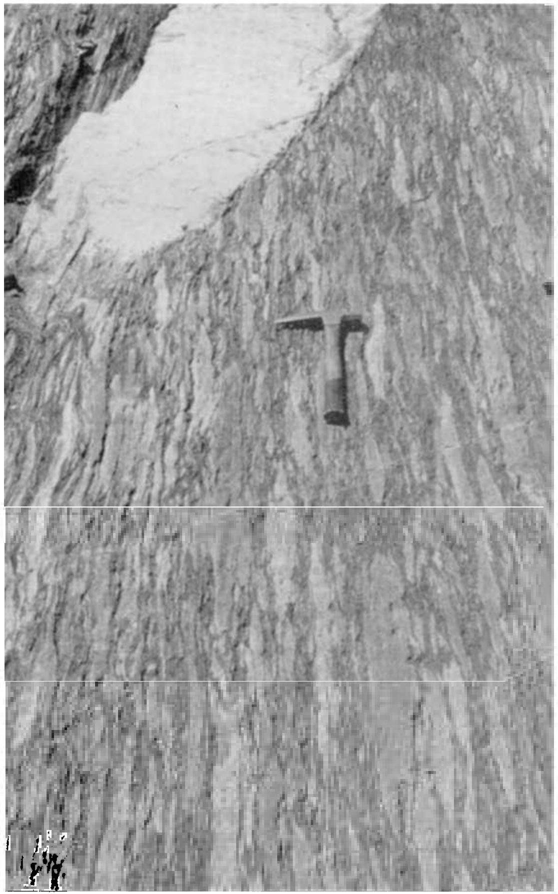

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Photo 18 — Dacite tuff-breccia; south shore of Lake St. Joseph, 1 mile west of Pedlarpath Bay. (Large quartz vein present in upper left corner.)

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Photo 19 — Volcanic breccia with dacite fragments in basaltic matrix; northwest shore, Soules Bay, Lake St. Joseph.

ODM7079

Photo 20

Volcanic breccia with dacite fragments in basaltic matrix. Note lack of sorting and structurally deformed fragments. Possible avalanche or mud-flow derivation.
Northwest shore, Soules Bay, Lake St. Joseph.

Photo 21

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Photo 22 — Volcanic breccia with dacite fragments; northwest shore, Soules Bay, Lake St. Joseph.

Zones of fine-grained banded tuff-breccia, as much as 200 feet thick, occur in the volcanic assemblage particularly at Pashkokogan Lake and again in the long northeast-trending peninsula in Lake St. Joseph near the west boundary of the map-area. Individual tuff-breccia beds, possibly products of individual explosive eruptions, are from 1 inch to 3 feet thick. Thin layers of fine-grained ash commonly lie adjacent to thick beds charged with white lenticular lithic fragments up to 4 inches long (Photo 15). The bedded character of the rock together with absence of grain gradation suggests derivation by explosive discharge of ash and lithic fragments followed by rapid subaqueous accumulation.

Tuff-breccia zones locally contain alternating bands of acid and basic material. The banding, which ranges in thickness from barely perceptible lamina up to 6 inches thick, is accentuated by varying proportions of amphibole, garnet, and feldspar metacrysts. Closely interbanded rocks of this type seemingly represent products of closely spaced and chemically contrasting explosive outbursts.

Mixed volcanic tuff and breccia are common in all parts of the volcanic pile. A great variety of types, ranging from closely interstratified tuff to coarse breccia containing felsic fragments up to 6 feet long, are present. In nearly all cases, the fragments are more acid in composition than the matrix. For the most part, the mixed pyroclastic rocks appear to represent products of mutual explosive discharge of acid and basic material from the same or neighbouring vents or fissures.

Mixed tuffs and breccias are particularly well exposed on the northwest shore of Soules Bay and vicinity (Photo 16). Unusually coarse breccia, composed of

Table 3 *Chemical composition of volcanic and sedimentary rocks, Pashkokogan Lake–Eastern Lake St. Joseph area, Samples 1 to 16*

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
SiO_2......	46.79	46.76	46.12	46.83	47.85	60.48	62.34	63.34	66.75	68.97	66.07	66.79	73.58	60.60	75.81	65.43
Al_2O_3.....	13.4	14.2	15.3	13.1	14.4	16.88	15.0	15.4	15.0	15.6	16.0	15.5	12.90	18.90	10.8	16.1
Fe_2O_3.....	1.4	0.85	0.84	0.78	0.66	1.83	1.20	2.38	0.39	1.28	1.59	0.55	0.24	3.01	0.79	1.50
FeO.......	7.97	12.10	9.88	8.72	11.52	4.36	6.65	2.14	3.45	1.15	3.13	2.55	2.72	4.53	2.47	4.03
MgO......	11.8	7.72	10.3	9.00	9.03	3.34	1.99	3.38	1.47	...	1.99	1.95	1.16	3.26	1.32	2.64
CaO......	12.3	10.0	12.7	14.3	10.5	7.71	4.95	4.51	3.94	3.21	2.52	2.27	1.38	2.40	1.38	1.72
Na_2O.....	2.26	2.96	1.40	3.83	2.13	3.28	3.04	2.91	3.64	4.39	3.84	2.25	2.72	2.96	2.48	2.20
K_2O......	0.57	2.51	0.24	2.35	0.41	0.72	0.88	2.11	1.24	1.35	1.89	5.44	4.10	2.51	1.62	2.78
H_2O+....	0.53	0.88	0.49	0.65	1.31	0.45	0.79	0.66	0.81	0.40	0.69	0.41	0.31	0.97	0.82	1.14
H_2O-....	0.09	0.13	0.06	0.09	0.21	0.02	0.11	0.13	0.15	0.07	0.30	0.14	0.02	0.02	0.37	0.26
CO_2......	0.28	0.09	0.05	0.69	0.05	0.07	0.86	0.85	0.46	0.02	0.42	0.08	none	0.11	0.02	0.03
TiO_2......	0.59	1.19	0.70	0.66	0.97	0.67	0.65	0.70	0.51	0.61	0.50	0.40	0.37	0.59	0.40	0.61
P_2O_5......	0.08	0.10	0.04	0.05	0.04	0.21	0.13	0.12	0.16	0.07	0.06	0.09	0.06	0.15	0.09	0.11
S.........	0.20	0.15	0.19	0.09	nil	0.05	0.07	0.07	nil	nil	nil	nil	trace	0.09	nil	nil
MnO......	0.18	0.20	0.18	0.17	0.19	0.12	0.30	0.08	0.08	0.44	0.07	0.07	0.04	0.07	0.09	0.09
S.G........	3.08	3.03	3.05	3.05	2.91	2.88	3.03	2.64	2.68	2.66	2.67	2.59	2.66	2.84	2.61	2.78

Rock type and location of samples

1—Amphibolite. Sanjo Iron Mines Limited property. Hole No. LSJ 23, 170–175 feet. Split core sample.

2—Amphibolite. East end of small island situated 1 mile northwest of narrow entrance to the main part of Lake St. Joseph, in the northwest part of the map-area. Chip sample.

3—Amphibolite. North shore of Pedlarpath Bay, Lake St. Joseph. Chip sample.

4—Basalt pillow lava. East shore of small island situated in the centre of the narrows between the north part and south part of Pashkokogan Lake. Chip sample.

5—Basalt flow breccia. Northwest shore of Lake St. Joseph at the west boundary of the map-area. Chip sample.

6—Andesite pillow lava. West shore of small lake situated 1 mile north of southwest corner of the south part of Pashkokogan Lake. Chip sample.

7—Dacite breccia. East Pashkokogan Lake; at entrance to Greenbush Lake portage. Chip sample.

8—Dacite schist. North shore of Medcalf Lake, 2.2 miles west of point where highway 599 crosses Medcalf Lake. Chip sample.

9—Rhyodacite breccia. South shore of Pashkokogan River, 1.5 miles west of the east boundary of the map-area. Chip sample.

10—Rhyodacite breccia (fragments only). Northwest shore of Lake St. Joseph at the west boundary of the map-area. Chip sample.

11—Rhyodacite feldspar porphyry breccia (fragments only). Small point at northwest entrance to Soules Bay of Lake St. Joseph. Chip sample.

12—Rhyodacite feldspar-quartz porphyry tuff-breccia. Southeast shore of main point at northwest entrance to Soule's Bay of Lake St. Joseph.

13—Impure arkose. Sanjo Iron Mines Limited property. Hole No. LSJ 14, 350–355 feet. Split core.

14—Andalusite-bearing schist. Sanjo Iron Mines Limited property. Hole No. LSJ 23. 115–120 feet. Split core.

15—Impure quartzite. South shore of Doran Lake. Interbanded with thin quartz pebble conglomerate. Chip sample.

16—Quartz-mica schist. At former site of Osnaburgh House on west shore of northeast arm of Lake St. Joseph. Chip sample.

large felsic fragments in a minor basaltic matrix, occurs interzoned with basalt lava flows (Photo 17). Acid breccia zones of this type range from 5 to 100 feet thick. Interzoned basalt flows are commonly 3 to 5 feet thick and rarely exceed 20 feet thick. The acid breccia typically contains fragments that are angular to subrounded, pale grey, and scoriaceous to porphyritic; these fragments lie in a dark green hornblende-rich matrix (Photo 18). Most fragments are 2 to 4 inches long; many are 12 inches long; occasional fragments are 6 feet long. A striking feature of the breccia deposits is the complete absence of sorting. However, crude internal stratification, due to abrupt changes in fragment size or proportion of fragments to matrix, is present locally. Many fragments contain abundant quartz-filled amygdules. Many fragments are slab-shaped; one such fragment measured 6 feet long, 1 foot wide, and 2 inches thick. These slabs are typically aligned in the direction of local structural plunge. Their present shape undoubtedly reflects some structural distortion. Other fragments are lenticular in plan view; others, generally the smaller ones, are round to spherical. The sparse matrix, more basic in composition, is composed of dark green to black amphibole-garnet-biotite-feldspar assemblages. The abundance of large amygdaloidal breccia fragments in this vicinity suggests a nearby explosive volcanic source.

Chemical Composition

The chemical compositions of some typical volcanic rock types present in the map-area are presented in Table 3. The most common rock type is normal basalt (Nos. 4, 5) with relatively low Al_2O_3 (average 14.1 percent), alkalis (average 3.74 percent combined Na_2O and K_2O), and TiO_2 (average 0.82 percent); it is present in the form of lava flows and breccias. Banded to massive amphibolites (Nos. 1, 2, 3) of the area correspond closely in composition to the basalts; they apparently represent metamorphosed tuffaceous and massive basalt in large part. Of the more acid volcanic type, dacite (Nos. 7, 8) and rhyodacite (Nos. 9, 10, 11, 12) are present in about equal proportions. They form the large bulk of fragmental volcanic rocks in the map-area. Field and chemical data suggest that andesites are rare and rhyolites are absent. Thus, the volcanic extrusive history appears to have been dominated by discharge of flows and fragmentals corresponding in composition to basalt and dacite-rhyodacite respectively.

In general, basalt effusion dominated the early volcanic stages and dacite-rhyodacite extrusion the later volcanic stages. In addition, common throughout the volcanic pile are closely spaced alternations and mutual association of basic and acid volcanic materials, evidenced by the presence of: (1) closely interbanded basalt flows and acid pyroclastic layers; and (2) mixed breccias composed of acid fragments in a basalt matrix.

Regarding the metasediments (Nos. 13, 14, 15, 16), a close chemical similarity to the acid volcanic rocks is apparent. Thus, quartz-mica schist (No. 16), the common metasediment of the map-area, is similar to rhyodacite (Nos. 9, 10, 11, 12). Andalusite-bearing or argillaceous schist (No. 14) and impure quartzite (No. 15) and arkose (No. 13) are, in turn, sufficiently similar to suggest a common parentage for all the sediments, namely: erosion and sedimentation, with local concentration of specific chemical elements, of a land mass underlain by extrusive and intrusive rocks of general dacite-rhyodacite composition.

GENERAL STRATIGRAPHIC RELATIONSHIPS

The stratigraphic sequence present in the map-area comprises 5,000 to 8,000 feet of metasediments, including banded iron formation, conformably overlain by 10,000 to 20,000 feet of metavolcanics that comprise lower, predominantly basic effusives and upper, predominantly acid extrusive rocks.

The main band of metasediments, which includes the economically important banded iron formation, is the lowest stratigraphic zone in the map-area. Because it is in contact to the west with younger intrusive granite, only part of the original sedimentary thickness has been preserved. A maximum stratigraphic thickness, estimated at 8,000 feet, is present southwest of Soules Bay. Generally, well-bedded arenaceous sediments predominate. Argillaceous and ferruginous components are locally significant. In addition, considerable intercalated volcanic tuff is present.

Metavolcanics gradationally and conformably overlie the main metasedimentary band of the area. Thus, a stratigraphic section taken northwest from Soules Bay includes 5,000 feet of intercalated acid to basic lava flows and pyroclastic rocks. A more complete stratigraphic section across the metavolcanic sequence near Pashkokogan Lake includes the following volcanic zones in descending stratigraphic succession:

Mainly acid breccia, tuff; minor basic flows:............7,500 feet.
Basic flows and breccia; minor acid pyroclastic rocks:....6,000 feet.
Massive to pillowed basic flows; amphibolite:...........6,000 feet.
Total volcanic sequence:......................19,500 feet.

This volcanic sequence also includes several thin zones of metasediments.

Early Basic Intrusions

Numerous thin gabbroic sills and dikes, generally less than 3 feet thick, are present in the volcanic pile. Crosscutting features leave no doubt that many of the dikes were emplaced following accumulation of the intruded volcanic rocks. Several good examples are exposed on the shores of Soules Bay (*see* Photo 16), and on the long northeastward-projecting peninsula of Lake St. Joseph 2 miles east of the west boundary of the map-area. Some of the sills and dikes probably represent volcanic feeders; others may be post-volcanic intrusions.

Several long linear belts of massive amphibolite, associated with the basic metavolcanics, are of uncertain origin. The presence of ghost pillow structures and well-banded phases suggests that much of the rock represents metamorphosed flow and pyroclastic rocks. Some are probably volcanic sheets and mantle sills. However, some thick massive zones may indeed represent post-volcanic intrusions.

Several long narrow biotite-hornblende lamprophyre dikes transect the older volcanic rocks.

Acid Intrusions

Acid intrusive rocks form numerous dikes, sills, stocks, and small batholithic masses. In addition, the north margin of a regional belt of massive to gneissic granite and migmatite underlies the south boundary of the area.

Granitic Rocks

The north boundary of the area is underlain by massive to porphyritic granite that forms part of a large batholithic mass extending at least 16 miles to the northwest. Also enclosed within the map-area itself are at least eight granite stocks, and innumerable dikes, sills, and other small masses. The largest of the stocks, measuring 9 miles long and 6 miles across, is situated between Doran Lake and Lake St. Joseph in the west half of the map-area. Seven other stocks, each from 1 to 3 miles in diameter, are present near Pashkokogan Lake as follows: (1) west Riach Lake; (2) south Riach Lake; (3) south shore of Lake St. Joseph and 2 miles west of Ace Lake; (4) Eric Lake; (5) west shore of the southern part of Pashkokogan Lake; (6) east shore of the southern part of Pashkokogan Lake; and (7) the southeast corner of East Pashkokogan Lake.

The common rock type is biotite-bearing granite that is massive to porphyritic, medium- to coarse-grained, and leucocratic. Both pink and white phases are present. The margins of the stocks are normally felsic and occasionally faintly gneissic. Barren quartz stringers and veinlets are common. Biotite generally forms 5 to 15 percent of the rock. Hornblende is locally present. The Eric Lake stock contains occasional inclusions of fine-grained amphibolite up to 2 feet long. The south Riach Lake stock is abnormally leucocratic containing less than 10 percent biotite, the sole femic mineral. Pegmatite dikes and sills are commonly present both at the margins of the stocks and in the adjoining country rocks. The Eric Lake stock in particular contains numerous quartz-feldspar-muscovite-tourmaline pegmatites up to 10 feet wide. Large inclusions of amphibolite, up to 6 feet long, are present in some pegmatite dikes. The Doran Lake stock, which is predominantly porphyritic, typically contains 10 to 20 percent euhedral to subhedral pink feldspar crystals up to 1 inch in diameter in a medium-grained hornblende-bearing matrix.

Pegmatite

The large granite batholith that is marginal to the area on the north contains numerous pegmatite dikes and sills at and near the south contact. The pegmatites assume a wide variety of shapes and sizes, ranging from isolated beaded stringers, lenses, and dikelets, to dikes 30 feet thick and several hundred feet long. However, most pegmatite dikes range from 5 to 7 feet thick. They occur locally in great profusion and comprise up to 50 percent of some outcrop areas. Transecting pairs of pegmatite dikes were observed. Both gradational contacts and sharp intrusive contacts with the host granite are equally common. At the north shore of Lake St. Joseph many pegmatite dikes with gradational contacts to granite are distributed along three preferred directions, a relationship suggesting in situ derivation by textural coarsening, or pegmatitization, of normal graphite along joint planes. However, other pegmatite dikelets were clearly formed by injection along fractures. All pegmatites observed are of simple granitic composition. No evidence of zoning was observed. Quartz, white feldspar, biotite, muscovite, and tourmaline are the common constituents. Some garnet is present locally. Perthitic and myrmekitic intergrowths of quartz and feldspar are common. Rare flakes of molybdenite and green beryl were observed at one locality on the north shore of Lake St. Joseph, north of Soules Bay. Pegmatites at Greenbush Lake to the southeast contain occasional small grains of blue-green apatite.

Pegmatite veins up to 3 feet wide are also present in the country rock bordering the granite stocks. Sills and dikes are present in equal proportions. Many pegmatites form lenticular, concordant layers in highly folded country rock. Most pegmatites comprise coarse-grained aggregates of quartz, feldspar, biotite, muscovite, and tourmaline. The lithium-bearing minerals spodumene and lepidolite are present in pegmatite at the southeast shore of East Pashkokogan Lake (*see* p. 54, 55).

Dikes and sills of granite and aplite are present in many parts of the area particularly in those marginal to the granite stocks.

Granite Gneiss and Migmatite

The south margin of the map-area is underlain by granite gneiss and migmatite, part of a broad regional belt that extends many miles to the south. Within the map-area the north contact of this belt extends from Greenbush Lake on the east to Doran Lake on the west (*see* Figure 2). In the interval from the south shore of Greenbush Lake to the south shore of Pashkokogan Lake, a distance of 6 miles, the contact underlies a fairly prominent straight-line topographic feature. To the west, the contact transects Medcalf Lake at a well-marked point of deflection situated 4 miles west of Pashkokogan Lake. Still farther west, the contact extends parallel to, and about 1 mile south of, the Doran River and Doran Lake. The contact zone is drift-covered for much of the distance between Greenbush Lake and Pashkokogan Lake and again near Medcalf Lake.

In detail, the contact represents a gradual transition from metamorphic schist on the north to granite gneiss and migmatite on the south. The transition occurs across an interval of ¼ to ½ mile. Traced from north to south, hornblende-biotite-garnet schist by gradual increase in intergranular quartz and feldspar, together with injected granite layers, grades through migmatite composed of interlayered dark grey porphyritic schist and grey granitic rock, to gneissic and massive granite, with variable schist inclusions. For example, a traverse due south from the southwest end of Doran Lake encountered the following rock sequence: 0 to 18 chains, grey hornblende schist becoming increasingly silicified and feldspathized; 18 to 38 chains, migmatite, a banded rock composed of equal parts of grey granite layers and fine-grained, biotite-hornblende-feldspar schist; 38 to 70 chains, granite gneiss and migmatite. The contact zone is gradational and appears to reflect progressive stages in the process of granitization and intrusion, by which pre-existing sedimentary and volcanic rocks have been altered to, and intruded by, granitic rocks.

Typical migmatite is composed of almost equal parts of whitish granitic layers 1 to 6 inches thick interbanded with dark greenish grey fine-grained feldspathized schist layers each 2 to 12 inches thick. Individual schist and granitic layers have an irregular lenticular and discontinuous distribution. Granitic layers are composed of white to pink biotite granite. Intervening schist layers are normally rich in white feldspar and biotite. The relative proportions of light-coloured granitic layers and dark-coloured schist layers vary considerably. Generally the proportion of granitic layers increases to the south. Locally, the granite layers of the migmatite contain feldspar phenocrysts up to ¾ inch long. The schist layers present in the migmatite, particularly south of Pashkokogan and Medcalf lakes, are generally rich in biotite.

The typical gneiss, present at the south boundary, is composed of medium-grained white-weathering dull-pink to grey granite. Gneissosity, which is seldom strongly developed, reflects slight differences in the proportions of femic constituents. Barren quartz veins and layers are common. Numerous remnants of grey schist are present. Occasional granite pegmatite dikes transect all other rocks of the migmatite-gneiss complex. The south shore lineament, referred to above, marks a relatively abrupt lithologic transition from silicified and feldspathized amphibole-biotite schist to the north to interlayered schist and granite migmatite to the south. It is emphasized that no change in metamorphic grade was observed across this lineament in the interval between Greenbush Lake on the east and Medcalf Lake on the west. At Doran Lake to the west, however, prevailing hornblende-garnet and biotite-quartz schists have been locally altered at the south shore of the lake to chlorite-sericite-bearing aggregates. The presence of such lower-grade metamorphic schists may reflect local faulting as is indicated on the geological map. Considering the entire area, however, the north contact of the migmatite belt appears to represent the north limit of granite emplacement and alteration rather than a major zone of faulting.

Metamorphic Relationships

Prevailing rock assemblages of the map-area belong to the amphibole facies of medium metamorphic rank. Hornblende-feldspar, garnet-hornblende-biotite, garnet-staurolite, staurolite-andalusite, and biotite-quartz-feldspar are typical mineral assemblages present in the metavolcanics and metasediments. It is thus clear that, with local exceptions, the older rocks have been extensively recrystallized.

The two possible agents of metamorphic recrystallization that merit consideration are: (1) the granite stocks that are enclosed within the metavolcanics and metasediments; and (2) the large granite gneiss-migmatite complex that underlies the south boundary of the map-area. Evidence within the map-area itself is inconclusive, because metamorphic grade is uniform throughout the area regardless of proximity to the two possible metamorphic agents. However, evidence outside the immediate map-area suggests that the enclosed granite stocks (that are enclosed within the metavolcanics and metasediments), were important metamorphic agents. Thus, along the extension of the Lake St. Joseph greenstone belt to the west, volcanic and sedimentary rocks in similar proximity to granite gneiss and migmatite on the south but at considerable distance from a number of enclosed granite stocks, are composed of low-rank mineral assemblages, namely chlorite-sericite-carbonate schist. This relationship suggests that, in the present map-area, the enclosed intrusive stocks, of which at least eight are present, were important agents of metamorphic recrystallization. In this regard, the Doran Lake stock with an apparent gentle east plunge may have been a particularly potent metamorphic agent upon intruded rocks, especially near Soules Bay.

In exception to the above rule of medium metamorphic rank, sheared chlorite-sericite schist is present along the south shore of Doran Lake. As previously mentioned, the presence of lower-grade metamorphic assemblages at this place may reflect local shearing and faulting.

Pleistocene and Recent

The grain of the map-area almost entirely reflects Pleistocene effects, depositional features predominating by far. Advancing ice, after sweeping clear the pre-existing debris down to bare rock, deposited a considerable thickness of material both sorted and unsorted. Recent erosion has removed this material locally particularly at shores of lakes and streams, but for the most part the blanket of debris remains pristine in distribution and composition.

As a result of ice-passage in a direction S.40°W., bedrock is uniformly scoured, sculptured, striated, and streamlined in that direction. Roches moutonnées, or mammillary rock forms, are very common. Resting upon and blanketing this surface, common glacial deposits composed of silty sand, impure gravel, and boulder till, include general ground moraine, outwash plains, drumlins, eskers, kames, and kettles. Long sinuous eskers are commanding features of the landscape as are numerous drumlinoid humps and ridges. Shadow effects are common: the north shores of lakes and bays are drift-covered and the south shores scoured bare; and elongated rocky islands are scoured bare on the north side but debris-burdened on the south side. The deposits probably reach several hundred feet locally in thickness; over the Sanjo Iron Mines Limited property the average thickness is 16 feet.

Boulder erratics are common in the morainal drift; some attain 20 feet in diameter. Exotic indicators include rare but widely scattered fragments of Paleozoic limestone and oölitic ironstone, both presumably derived from the Hudson Bay region to the northeast. No clay deposits indicative of long standing water were observed.

Structural Geology

Volcanic and sedimentary rocks have been folded about east-trending and plunging axes. A principal anticline, isoclinally overturned to the north, follows the south shore of Lake St. Joseph including Soules Bay. Other parallel folds are indicated. The major folds are accompanied by abundant minor folds that range in amplitude down to a few inches.

Stratigraphic tops are indicated mainly by pillow structures in lava flows, and by graded bedding and scour-and-fill structures developed in sediments. Numerous linear elements, particularly alignment of tabular and rod-shaped minerals, crenulations present on planes of schistosity, and axial lines of S- and Z-dragfolds, are present.

Local transverse faults are common. Sericite-chlorite schist, present at the south shore of Doran Lake and along the Doran River, may reflect local faulting. Otherwise, no evidence of significant faulting was observed.

Folds

An east-northeast-trending and plunging anticline, overturned to the north, constitutes the main defined fold element. The axis of the anticline, traced from west to east, crosses the Doran Lake porphyry stock, extends along the southeast shore of Soules Bay and so through Ace Lake to the east boundary of the map-area. Accordingly, layered rocks in the vicinity of Pedlarpath Bay, the northwest shore of Soules Bay, and the south shore of Lake St. Joseph, lie on the north limb of the anticline; they face mainly to the north and dip south. Their stratigraphic attitude is indicated by: pillow structures at Pedlarpath Bay, at the northwest shores of Soules Bay, and at the southeast shore of Lake St. Joseph near the west boundary; and graded beds and scour-and-fill structures at Soules Bay and at several small islands and the adjoining peninsula in the northwest quarter of the map-area (*see* Fig. 2). Layered rocks at Doran Lake, Thelma Lake, and at the north end of Pashkokogan Lake lie on the south limb of the anticline; for the most part they face and dip steeply south. Specifically, south-facing graded beds are present at Doran Lake and along the sedimentary belt extending to the northeast; south-facing pillows are also exposed in lava flows at a small lake situated 1 mile north of the southwest extension of Pashkokogan Lake and due south of Riach Lake.

The plunge of the main anticline is to the east, on the basis of numerous linear elements, particularly local dragfolds. The angle of plunge ranges from 35° to 55° eastward in the west half of the map-area including Soules Bay; in the eastern part of the map-area, the plunge is steeper, ranging from 60 degrees east to vertical. Dragfolds at the west end of Doran Lake suggest a local steep west plunge.

In addition to the main anticlinal fold, parallel folds of major dimension are indicated in the southeast quarter of the map-area. On the basis of the structural attitude of local rock units and of the shape of local dragfolds, a synclinal axis crossing the southern part of Pashkokogan Lake is indicated. On similar basis, a parallel anticlinal axis is inferred to cross the south end of East Pashkokogan Lake. According to local linear elements, the folds in the southeast quarter of the map-area plunge steeply east, the amount of plunge ranging from 75° to 90°.

In addition to major folds, countless minor folds are present. For example, on the long northeast-trending peninsula extending 1 mile north of the northwest entrance to Soules Bay, pillowed lava flows, which are 200 feet apart across-strike, are situated on opposing limbs of a tightly compressed syncline. Also, the metasediments of the main iron zones at the Sanjo Mines property have been thrown into numerous isoclinal folds, as have the iron-bearing metasediments at Doran Lake. Large-scale and small-scale dragfolds, abundant in number and varied in size and shape, are well exposed in metasediments at Soules Bay and Doran Lake. In both localities, duplication by folding of iron-bearing zones appears to have been a significant factor in the formation of potential iron ore deposits.

Faults

Although small transverse fractures with horizontal offsets up to 2 feet long are common, no major fault zones were delineated in the map-area. Some narrow discontinuous zones of shearing were encountered in diamond-drilling (e.g. drill-hole LSJ No. 33, footages 135 to 139.5) at the property of Sanjo Iron Mines Limited situated west of Soules Bay. Metasediments and metavolcanics, exposed on the south shore of Doran Lake and along the south shore of the Doran River, have been locally sheared to chlorite-sericite-carbonate mineral assemblages. Such low-rank metamorphic assemblages, which stand in contrast to prevailing amphibole-biotite schist exposed on the islands and north shore of Doran Lake, may reflect local shearing.

It has been suggested elsewhere that the straight-line lineament formed by the south shore of Pashkokogan Lake marks a major fault zone. Other than the evidence of local shearing, which refers to the immediate Doran Lake vicinity, no evidence of fault movement was observed along the south shore of Pashkokogan Lake and vicinity either in terms of shearing or of steep metamorphic gradient across the lineament. Although a substantial part of the critical zone is drift-covered and water-covered, and thus removed from direct observation, it is considered unlikely that any major through-going fault is present at this particular lithologic contact. Uniform metamorphic grade across the contact zone indicates that, if major faulting did occur, it was a pre-metamorphic event, since healed beyond casual recognition.

Economic Geology

The map-area contains two large deposits of low-grade concentrating-type magnetite iron formation. A lithium-bearing pegmatite dike is present at East Pashkokogan Lake. A number of small local zones of disseminated sulphides contain traces of copper and nickel. Schistose rocks that contain minor disseminated pyrite at Doran Lake warrant further investigation.

Sanjo Iron Mines Limited, a wholly-owned subsidiary of Steep Rock Iron Mines Limited, holds a group of 181 claims on the southeast shore of Lake St. Joseph. Detailed geophysical and geological investigations, including 23,000 feet of diamond-drilling, indicate the presence of 618,000,000 tons of open-pit magnetite-bearing iron formation, averaging 23.1 percent soluble iron. Metallurgical testing indicates that a concentrate averaging 67.6 percent soluble iron is obtainable at a ratio of concentration of 3.5 to 1.

The Belcher-Doran property, owned by Little Long Lac Gold Mines Limited through its associated exploration and development companies Belcher Mining Corporation Limited and Lun-Echo Gold Mines Limited, consists of eighty-one mining claims situated at Doran Lake. Preliminary investigations, including 7,500 feet of diamond-drilling, indicate the presence of 376,000,000 tons of open-pit magnetite-bearing iron formation, averaging 19.2 percent magnetic iron. Metallurgical testing indicates that a concentrate averaging 68.1 percent soluble iron and 4.8 percent silica is obtainable at an over-all ratio of concentration of 4.52 to 1. At least 65 percent of the tonnage lies beneath Doran Lake.

All significant iron observed in the map-area is in the form of magnetite. It follows that iron deposits of economic significance may be expected to have a marked magnetic expression. In this regard, examination of regional aeromagnetic maps does not reveal the presence of significant magnetic anomalies other than over and immediately adjacent to the two properties described above.

A spodumene-bearing pegmatite zone, approximately 50 feet wide and 100 feet in exposed length, is situated on the northeast shore of the southeast bay of East Pashkokogan Lake. A chip sample, taken across 50 feet, gave 1.25 percent Li_2O. Further examination may reveal significant extensions to this zone, or the presence of other similar zones in the vicinity.

Of the numerous small local conformable zones of disseminated sulphides present mainly in volcanic rocks, sixteen were sampled and analyzed for trace element and gold contents. The results gave traces only of copper, nickel, vanadium, and chromium. Of the 16 samples, 8 assayed trace in gold and 8 assayed nil in gold.

Minor disseminated pyrite is present in chlorite-sericite schist at the south shore of Doran Lake and near a granite contact. Further work in this vicinity may reveal significant mineralized sulphides.

IRON

DESCRIPTION OF PROPERTIES

Sanjo Iron Mines Limited

Location and Access

Sanjo Iron Mines Limited owns a group of 181 mining claims situated at the southeast shore of Lake St. Joseph (Figure 3) (Photo 23). As of October 1964, this group included 181 mining claims held under patent or license of occupation, covering a total of 7143.63 acres, as follows: Pa.17227–42, 17260–91, 18278–95, 18742–47, 19151, 19152, 19156–58, 19161–63, 19166–68, 19172–75, 19177–79, 19181–83, 19185, 19186, 19188–89, 19192, 19195, 19197–99, 22515–59, 26281–98, 26355–73, 26400–05, 26408, and 26410–39 inclusive. Detailed geological and geophysical surveys, together with diamond-drilling programs, have outlined two iron deposits referred to, respectively, as the North Zone deposit and the South Zone deposit (*see* Figure 4). The centre of the claim group, at Lat. 51°01′N. and Long. 90°03′W. lies 90 miles northeast of Sioux Lookout, and 56 miles north of Savant Lake station on the Canadian National railway.

Provincial Highway 599 connecting Ignace on the Trans-Canada highway with Pickle Lake to the north, passes around the east end of Lake St. Joseph at a point 5 miles east of the property. Transportation from this highway to the property is provided by boat during the summer; in addition a winter road, passable by tractor, connects with the property.

An area of about 80 square miles surrounding the claim group (*see* Figure 3) has been withdrawn from staking by the Ontario Department of Mines in order to assist the owner in orderly development of the property.

History

The presence of iron formation in the Lake St. Joseph region was noted by E. L. Bruce in 1921 and by W. S. Dyer in 1932. However, the presence of significant iron formation on the present property of Sanjo Iron Mines Limited was not recorded until 1956, when forty-eight claims were staked by C. K. Hansen. The claim group was optioned to Steerola Exploration Limited, a subsidiary of Steep Rock Iron Mines Limited. Between 1956 and 1961, the property was systematically examined and tested by means of: airborne magnetometer survey; geological mapping; detailed ground magnetometer surveys; 28,290 feet of diamond-drilling; bulk sampling (250 tons) by shaft-sinking and crosscutting; metallurgical test work; and economic appraisals and engineering studies.

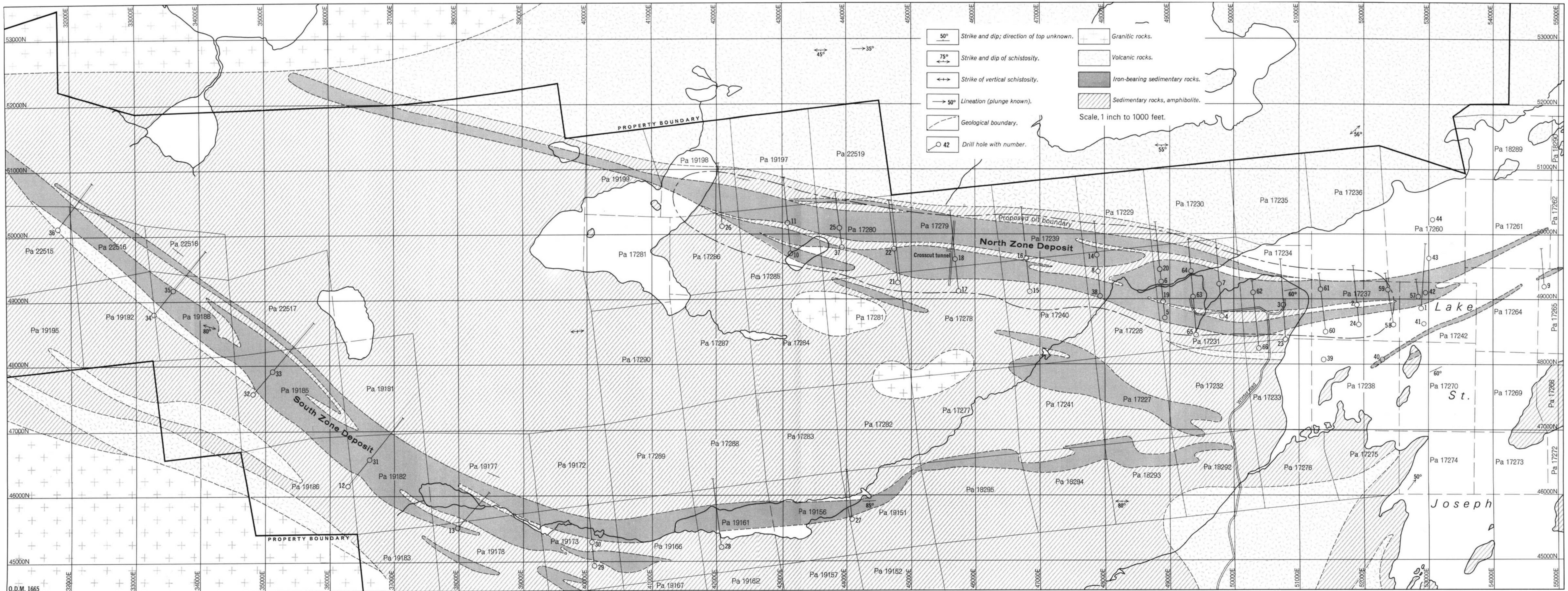
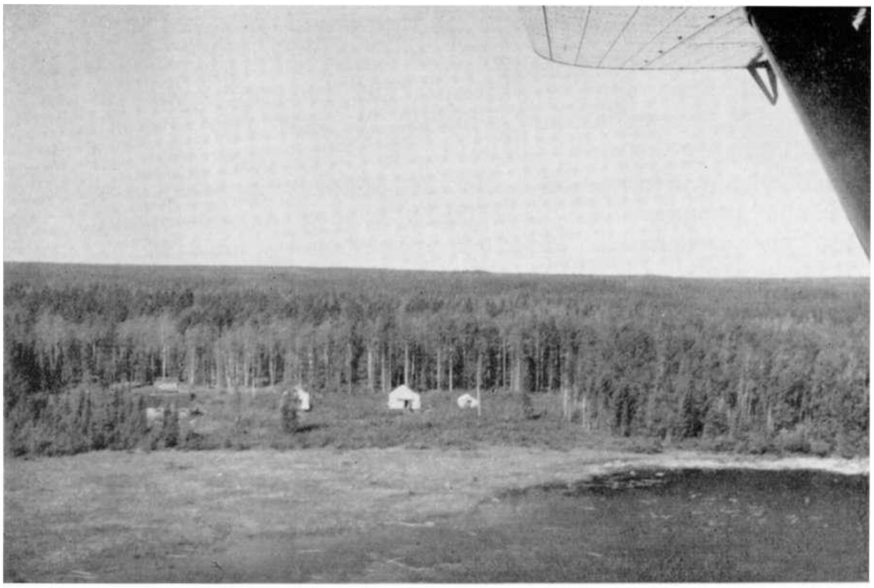


Fig. 4—Geological Sketch Map of Part of Sanjo Iron Mines Limited Iron Property, Lake St. Joseph.



ODM7082

Photo 23 — Drill camp, Sanjo Iron Mines Limited, Soules Bay, Lake St. Joseph.

As a result of this work two iron deposits, the North Zone deposit and the South Zone deposit, have been delineated. At the present time further development of the deposits awaits more favourable market conditions.

The author gratefully acknowledges the value of and has drawn freely upon a comprehensive company report written by A. T. Avison, geologist with Steep Rock Iron Mines Limited.

GENERAL GEOLOGY

Iron deposits represent those parts of a thick metasedimentary sequence that contain substantial amounts of banded iron formation. This sequence is gradationally overlain by metamorphosed volcanic flows and pyroclastic rocks. Younger granitic sills, dikes, and stocks are present. Structurally, the metasediments and metavolcanics have been folded into a complex east-trending east-plunging anticline. Duplication of banded iron formation by folding is an important feature in the development of both iron deposits.

Metasediments

The metasedimentary sequence comprises pebble conglomerate, impure quartzite, arkose, greywacke, argillite, and their derived schists together with banded iron formation. Well-banded to massive tuff and amphibolite of probable volcanic derivation are associated. By far the most common rock type of the assemblage is quartz-biotite schist. Toward the top of the sequence of metasediments and near Soules Bay of Lake St. Joseph, argillaceous schist is common; it contains prominent aluminium-rich metacrysts such as andalusite, staurolite, and garnet. The banded iron formations that contain the iron deposits are closely associated with these argillaceous schists.

Banded Iron Formation

Banded iron formation, composed of closely interbanded quartz, siliceous magnetite, and fine-grained argillaceous and quartzitic sediments, forms an integral part of the sedimentary sequence at Soules Bay and in the interval extending 4 miles to the west.

The banded iron formation is composed of fine-grained quartz and magnetite with variable amounts of biotite, chlorite, epidote, amphibole, garnet, specular hematite, and carbonate. Magnetite accounts for almost all the iron oxide present; some specular hematite is present locally. Grain-size of the magnetite ranges from 0.001 to 0.2 millimetres in diameter. The banding of the iron formation is due to alternating layers, each ½ to 10 inches thick, of black iron-rich layers, white quartz-rich layers, and grey, green, or brown silicate-rich layers. The iron-rich layers are themselves commonly minutely laminated, the light and dark shades reflecting relative proportions of quartz and magnetite, respectively. The banding is normally irregular. Individual bands typically pinch and swell, bifurcate, coalesce, and terminate abruptly. A large amount of grey to green tuffaceous rock is present.

Richer phases of the iron formation, which form the iron deposits, are composed mainly of alternating magnetite-rich and quartz-rich layers; leaner phases of the iron formation contain, in addition, variable amounts of interbanded barren schist. Richer phases and leaner phases of iron formation are gradational one to the other along and across the strike of the sedimentary assemblage. The richest phase of iron formation, composed of alternating black and grey layers, has been aptly termed "zebra-striped" iron formation; it forms a distinct zone, 50 to 200 feet thick, present at the north margin of each of the two iron deposits.

In mode of occurrence, mineral composition, and layered construction the banded iron formation has all essential aspects of a metamorphosed sedimentary iron formation formed by chemical deposition of alternating chert and iron-rich layers. The nature of the original iron precipitate, now wholly crystallized to iron oxide and silicate minerals, is unknown. Possibly it was siderite as is present in non-metamorphosed banded iron formation at Pickle Lake 40 miles to the northeast.

Metavolcanics

Metamorphosed volcanic rocks to the north are intercalated with, and overlie, the metasedimentary rocks. In addition, the iron-bearing sedimentary rocks are gradational along-strike to the west to predominantly metavolcanic rocks.

Metamorphosed basic lavas, tuff, and breccia predominate. Lava flows range from 3 to 50 feet thick and average 15 feet thick; pillowed phases are present. The lava flows are typically intercalated with substantial thicknesses of banded to massive tuff and breccia, now in the form of amphibolite. On the northwest shore of Soules Bay, mixed volcanic breccia, or agglomerate, composed of angular to subrounded dacitic fragments in a basaltic matrix, is present. This breccia grades along-strike to closely interbanded fine-grained grey dacitic and dark green basaltic tuff. In addition, numerous thin zones of acid volcanic breccia are interspersed with predominantly basaltic volcanic rocks.

Thin layers and small irregular masses of gabbro porphyry, characterized by the presence of abundant feldspar (andesine-labradorite) laths, are associated with the metavolcanic-metasedimentary assemblage, particularly at the hangingwall side of the two iron deposits and near the Doran Lake granite stock to the southwest. The gabbro porphyry appears to represent a metamorphosed phase of the basic volcanic sequence, either altered tuff or associated volcanic sill. Other massive gabbro sills and dikes present in the rock sequence also appear to represent volcanic phases. However, some may represent distinctly younger intrusive bodies.

Granitic Rocks

The northeast margin of the large Doran Lake granite stock underlies the southwest corner of the property. Intrusive granite similarly underlies the north margin of the property. Smaller masses of granite are distributed between the North Zone and South Zone deposits (Figure 4). In addition, numerous granite dikes and sills, up to 150 feet thick, have penetrated the metavolcanics and metasediments, including the banded iron formations. The common type of granite that is present is grey to pink, fine- to medium-grained, and massive. Aplitic and pegmatitic phases are present locally.

Surficial Deposits

Pleistocene and Recent overburden, composed of sand, silt, boulder till, and general organic material, is extensive. Broad sphagnum swamp and marsh tracts are interspersed with low-lying gently rolling ridges and drumlinoid masses that are formed mainly of silty sand. The overburden reaches 50 feet thick; it averages 16 feet thick over the iron deposits. Most drillholes encountered a layer of boulders at, or close to, the bedrock.

Structure

Folding is the dominant structural feature of the area. Metasediments and metavolcanics underlying the property lie on the north limb of an east-northeast-trending and east-northeast-plunging anticline that is overturned to the north with the axis extending along the southeast shore of Soules Bay. In the western part of the property, the rocks generally strike east to west or northwest to southeast and dip 60° to 80° south. In the eastern part of the property, they strike generally northeast to southwest and dip steeply southeast. The prevailing plunge of linear elements, associated with the folding, is 35° to 60° eastward.

In addition to the regional anticline described above, innumerable dragfolds are present. They range from minute crenulations to those with amplitudes of many hundreds of feet. However, all folds observed have in common a gentle to moderate east plunge, suggesting that they are all parts of a larger parent structure.

The banded iron formation and associated clastic sedimentary and volcanic rocks of the main iron deposits have also been complexly folded. Stratigraphic top determinations made in outcrops and diamond-drill core are almost equally divided between those indicating tops north and those indicating tops south. Specifically, of 44 top determinations made by the author in the diamond-drill core, 27 determinations (60%) indicate tops south, and 17 determinations (40%) indicate tops north (*see* Table 4). These north and south determinations are distributed in the drilled intersections without discernible pattern. These relationships provide strong evidence for the presence of complexly folded strata in the iron deposits.

Table 4 *Top determinations in drill core, Sanjo Iron Mines Ltd. iron deposits, Lake St. Joseph*

DEPOSIT AND SECTION	NUMBER OF TOP DETERMINATIONS Total	Tops South	Tops North
SOUTH ZONE			
32,000E	0	0	0
33,600E	1	1	0
35,000E	0	0	0
36,500E	0	0	0
40,100E	2	0	2
42,050E	1	1	0
44,050E	1	1	0
	5	3	2
NORTH ZONE			
43,900E	1	1	0
44,800E	3	2	1
46,800E	5	4	1
47,900E	3	3	0
48,500E	0	0	0
49,350E	3	2	1
50,300E	5	4	1
51,350E	6	3	3
52,400E	7	1	6
54,800E	6	4	2
	39	24	15
Totals for both zones	44	27	17

Most top determinations are based on graded beds. Cut-and-fill structures are locally present in banded iron formation (Photo 9). Graded bedding is best developed in relatively thick pure quartzite beds such as are present in the eastern part of the property. Graded beds are not as common in the western part of the property where the tuff content of the rock is higher and apparently inimical to development of grain gradation. This proportionate increase to the west in tuff content and concomitant decrease in graded bedding is reflected in the distribution of top determinations as follows: of the 44 determinations, 39 are in layered rocks of the North Zone deposit particularly in the eastern part; only 5 are in layered rocks of the South Zone deposit, the apparent stratigraphic extension to the west.

The percentage lithologic content of drilled sections in the North Zone and South Zone iron deposits, based on study of diamond-drill core, is presented in Table 5, and graphically in Figure 5. The sections, arranged from section 52,900E. on the east to 32,000E. on the west, extend consecutively from east to west along the North Zone deposit, followed by the South Zone deposit. When so arranged it is evident that the proportions of sedimentary to volcanic rocks change gradually along the strike. For example, the proportion of clastic sediments decreases

Table 5 *Lithologic content of diamond-drill intersections, Sanjo IronMines Limited iron deposits, Lake St. Joseph*

DEPOSIT AND SECTION	DIAMOND-DRILLHOLE NUMBERS	TOTAL DRILLED	GRANITE	IRON FORMATION			SEDIMENTARY ROCKS	VOLCANIC ROCKS
				Lean (Wt. recov. 8 to 20%)	Rich (Wt. recov. greater than 20 %)	Total of Rich and Lean		
		feet	percent	percent	percent	percent	percent	percent
NORTH ZONE								
52,900E	1, 57	638	3	30	31	61	33	3
52,400E	58, 59	1,042	......	11	50	61	30	9
51,950E	24, 2	983	......	15	57	72	21	7
51,350E	60, 61	1,038	......	13	47	60	36	4
50,750E	23, 3	1,098	3	36	30	66	22	9
50,300E	66, 62	1,052	3	14	49	63	27	7
49,800E	4, 7	1,060	......	33	50	83	16	1
49,350E	65, 63, 64	1,490	2	10	65	75	20	3
48,850E	5, 19, 6, 20	2,044	4	27	60	87	6	3
47,900E	38, 8, 14	1,773	20	2	59	61	14	3
46,800E	15, 16	1,397	2	13	66	79	5	14
45,750E	17, 18	1,418	6	32	39	71	13	10
44,800E	21, 22	1,238	6	30	45	75	16	3
43,900E	37, 25	887	7	9	63	72	17	4
43,100E	10, 11	1,038	10	5	73	78	3	9
SOUTH ZONE								
44,050E	27	489	16	28	24	52	25	7
42,000E	28	539	2	17	50	67	10	21
40,100E	29, 30	1,206	......	4	48	52	21	27
38,100E	13	719	......	7	62	69	12	19
36,500E	12, 31	1,171	......	14	60	74	10	16
35,000E	32, 33	1,126	1.0	27	50	77	5	17
33,600E	34, 35	1,191	1.0	16	40	56	6	37
32,000E	36	608	......	17	33	50	15	35

erratically from 33 percent at section 52,900E. to 15 percent at section 32,000E. Conversely, the proportion of volcanic rock increases from 3 percent at section 52,900E. to 35 percent at section 32,000E. These progressive changes in lithologic proportions along the sedimentary strike are considered to represent original facies changes in sedimentary-volcanic accumulation.

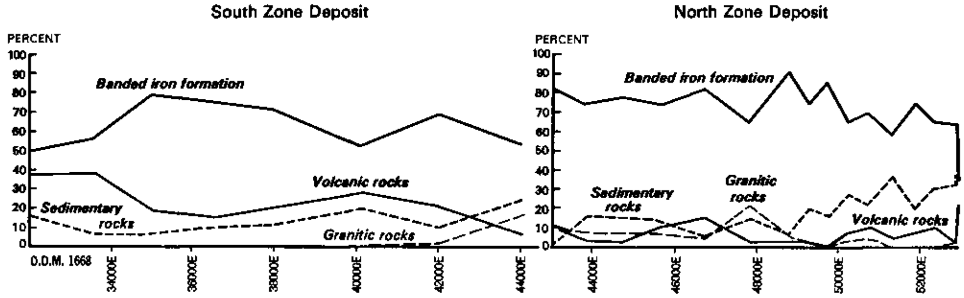


Figure 5 — Lithologic content of iron deposits, Sanjo Iron Mines Ltd., Lake St. Joseph.

The association in the iron deposits of highly folded strata together with progressive lithologic changes between the North Zone and the South Zone deposits suggests that the two deposits actually represent complexly folded portions of one and the same stratigraphic zone. The two iron deposits are attributed largely to structural duplication, by folding, of a single iron-rich sedimentary facies. Beyond the property boundaries, this iron-rich sedimentary facies grades laterally by increase in clastic sedimentary rock (to the east) and volcanic rock (to the west) to sub-economic iron-bearing facies.

No faulting of significance was observed on the property. Numerous transverse offsets, up to 6 inches, appear in the outcrop. Local fracture zones were encountered in three diamond-drillholes. Because much of the property is drift-covered, faulting of more significant dimensions may yet be revealed.

IRON DEPOSITS

Distribution and Thickness

North Zone Deposit. This deposit is about 10,600 feet long (*see* Figure 4) and 490 to 1,180 feet in surface-width. Cross-sections drilled at approximately 1,000-foot intervals along-strike in the western part, and 500-foot intervals along-strike in the eastern part to an average depth of 500 feet below surface, indicate that the deposit maintains a constant width at least to this depth. The strike of the deposit changes from N.75°E. at the east end to N.75°W. at the west end. The dip of the iron-bearing rocks varies from 55° to 80° south.

Magnetic surveys indicate that similar iron-bearing rocks extend to the northeast along the length of Soules Bay.

South Zone Deposit. This deposit is situated 8,000 feet southwest of the North Zone deposit. As stated above, the two deposits are considered to represent folded portions of the same iron-bearing zone. The South Zone deposit is at least 12,000 feet long (Figure 4). It ranges in surface-width from 320 to 800 feet. Diamond-drill intersections at approximately 2,000-foot intervals along-strike indicate vertical continuity to a depth of 300 to 500 feet below surface. The iron-bearing rocks strike N.70°W. at the west end of the deposit, and N.75°E. at the east end of the deposit. They dip 60° to 80° south.

Several small zones of iron-bearing rock, situated between the South Zone deposit and the North Zone deposit (Figure 4), may represent folded extensions of the main iron-bearing zone.

Composition

The North Zone and South Zone deposits are essentially similar in composition. They vary only in their relative proportions of magnetite, quartz, schist, and intrusive granite. The percentage lithologic composition of the deposits, based upon forty-seven drilled intersections, is tabulated in Table 6. (*See also* Table 5.)

Table 6 | *Lithologic composition of deposits, Sanjo Iron Mines Limited*

ROCK TYPE	RANGE IN CONTENT	AVERAGE CONTENT
	percent	percent
Iron formation	50–87	68
Sedimentary schist	3–36	16
Volcanic schist	1–37	12
Granite	0–20	4

As previously stated, Table 5 illustrates that the percent content of sedimentary rocks is highest in the eastern part of the North Zone deposit and decreases erratically to the west along the North Zone and South Zone deposits, consecutively. There is a corresponding increase to the west in the percentage content of volcanic schist. These trends are considered to represent primary sedimentary facies changes.

Both North Zone and South Zone deposits are composed of many irregular lenses and bands of iron formation that are interbanded in an extremely irregular discontinuous manner with clastic sedimentary and volcanic rocks. The banded iron formation is a banded sedimentary rock composed of fine-grained magnetite and quartz with minor amounts of biotite, chlorite, epidote, amphibole, garnet, specular hematite, and carbonate. Magnetite accounts for almost all the iron oxide present. Minor amounts of specular hematite have been noted locally. Grains of epidote and needles of amphibole are commonly distributed through the formation. The magnetite varies in grain-size between 0.001 and 0.2 millimetres.

The banding of the iron formation is due to alternating layers, each ½ to 10 inches thick, of magnetite-rich quartz, and schist. All proportions of iron-rich to iron-poor layers are present, ranging from closely interbanded black magnetite and white quartz layers (zebra-striped iron formation) to predominant schist with the occasional magnetite-bearing layer. In this manner, richer and leaner phases of iron formation and barren schist grade one into the other along and across the sedimentary strike. The south, or hanging wall, contacts of both deposits are gradational across 50 to 100 feet of stratigraphic section to barren schist. The north or footwall contacts, in contrast, are abrupt, the transition from ore-grade material to waste occurring in 5 to 20 feet of stratigraphic section.

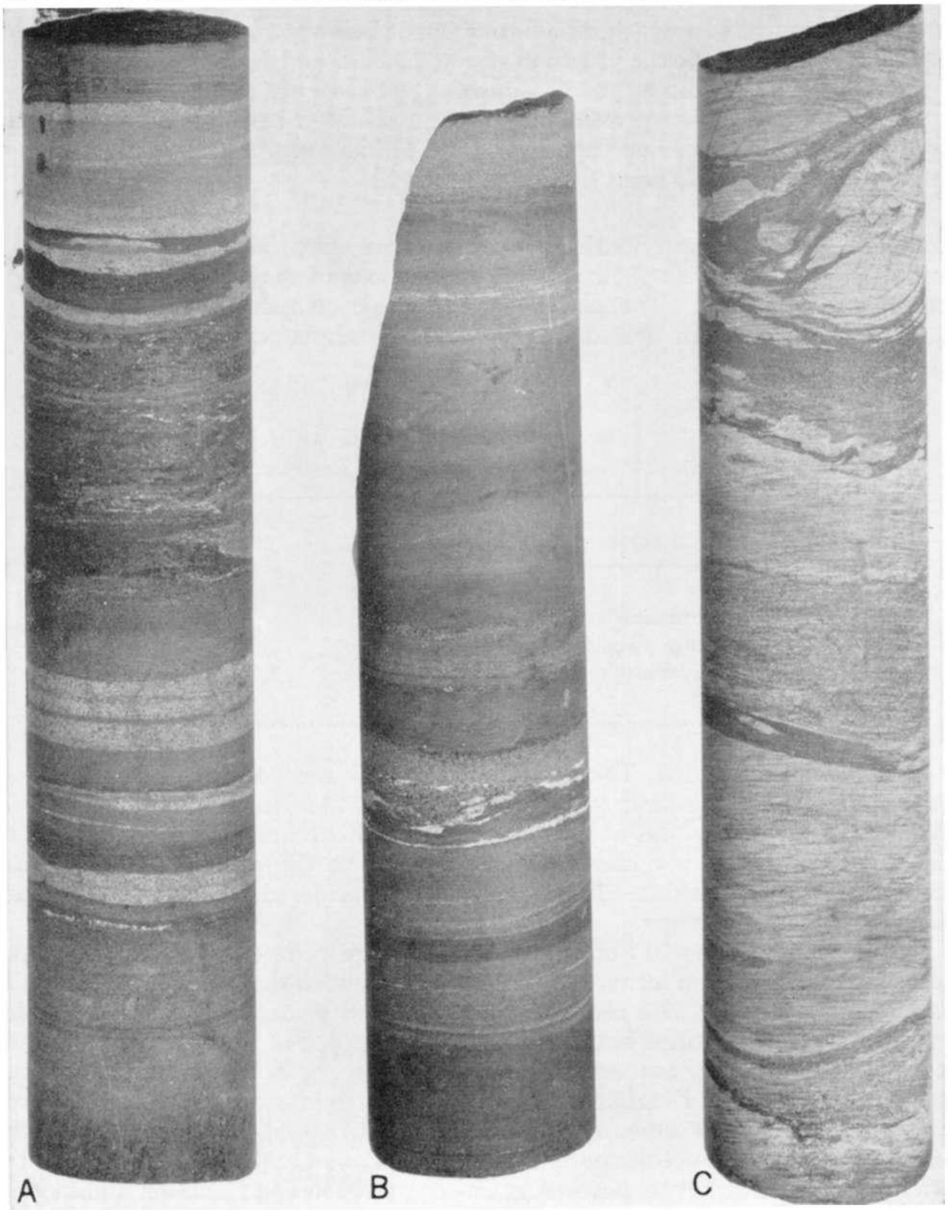


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Photo 24 — Diamond-drill cores showing nature of banding in iron formation, Lake St. Joseph Area. Diameter of core is 1¼ inches.

Core A – DDH 25 at 316 feet; Sanjo Iron Mines Limited, Soules Bay. Thin black bands, magnetite. Light grey bands, impure quartzite. Medium grey broader bands, quartz-biotite-amphibole schist. In upper centre of drill core, the development of dark green iron-rich secondary amphiboles has obliterated much of the banding.

Core B – DDH 34 at 640 feet; Sanjo Iron Mines Limited, Soules Bay. A richer phase of iron formation. Black bands, magnetite. Light grey granular bands, quartz-biotite-amphibole schist. Medium grey bands (merging into black bands), magnetite-quartz-amphibole schist containing occasional large dark green iron-rich amphibole metacrysts. Secondary amphiboles are concentrated at the mutual boundary of the magnetite-rich and quartz-rich bands.

Core C – DDH 1 at 31 feet; Doran Lake iron property. Thin black bands, magnetite. Grey bands, quartz-biotite-amphibole schist. Note irregular wavy banding. Irregular clusters near the top may reflect penecontemporaneous slumping.

Tonnage Estimates

The following tonnage estimates, prepared by A. T. Avison, geologist with Steep Rock Iron Mines Limited, are based mainly upon diamond-drill intersections. In the North Zone deposit, 15 intersections, spaced at 1,000-foot intervals include 34 diamond-drillholes totalling 18,196 feet of diamond-drilling. In addition, 10 diamond-drillholes, totalling 5,189 feet, were drilled to provide a spacing of 500 feet in the eastern 4,000 feet of the North zone deposit. In the South Zone deposit, 8 intersections, spaced at 2,000-foot intervals, include 12 diamond-drillholes totalling 7,049 feet of diamond-drilling.

In preparing tonnage estimates, pit limits were established on each geological section according to the following 5 rules: slope of pit wall, 60°; minimum pit width, 150 feet; maximum projection down the dip from a drillhole intersection, 300 feet; ratio of wallrock to ore, 1 to 1, measured along the wall of the pit; pit-bottom elevation 700 feet above sea-level (approximately 550 feet below surface). A factor of 11 cubic feet per long ton has been used in calculating all ore reserves.

Estimated open-pit reserves and grade, together with estimated stripping requirements, are presented in Table 7.

The overburden covering the iron deposits is composed of sand, boulder till, and organic muck. It ranges from 0 to 55 feet thick. The average thickness, based on available drill intersections, is 16 feet over the North Zone deposit, and 20 feet over the South Zone deposit.

Table 7 *Summary of estimated open-pit reserves and grades, by A. T. Avison, Steep Rock Iron Mines Ltd.*

DEPOSIT	RESERVES	CRUDE SOL. FE	CONC. SOL. FE	RECOVERY		STRIPPING	
				Sol. Fe.	Wt.	Wallrock	Overburden
	tons	percent	percent	percent	percent	cu. yds.	cu. yds.
North Zone	340,250,000	23.7	67.6	85.8	30.4	20,890,200	10,244,100
South Zone	275,608,000	22.2	67.6	83.7	27.9	10,294,000	7,040,000
Totals or Average	615,858,000	23.0	67.6	84.8	29.3	31,184,200	17,284,100

Note: Sol. Fe. = acid soluble iron.
Recovery is by Davis tube at a grind of 85 percent minus-325-mesh.

Grade and Concentration Tests[1]

Of the 28,290 feet of diamond-drill core, 73.4 percent or 20,754 feet, was split into either 5-foot or 10-foot samples, each of which was assayed for soluble iron. Composite samples, each representing not more than 50 feet of core, were submitted for Davis tube tests that were carried out at a grind of 85 percent minus-325-mesh.

The average grade of material in the iron deposits, based upon sampling of diamond-drill core, is presented in Table 7. The calculated content of individual geological sections ranges from 16.4 to 26.4 percent soluble iron. The calculated average content of crude material in the North Zone deposit and South Zone

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[1] Estimates by A. T. Avison, geologist with Steep Rock Iron Mines Limited.

deposit, respectively, is 23.7 and 22.2 percent soluble iron. The North Zone and South Zone deposits combined contain an estimated 615,858,000 tons of material with an average estimated grade of 23.0 percent soluble iron.

Davis tube tests on representative materials from the North Zone deposit indicate that a concentrate containing 67.6 percent soluble iron can be made from the material with a weight recovery of 30.4 percent of the crude (*see* Table 7). Similarly, test work on representative material from the South Zone deposit indicates that a concentrate containing 67.6 percent soluble iron can be made from the material with a weight recovery of 27.9 percent of the crude. The calculated average for North Zone and South Zone combined is 67.6 percent soluble iron with a weight recovery of 29.3 percent of the crude.

Belcher-Doran Property

LOCATION AND ACCESS

Little Long Lac Gold Mines Limited, through its associated exploration and development companies Belcher Mining Corporation Limited and Lun-Echo Gold Mines Limited, owns a group of eighty-one mining claims at Doran Lake in the District of Thunder Bay, Patricia Mining Division. This property is referred to, for convenience, as the Belcher-Doran property. As of May 1964, the claim group includes the following thirty-eight claims that are either surveyed or held under license of occupation: Pa.16805–11, 17145, 17146, 18085–87, 18090, 18093, 18097–99, 18106, 18107, 18110, 18111, 18118, 18141–46, 18149–52, and Pa. 26571–76 inclusive. The claim group is approximately 3 miles long and 1.5 miles wide. It covers most of the west part of Doran Lake (*see* Figure 6).

Doran Lake is readily accessible by aircraft either from Sioux Lookout 90 miles south, or from Pickle Lake 40 miles northeast. A water route leads from provincial Highway 599 that touches the east end of Lake St. Joseph 20 miles northeast; following this route, access is by way of Soules Bay of Lake St. Joseph and Thelma Lake to Doran Lake.

HISTORY

The presence of iron formation at Doran Lake was first recorded by W. S. Dyer in a report of the Ontario Department of Mines in 1932 (Dyer 1934). A total of eighty-one mining claims was staked by Oglebay Norton Company Limited in the mid-1950s. A geological map was prepared and a dip-needle survey of the property was completed. In 1958, six diamond-drillholes totalling 3,403 feet were completed by Oglebay Norton Company Limited. The property was optioned to Lun-Echo Gold Mines Limited in 1958. In 1960, Belcher Mining Corporation completed a patent survey of the property. They drilled eight diamond-drillholes totalling 4,100 feet. In addition, metallurgical tests, preparation of ore reserve estimates, and engineering studies were completed.

GENERAL GEOLOGY

The Belcher-Doran property is underlain by: fine-grained metasediments, including banded iron formation; minor intercalated basic volcanic rocks; and younger granite intrusions. Structurally, the metasediments are situated on the south limb of an east-trending anticline. The rocks generally strike east-west and dip steeply south. Considerable local folding is present.

Metasediments

The metasediments form an east-trending band, about 8,000 feet wide, that lies between the Doran Lake granite stock to the north and a broad zone of granite gneiss and migmatite to the south. The metasediments comprise impure quartzite, pebble conglomerate, arkose, greywacke, shale, tuff, and derived schists, together with extensive bands of iron formation.

Metasediments exposed at the north shore and nearby islands of Doran Lake are predominantly grey to green, fine-grained quartzite and arkose. Common metamorphic assemblages include quartz-biotite, quartz-feldspar-biotite, quartz-garnet-biotite, and quartz-feldspar-amphibole. Finely banded, impure quartzite and greywacke with graded bedding is associated with the main zone of iron formation that crosses the centre of the property. Pebble conglomerate is present in several small islands at the southeast corner of the main part of Doran Lake. Dark grey to green thinly banded greywacke and impure arkose, and tuffaceous schist, are present in the southern part of the property and along the south shore of Doran Lake.

Banded Iron Formation

Banded iron formation is intimately associated with the fine-grained metasediments, as an integral sedimentary component. Typical iron formation is a thinly banded rock composed of alternating layers of magnetite, quartz, and schist. Individual bands are generally 1/16 to 1/4 inch thick; they seldom exceed 1/2 inch thick. Individual bands lack continuity along-strike, swelling and pinching, bifurcating and pinching out in an extremely irregular manner. The relative proportions of magnetite-rich to barren quartz and schist layers is highly variable both along and across the strike. In this manner the iron zones have gradational contacts, the iron-rich and iron-poor phases merging gradually one to the other along and across the strike.

The main zone of iron formation extends in an east-west direction across the west half of Doran Lake. The zone is about 15,000 feet long. It ranges from 300 feet wide at the east end to 1,300 feet wide at midlength. The average width is about 600 feet. A smaller zone at the north shore of Doran Lake is 2,500 feet long and 200 to 300 feet wide.

The iron formation locally contains scour-and-fill structures that are of value as stratigraphic top indicators. In addition, interbanded quartzite commonly displays graded bedding.

Granite Intrusions

The northern part of the property is underlain by pink to white massive to porphyritic granite that forms the south edge of the large Doran Lake porphyry stock (*see* p. 34). To the south of the property the north margin of a broad zone of granite gneiss and migmatite is present. Numerous dikes and sills in the metasediments including the banded iron formation, ranging from 3 to 80 feet thick, are typically composed of pink aphanitic to porphyritic granite. The North Zone in particular contains many granite dikes. For example, drillhole No. 3 (*see* Figure 6) intersected 6 separate granite masses, each 2 to 80 feet thick, for a total length of 337 feet.

Structure

For the most part, the metasediments, including the banded iron formation, trend east-west and dip 70° to 90° south. At the northwest corner of the property, the rocks strike N.70°W. and dip steeply south.

Generally, the rocks are situated on the south limb of a regional, east-trending anticline, the axis of which passes through the centre of the Doran Lake porphyry stock to the north. In detail, the fold pattern is complicated; this is evidenced by abundant dragfolds including minute plications visible on many outcrops. Stratigraphic tops, based on grain gradation and scour-and-fill structures, are mainly to the south, but include a substantial number to the north. All linear elements have a steep plunge, mainly to the east, but locally, for example at the west end of Doran Lake, the plunge is to the west. These relations indicate that the iron-bearing rocks of the area have been largely folded about east-trending steeply plunging fold axes. Like the iron deposits at Soules Bay to the northeast, the iron deposits at Doran Lake may be reasonably attributed to structural duplication, by folding, of an original iron-rich sedimentary facies.

IRON DEPOSITS

Distribution and Thickness

Two iron deposits are present on the property. The North Zone deposit, approximately 1,600 feet long and 250 feet wide, is located at the north shore of Doran Lake on mining claims Pa.16806, 16810, and 16811 inclusive. The South Zone deposit, by far the larger, extends across the west half of Doran Lake on mining claims Pa.26573, 18118, 18141–46, 18098, 18099, 18149–52, 18085–87, 18106, 18107, and Pa.18110 inclusive (*see* Figure 6).

The combined length of the North and South deposits is 17,500 feet. The width ranges from 300 to 1,500 feet. About 65 percent of the deposits lies beneath the waters of Doran Lake. The average depth of water varies between 15 and 25 feet. Below this is 5 to 25 feet of mud covering 2 to 5 feet of boulders resting on bedrock.

Composition

The iron deposits are composed of fine-grained sedimentary rocks including banded iron formation. Richer phases contain relatively high proportions of iron formation, but lean and barren phases contain small to negligible proportions. The rich, lean, and barren phases are gradational one to the other along and across the sedimentary strike. The iron deposits represent those portions of the sedimentary assemblage that, as a result of initial iron-rich sedimentary deposition augmented by structural duplication by folding, contain a substantial proportion of banded iron formation. The margins of the deposits are gradational to barren schist across 50 to 100 feet of stratigraphic section. Both deposits contain internal waste bands of substantial dimensions.

Typical banded iron formation contains alternating magnetite-rich and quartz-rich layers together with more or less schist. Most iron is present in the form of magnetite. Only minor hematite was observed in outcrop and thin section. In the richer phases of the iron formation, magnetite dust, grains, and coalescing clumps are distributed in faintly discernible layers with minor intergranular quartz. In leaner phases, predominantly suture-bonded quartz grains are associated with disseminated dust and coalescing beads of magnetite. All transitions from one to the other are represented. Both the magnetite and the quartz-rich layers normally contain isolated grains and crystal clusters of blue-green hornblende and occasional epidote. Isolated apatite grains were observed. Fine-grained, acicular amphibole is commonly present at the quartz-magnetite borders. Minor calcitic carbonate is commonly associated with magnetite and hornblende

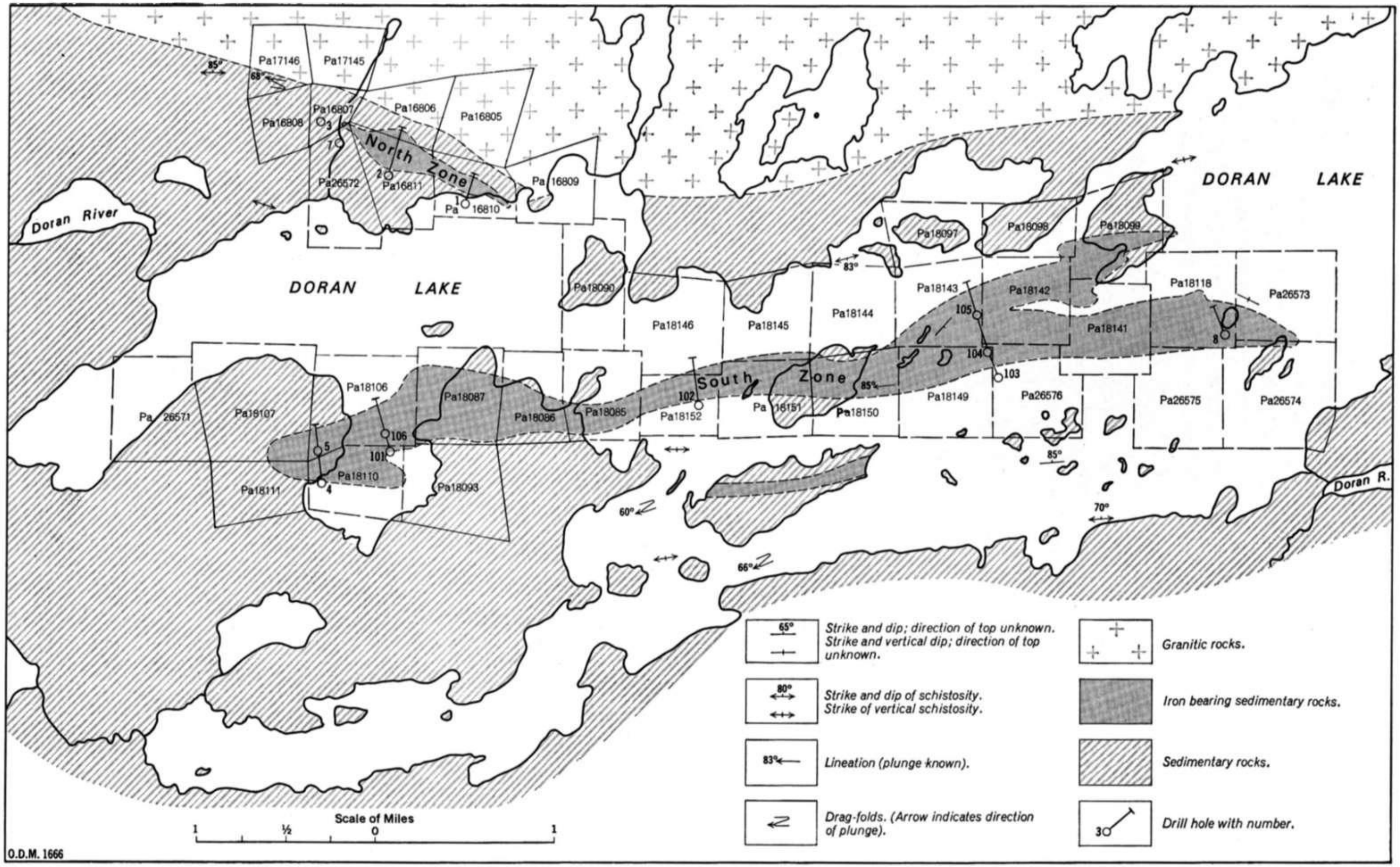

Figure 6 — Geological sketch map of Belcher-Doran iron property, Doran Lake.

Tonnage Estimates and Grades

The following tonnage estimates prepared for the owners by G. B. Darling, independent mining engineer, are based upon: limited geological mapping; dip-needle survey of the property; and 7,500 feet of diamond-drilling. Of the 14 diamond-drillholes, 3 intersected the North Zone deposit and 10 intersected the South Zone deposit. The drillholes are spaced at intervals of 1,000 to 4,600 feet along the strike. Accordingly, tonnages and grades presented below represent preliminary estimates only.

In preparing the tonnage estimates, the surface areas of both iron deposits were divided into: higher-grade iron formation (average greater than 22 percent magnetic iron); lower-grade iron formation (average between 16 and 22 percent magnetic iron); and waste rock (average under 10 percent magnetic iron). The respective areas were then extended to a depth of 500 feet for purposes of tonnage calculation. The tonnage factor used was 10.5 cubic feet per ton for higher-grade iron formation, 11.5 cubic feet per ton for lower-grade iron formation, and 13 cubic feet per ton waste rock. Only the waste rock within the iron deposits was considered in calculating the tons of waste present. Thus, no allowance was made for wallrock stripping.

On the above basis, the North Zone deposit and the South Zone deposit combined contain an estimated 170,807,000 tons of iron formation averaging 22.3 percent magnetic iron, together with an estimated 204,856,500 tons of iron formation averaging 16.7 percent magnetic iron. The total estimated tonnage of the two deposits combined is 375,664,000 tons of iron formation averaging 19.2 percent magnetic iron. Associated with this tonnage of iron formation is 102,761,000 tons of intraformational waste rock.

Concentration Tests

Diamond-drill core from the iron deposits was logged and divided into 10-foot samples. The samples were submitted for grinding and magnetic tube tests. Concentration tests were conducted at minus-325-mesh. Concentrates and tails were analyzed for iron and silica.

The results of this test-work indicate that a concentrate averaging 68.1 percent iron and 4.8 percent silica can be made with a weight recovery of 27.92 percent. The ratio of concentration is indicated to be 3.58 to 1.

However, when the indicated tonnage of intraformational waste rock referred to above is added, the over-all ratio of concentration is raised to 4.52 to 1.

With the North and South deposits combined, to a depth of 500 feet, the estimated tonnage is 375,664,000 tons of iron formation grading 19.2 percent magnetic iron; the estimated weight recovery is 27.9 percent at a ratio of concentration of 3.58 to 1 for the iron formation alone; for iron formation and intraformational waste rock combined, the ratio of concentration is estimated to be 4.52 to 1.

LITHIUM

A spodumene-bearing zone about 50 feet wide and 100 feet in exposed length is situated on the northeast shore of the southeast bay of East Pashkokogan Lake, 1 mile northeast of the mouth of Savant River (*see* Figure 2). This zone is bounded by water on the south and west, and by drift on the north and east.

The zone comprises medium- to coarse-grained granite pegmatite composed of pink feldspar, muscovite, quartz, tourmaline, spodumene, and possibly minor lepidolite. The lithium-bearing minerals have an erratic distribution within the zone. The pegmatite lies in a host rock of acid volcanic breccia composed of light-coloured rhyolite fragments in a grey dacitic matrix. Where visible at the water's edge to the west, the pegmatite zone is thinning out. To the east it disappears beneath overburden.

A chip sample taken by the author across the full width of 50 feet was analyzed by the Laboratory Branch of the Ontario Department of Mines with the following results: Li_2O, 1.25 percent; beryllium, trace (about 0.03 percent); cesium, trace (about 0.03 percent); rubidium, trace (low, about 0.15 percent).

Because of drift and water cover, the full extent of the mineralization cannot be determined by direct observation. Further work may reveal significant extensions to this zone or the presence of other zones in the vicinity.

OTHER MINERALS

Numerous small local conformable zones of disseminated sulphides are present in the metavolcanics and associated metasediments of the map-area. The zones are generally 1 to 5 feet wide and 20 to 80 feet long. They contain variable amounts of disseminated pyrite and pyrrhotite, commonly with some magnetite. During the field season, sixteen representative zones were sampled, and the material submitted for assay. Assay results of the sixteen samples gave traces only of copper, nickel, vanadium, and chromium. Of the 16 samples submitted, 8 assayed nil in gold content, and 8 assayed trace in gold. These results offer little encouragement. They indicate that the disseminated sulphide zones of the type sampled and assayed are of no commercial interest.

Traces of disseminated pyrite are present in sheared chlorite-sericite schist at the south shore of Doran Lake and near a granite contact approximately ½ mile south of Doran Lake. The sheared rock may well reflect faulting in the vicinity. Further work may reveal significant amounts of sulphides.

SELECTED REFERENCES

Texts

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1922: Eastern part of Lake St. Joseph; accompanied by Map 31f; Ontario Dept. Mines, Vol. XXXI, pt. 8, p. 33-38. (Published 1923.)

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1933: Geology of the Pashkokogan-Misehkow area; accompanied by Map 42e; Ontario Dept. Mines, Vol. XLII, pt. 6, p. 1-20. (Published 1934.)

Goodwin, A. M.
1962: Geology of Pashkokogan Lake–Eastern Lake St. Joseph area; Ontario Dept. Mines, Prelim Rept. 1962-5, p. 1-10.

Maps

Geol. Surv. Canada
Map 51-1960. Geology, Lake St. Joseph, Ontario. Scale 1 inch to 4 miles. (N.T.S. sheet 52 O.) Geology by R. F. Emslie; published 1961.

Ontario Dept. Mines:
Map 31f. Eastern part of Lake St. Joseph, Districts of Thunder Bay and Patricia. Scale 1 inch to 2 miles. (Accompanies O.D.M. Vol. XXXI, pt. 8.) Geology by E. L. Bruce; published 1923.
Map 42e. Pashkokogan-Misehkow area, District of Thunder Bay. Scale 1 inch to 4 miles. (Accompanies O.D.M. Vol. XLII, pt. 6.) Geology by W. S. Dyer; published 1933.

O.D.M.–G.S.C.
Maps 911G, 912G, 921G, 922G. Aeromagnetic Series; scale 1 inch to 1 mile. Ontario Dept. Mines–Geol. Surv. Canada; published 1960.

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ONTARIO
DEPARTMENT OF MINES

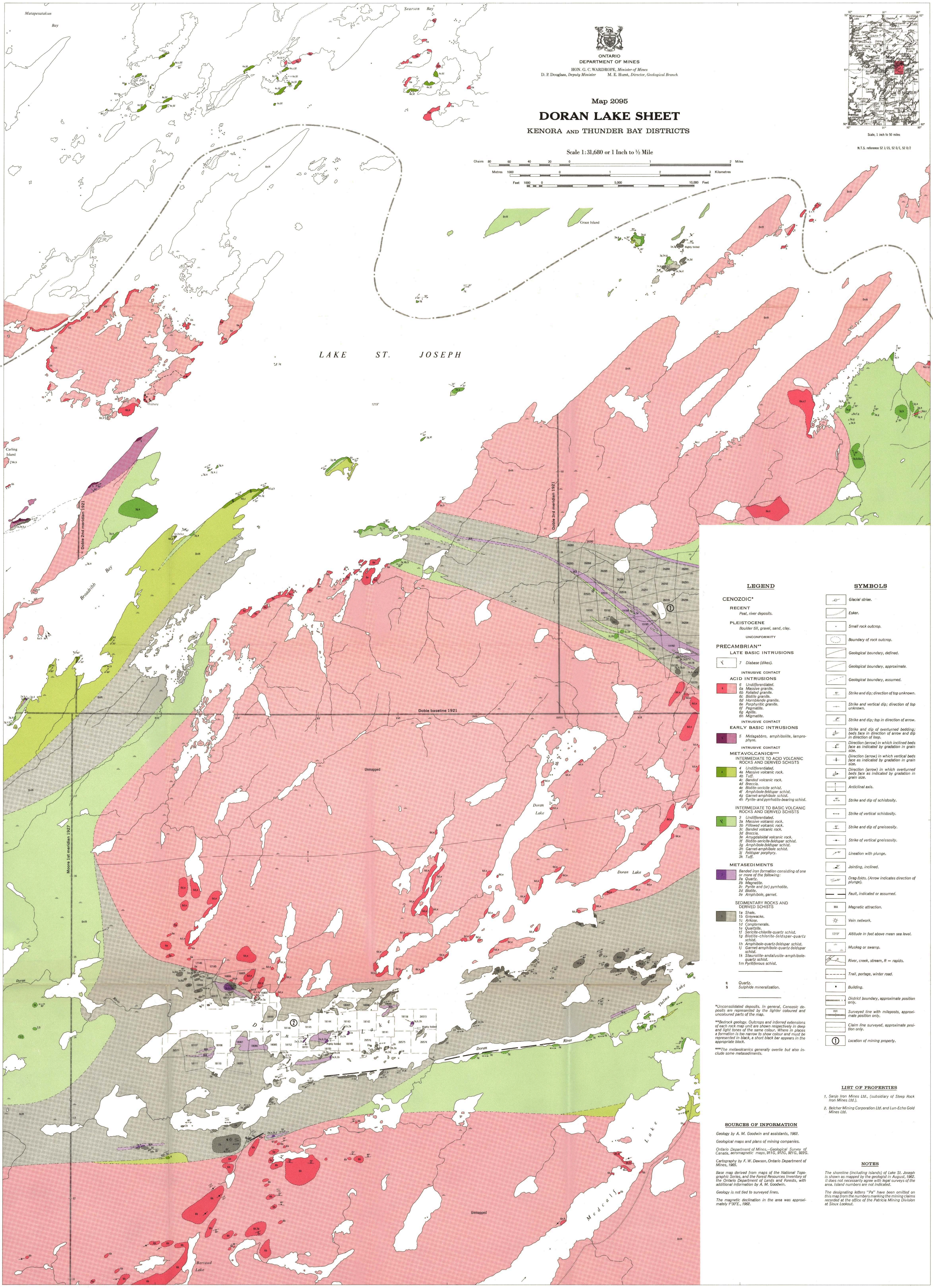
HON. G. C. WARDROPE, *Minister of Mines*
D. P. Douglass, *Deputy Minister* M. E. Hurst, *Director, Geological Branch*

Map 2095

DORAN LAKE SHEET

KENORA AND THUNDER BAY DISTRICTS

Scale 1:31,680 or 1 Inch to ½ Mile



N.T.S. reference 52 J/15, 52 O/1, 52 O/2

LEGEND

CENOZOIC*

RECENT
Peat, river deposits.

PLEISTOCENE
Boulder till, gravel, sand, clay.

UNCONFORMITY

PRECAMBRIAN**

LATE BASIC INTRUSIONS

- 7 *Diabase (dikes).*

INTRUSIVE CONTACT

ACID INTRUSIONS

- 6 *Undifferentiated.*
- 6a *Massive granite.*
- 6b *Foliated granite.*
- 6c *Biotite granite.*
- 6d *Hornblende granite.*
- 6e *Porphyritic granite.*
- 6f *Pegmatite.*
- 6g *Aplite.*
- 6h *Migmatite.*

INTRUSIVE CONTACT

EARLY BASIC INTRUSIONS

- 5 *Metagabbro, amphibolite, lamprophyre.*

INTRUSIVE CONTACT

METAVOLCANICS***

INTERMEDIATE TO ACID VOLCANIC ROCKS AND DERIVED SCHISTS

- 4 *Undifferentiated.*
- 4a *Massive volcanic rock.*
- 4b *Tuff.*
- 4c *Banded volcanic rock.*
- 4d *Breccia.*
- 4e *Biotite-sericite schist.*
- 4f *Amphibole-feldspar schist.*
- 4g *Garnet-amphibole schist.*
- 4h *Pyrite- and pyrrhotite-bearing schist.*

INTERMEDIATE TO BASIC VOLCANIC ROCKS AND DERIVED SCHISTS

- 3 *Undifferentiated.*
- 3a *Massive volcanic rock.*
- 3b *Pillowed volcanic rock.*
- 3c *Banded volcanic rock.*
- 3d *Breccia.*
- 3e *Amygdaloidal volcanic rock.*
- 3f *Biotite-sericite-feldspar schist.*
- 3g *Amphibole-feldspar schist.*
- 3h *Garnet-amphibole schist.*
- 3j *Feldspar porphyry.*
- 3k *Tuff.*

METASEDIMENTS

- 2 *Banded iron formation consisting of one or more of the following:*
  - 2a *Quartz.*
  - 2b *Magnetite.*
  - 2c *Pyrite and (or) pyrrhotite.*
  - 2d *Biotite.*
  - 2e *Amphibole, garnet.*

SEDIMENTARY ROCKS AND DERIVED SCHISTS

- 1a *Shale.*
- 1b *Greywacke.*
- 1c *Arkose.*
- 1d *Conglomerate.*
- 1e *Quartzite.*
- 1f *Sericite-chlorite-quartz schist.*
- 1g *Biotite-chlorite-feldspar-quartz schist.*
- 1h *Amphibole-quartz-feldspar schist.*
- 1j *Garnet-amphibole-quartz-feldspar schist.*
- 1k *Staurolite-andalusite-amphibole-quartz schist.*
- 1m *Pyritiferous schist.*

---

q *Quartz.*
s *Sulphide mineralization.*

**Unconsolidated deposits. In general, Cenozoic deposits are represented by the lighter coloured and uncoloured parts of the map.*

***Bedrock geology. Outcrops and inferred extensions of each rock map unit are shown respectively in deep and light tones of the same colour. Where in places a formation is too narrow to show colour and must be represented in black, a short black bar appears in the appropriate block.*

****The metavolcanics generally overlie but also include some metasediments.*

SYMBOLS

Glacial striae.
Esker.
× *Small rock outcrop.*
Boundary of rock outcrop.
Geological boundary, defined.
Geological boundary, approximate.
Geological boundary, assumed.
45° *Strike and dip; direction of top unknown.*
Strike and vertical dip; direction of top unknown.
40° *Strike and dip; top in direction of arrow.*
45° *Strike and dip of overturned bedding; beds face in direction of arrow and dip in direction of loop.*
45° *Direction (arrow) in which inclined beds face as indicated by gradation in grain size.*
Direction (arrow) in which vertical beds face as indicated by gradation in grain size.
45° *Direction (arrow) in which overturned beds face as indicated by gradation in grain size.*
Anticlinal axis.
45° *Strike and dip of schistosity.*
Strike of vertical schistosity.
45° *Strike and dip of gneissosity.*
Strike of vertical gneissosity.
45° *Lineation with plunge.*
40° *Jointing, inclined.*
60° *Drag-folds. (Arrow indicates direction of plunge).*
Fault, indicated or assumed.
MA *Magnetic attraction.*
Vein network.
1219′ *Altitude in feet above mean sea level.*
Muskeg or swamp.
R *River, creek, stream, R = rapids.*
Trail, portage, winter road.
■ *Building.*
District boundary, approximate position only.
XVI *Surveyed line with mileposts, approximate position only.*
Claim line surveyed, approximate position only.
① *Location of mining property.*

LIST OF PROPERTIES

1. *Sanjo Iron Mines Ltd., (subsidiary of Steep Rock Iron Mines Ltd.).*
2. *Belcher Mining Corporation Ltd. and Lun-Echo Gold Mines Ltd.*

SOURCES OF INFORMATION

Geology by A. M. Goodwin and assistants, 1962.

Geological maps and plans of mining companies.

Ontario Department of Mines,—Geological Survey of Canada, aeromagnetic maps, 911G, 912G, 921G, 922G.

Cartography by F. W. Dawson, Ontario Department of Mines, 1965.

Base map derived from maps of the National Topographic Series, and the Forest Resources Inventory of the Ontario Department of Lands and Forests, with additional information by A. M. Goodwin.

Geology is not tied to surveyed lines.

The magnetic declination in the area was approximately 1°30′E., 1962.

NOTES

The shoreline (including islands) of Lake St. Joseph is shown as mapped by the geologist in August, 1962. It does not necessarily agree with legal surveys of the area. Island numbers are not indicated.

The designating letters "Pa" have been omitted on this map from the numbers marking the mining claims recorded at the office of the Patricia Mining Division at Sioux Lookout.

Published 1965

ONTARIO
DEPARTMENT OF MINES

HON. G. C. WARDROPE, *Minister of Mines*
D. P. Douglass, *Deputy Minister* M. E. Hurst, *Director, Geological Branch*

Map 2094
Pashkokogan Lake Sheet

SYMBOLS

	Glacial striae.
	Esker.
×	*Small rock outcrop.*
	Boundary of rock outcrop.
	Geological boundary, defined.
	Geological boundary, approximate.
	Geological boundary, assumed.
45°	*Strike and dip; direction of top unknown.*
	Strike and vertical dip; direction of top unknown.
65°	*Strike and dip; top in direction of arrow.*
30°	*Strike and dip of overturned bedding; beds face in direction of arrow and dip in direction of loop.*
50°	*Direction (arrow) in which inclined beds face as indicated by gradation in grain size.*
80°	*Direction (arrow) in which overturned beds face as indicated by gradation in grain size.*
	Direction in which lava flows face as indicated by shape of pillows.
	Synclinal axis.
	Anticlinal axis.
70°	*Direction of plunge of fold axis, crest line or trough line.*
40°	*Strike and dip of schistosity.*
	Strike of vertical schistosity.
	Strike of schistosity, dip unknown.
75°	*Strike and dip of gneissosity.*
	Strike of vertical gneissosity.
60°	*Lineation (plunge known, plunge unknown).*
70°	*Drag-folds. (Arrow indicates direction of plunge).*
MA	*Magnetic attraction.*
	Vein.
•	*Mineral occurrence.*
1237′	*Altitude in feet above mean sea level.*
	Muskeg or swamp.
R F	*River, creek, stream, R = rapids; F = falls.*
599	*Motor road with provincial highway number.*
	Other road.
	Trail, portage, winter road.
▪	*Building.*
I	*Surveyed line with mileposts, approximate position only.*
III	*Indian reserve boundary with mileposts, approximate position only.*
	Claim line surveyed, approximate position only.
①	*Location of mining property.*

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1. *Sanjo Iron Mines Ltd., (subsidiary of Steep Rock Iron Mines Ltd.).*

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Geological maps and plans of mining companies.

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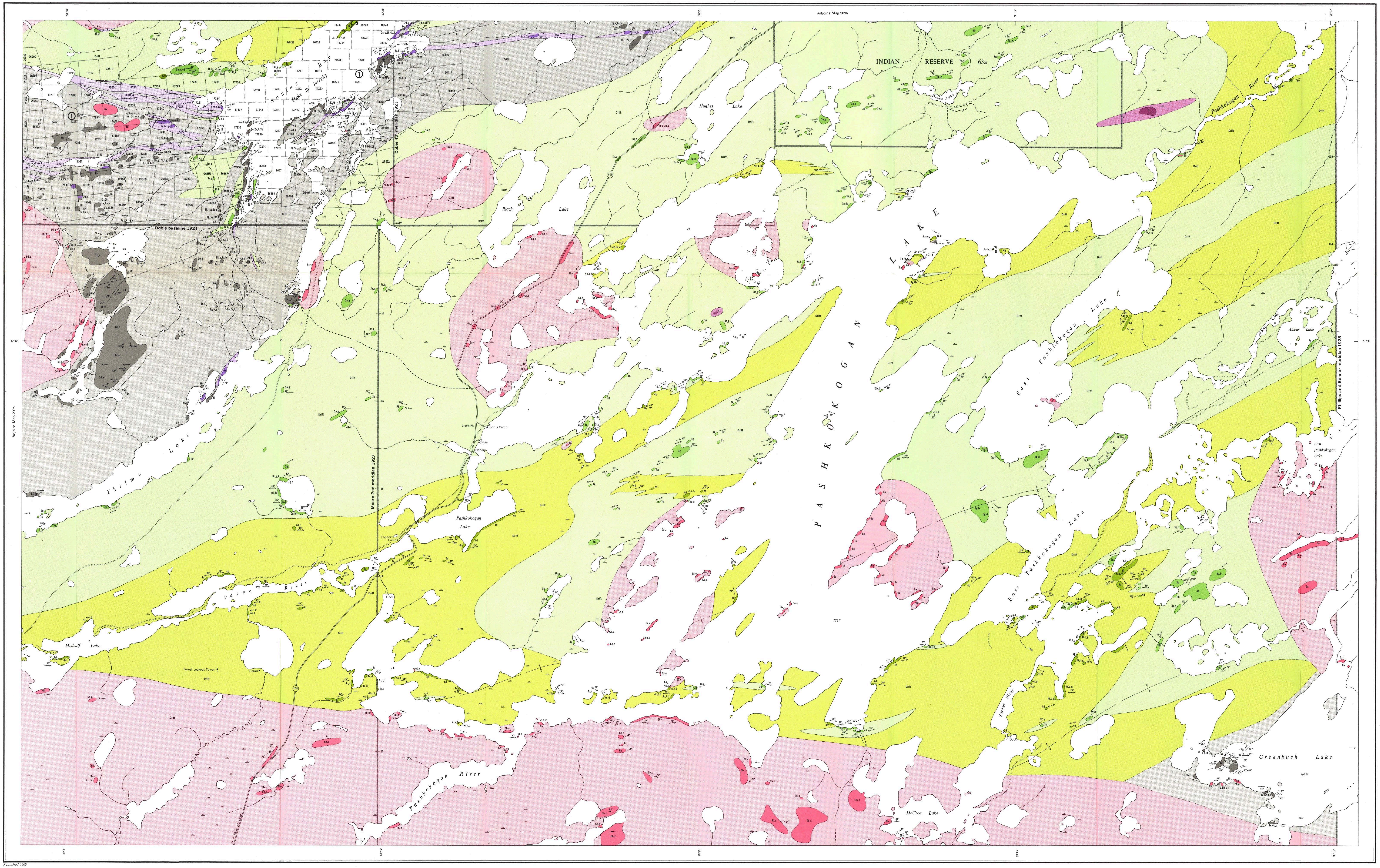

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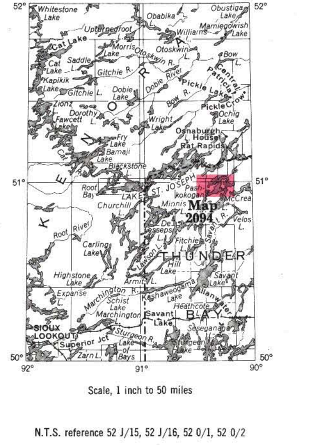

Scale, 1 inch to 50 miles

N.T.S. reference 52 J/15, 52 J/16, 52 0/1, 52 0/2

LEGEND

CENOZOIC*

RECENT
Peat, river deposits.

PLEISTOCENE
Boulder till, gravel, sand, clay.

UNCONFORMITY

PRECAMBRIAN**

LATE BASIC INTRUSIONS

7	7 *Diabase (dikes).*

INTRUSIVE CONTACT

ACID INTRUSIONS

6	6 *Undifferentiated.* 6a *Massive granite.* 6b *Foliated granite.* 6c *Biotite granite.* 6d *Hornblende granite.* 6e *Porphyritic granite.* 6f *Pegmatite.* 6g *Aplite.* 6h *Migmatite.*

INTRUSIVE CONTACT

EARLY BASIC INTRUSIONS

5	5 *Metagabbro, amphibolite, lamprophyre.*

INTRUSIVE CONTACT

METAVOLCANICS***

INTERMEDIATE TO ACID VOLCANIC ROCKS AND DERIVED SCHISTS

4	4 *Undifferentiated.* 4a *Massive volcanic rock.* 4b *Tuff.* 4c *Banded volcanic rock.* 4d *Breccia.* 4e *Biotite-sericite schist.* 4f *Amphibole-feldspar schist.* 4g *Garnet-amphibole schist.* 4h *Pyrite- and pyrrhotite-bearing schist.*

INTERMEDIATE TO BASIC VOLCANIC ROCKS AND DERIVED SCHISTS

3	3 *Undifferentiated.* 3a *Massive volcanic rock.* 3b *Pillowed volcanic rock.* 3c *Banded volcanic rock.* 3d *Breccia.* 3e *Amygdaloidal volcanic rock.* 3f *Biotite-sericite-feldspar schist.* 3g *Amphibole-feldspar schist.* 3h *Garnet-amphibole schist.* 3j *Feldspar porphyry.* 3k *Tuff.*

METASEDIMENTS

2	*Banded iron formation consisting of one or more of the following:* 2a *Quartz.* 2b *Magnetite.* 2c *Pyrite and (or) pyrrhotite.* 2d *Biotite.* 2e *Amphibole, garnet.*

SEDIMENTARY ROCKS AND DERIVED SCHISTS

1	1a *Shale.* 1b *Greywacke.* 1c *Arkose.* 1d *Conglomerate.* 1e *Quartzite.* 1f *Sericite-chlorite-quartz schist.* 1g *Biotite-chlorite-feldspar-quartz schist.* 1h *Amphibole-quartz-feldspar schist.* 1j *Garnet-amphibole-quartz-feldspar schist.* 1k *Staurolite-andalusite-amphibole-quartz schist.* 1m *Pyritiferous schist.*

Li	*Lithium.*
q	*Quartz.*
S	*Sulphide mineralization.*

**Unconsolidated deposits. In general, Cenozoic deposits are represented by the lighter coloured and uncoloured parts of the map.*

***Bedrock geology. Outcrops and inferred extensions of each rock map unit are shown respectively in deep and light tones of the same colour. Where in places a formation is too narrow to show colour and must be represented in black, a short black bar appears in the appropriate block.*

****The metavolcanics generally overlie but also include some metasediments.*

NOTES

The shoreline (including islands) of Lake St. Joseph is shown as mapped by the geologist in August, 1962. It does not necessarily agree with legal surveys of the area. Island numbers are not indicated.

The designating letters "Pa" have been omitted on this map from the numbers marking the mining claims recorded at the office of the Patricia Mining Division at Sioux Lookout.

Map 2094

PASHKOKOGAN LAKE SHEET

THUNDER BAY DISTRICT

Scale 1:31,680 or 1 Inch to ½ Mile

Chains 80 60 40 20 0 1 2 Miles

Metres 1000 0 1 2 3 Kilometres

Feet 1000 0 5,000 10,000 Feet

LEGEND

CENOZOIC*

RECENT

Peat, river deposits.

PLEISTOCENE

Boulder till, gravel, sand, clay.

UNCONFORMITY

PRECAMBRIAN**

LATE BASIC INTRUSIONS

7 — 7 *Diabase (dikes).†*

INTRUSIVE CONTACT

ACID INTRUSIONS

6
- 6 *Undifferentiated.*
- 6a *Massive granite.*
- 6b *Foliated granite.*
- 6c *Biotite granite.*
- 6d *Hornblende granite.*
- 6e *Porphyritic granite.*
- 6f *Pegmatite.*
- 6g *Aplite.*
- 6h *Migmatite.*

INTRUSIVE CONTACT

EARLY BASIC INTRUSIONS

5 — 5 *Metagabbro, amphibolite, lamprophyre.†*

INTRUSIVE CONTACT

METAVOLCANICS***

INTERMEDIATE TO ACID VOLCANIC ROCKS AND DERIVED SCHISTS

4
- 4 *Undifferentiated.*
- 4a *Massive volcanic rock.*
- 4b *Tuff.*
- 4c *Banded volcanic rock.*
- 4d *Breccia.*
- 4e *Biotite-sericite schist.*
- 4f *Amphibole-feldspar schist.*
- 4g *Garnet-amphibole schist.*
- 4h *Pyrite- and pyrrhotite-bearing schist.*

INTERMEDIATE TO BASIC VOLCANIC ROCKS AND DERIVED SCHISTS

3
- 3 *Undifferentiated.*
- 3a *Massive volcanic rock.*
- 3b *Pillowed volcanic rock.*
- 3c *Banded volcanic rock.*
- 3d *Breccia.*
- 3e *Amygdaloidal volcanic rock.*
- 3f *Biotite-sericite-feldspar schist.*
- 3g *Amphibole-feldspar schist.*
- 3h *Garnet-amphibole schist.*
- 3j *Feldspar porphyry.*
- 3k *Tuff.*

METASEDIMENTS

2 — *Banded iron formation consisting of one or more of the following:*
- 2a *Quartz.*
- 2b *Magnetite.*
- 2c *Pyrite and (or) pyrrhotite.*
- 2d *Biotite.*
- 2e *Amphibole, garnet.*

SEDIMENTARY ROCKS AND DERIVED SCHISTS

1
- 1a *Shale.*
- 1b *Greywacke.*
- 1c *Arkose.*
- 1d *Conglomerate.*
- 1e *Quartzite.*
- 1f *Sericite-chlorite-quartz schist.*
- 1g *Biotite-chlorite-feldspar-quartz schist.*
- 1h *Amphibole-quartz-feldspar schist.*
- 1j *Garnet-amphibole-quartz-feldspar schist.*
- 1k *Staurolite-andalusite-amphibole-quartz schist.*
- 1m *Pyritiferous schist.*

S *Sulphide mineralization.*

**Unconsolidated deposits. In general, Cenozoic deposits are represented by the lighter coloured and uncoloured parts of the map.*

***Bedrock geology. Outcrops and inferred extensions of each rock map unit are shown respectively in deep and light tones of the same colour. Where in places a formation is too narrow to show colour and must be represented in black, a short black bar appears in the appropriate block.*

****The metavolcanics generally overlie but also include some metasediments.*

† Formations without colour in the legend blocks are mapped on companion sheets.

SYMBOLS

- *Glacial striae.*
- *Esker.*
- *Small rock outcrop.*
- *Boundary of rock outcrop.*
- *Geological boundary, defined.*
- *Geological boundary, approximate.*
- *Geological boundary, assumed.*
- 60° *Strike and dip; direction of top unknown.*
- *Strike and vertical dip; direction of top unknown.*
- 70° *Strike and dip; top in direction of arrow.*
- 50° *Strike and dip of overturned bedding; beds face in direction of arrow and dip in direction of loop.*
- *Direction in which lava flows face as indicated by shape of pillows.*
- *Anticlinal axis.*
- *Direction of plunge of fold axis, crest line or trough line.*
- 55° *Strike and dip of schistosity.*
- *Strike of vertical schistosity.*
- *Strike of schistosity, dip unknown.*
- 60° *Strike and dip of gneissosity.*
- 70° *Lineation (plunge known, plunge unknown).*
- 55° *Drag-folds. (Arrow indicates direction of plunge).*
- MA *Magnetic attraction.*
- 1219′ *Altitude in feet above mean sea level.*
- *Muskeg or swamp.*
- R F *River, creek, stream, R = rapids; F = falls.*
- 599 *Motor road with provincial highway number.*
- *Other road.*
- *Trail, portage, winter road.*
- *Building.*
- *District boundary, approximate position only.*
- 119 *Surveyed line with mileposts, approximate position only.*
- II *Indian reserve boundary with mileposts, approximate position only.*
- *Claim line surveyed, approximate position only.*
- ① *Location of mining property.*

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1. *Sanjo Iron Mines Ltd., (subsidiary of Steep Rock Iron Mines Ltd.).*

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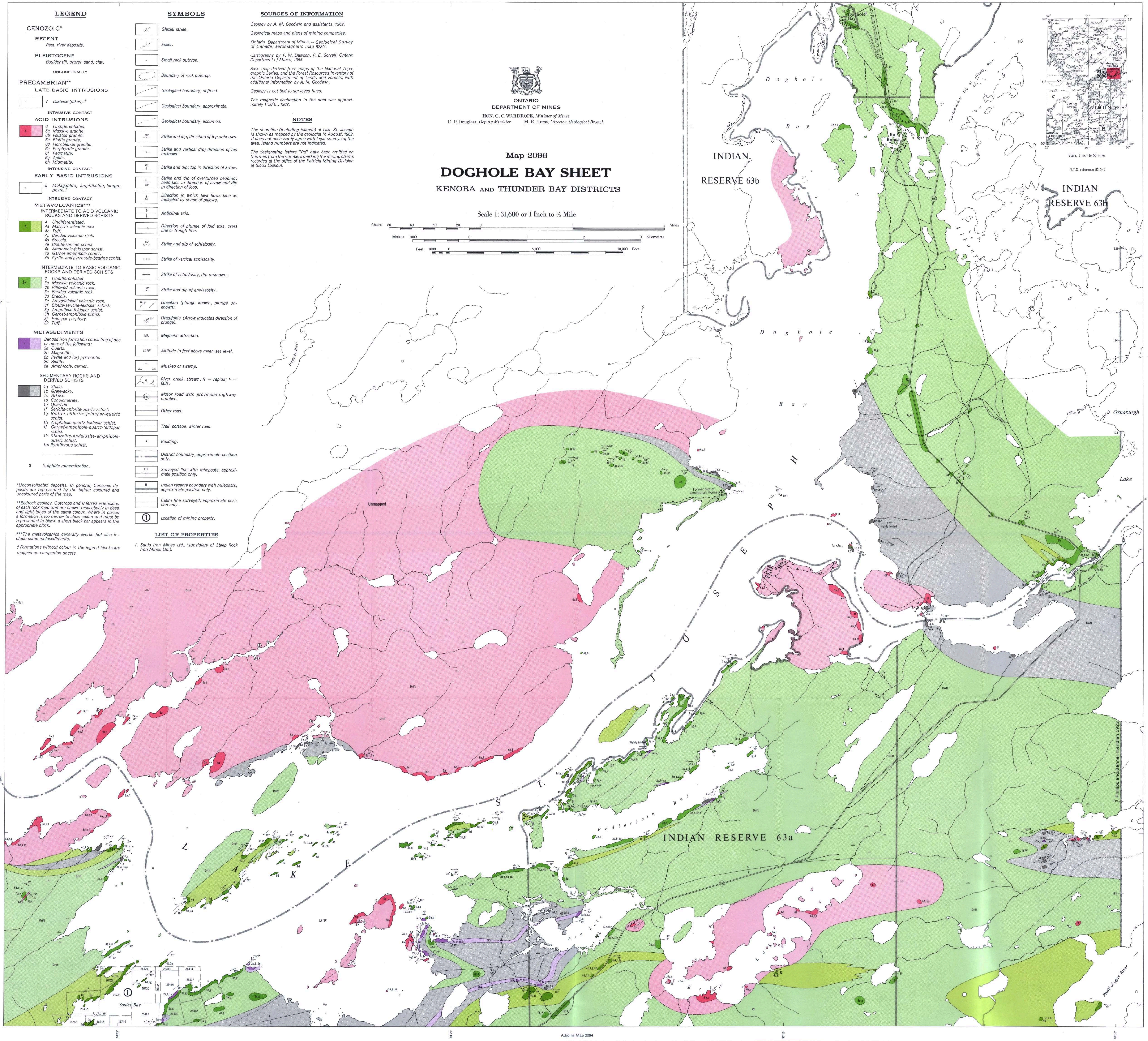
Map 2096

DOGHOLE BAY SHEET

KENORA AND THUNDER BAY DISTRICTS

Scale 1:31,680 or 1 Inch to ½ Mile



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