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Espanola-Whitefish Falls Area
District of Sudbury, Ontario

by
K.D. Card

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ABSTRACT

The Espanola-Whitefish Falls map-area, an area of about 144 square miles (375 km^2) which includes the townships of Merritt, Foster, Mongowin, and Curtin; is located along the North Shore of Lake Huron in the eastern part of the Southern Province.

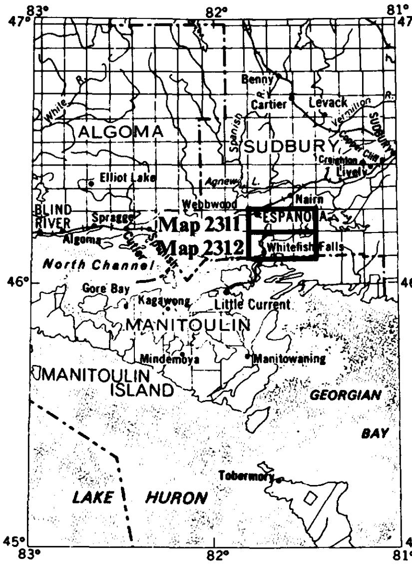

Figure 1–Key map showing location of Espanola-Whitefish Falls area. Scale 1 inch to 50 miles or 1:3,168,000.

Middle Precambrian (Proterozoic) metasediments and mafic intrusives underlie the area. The metasediments, which belong to the Huronian Supergroup, can be subdivided into four groups and ten lithostratigraphic formations. The medium- to coarse-grained clastic metasediments which constitute these formations were derived from a granitoid source to the north, and were deposited in a deltaic or shelf-type environment.

Mafic intrusions of several ages are present, and include Nipissing Diabase, amphibolite dikes, a differentiated ultramafic-granophyric pluton, and late olivine diabase dikes.

The rocks of the area were deformed and regionally metamorphosed during a protracted series of orogenic events. There is geological and radiometric age evidence for major deformation of the Huronian rocks before the intrusion of Nipissing Diabase (2,150 million years) and for later, post-Nipissing deformation and regional metamorphism.

During the Pleistocene there was extensive glacial scouring and minor related deposition.

There are occurrences of gold, copper, nickel, cobalt, and tungsten in the area. Gold was produced from several deposits in the area. Silica for smelting purposes is currently being quarried from the Lorrain Formation.

Geology

of the

Espanola-Whitefish Falls Area

District of Sudbury, Ontario

by

K. D. Card[1]

INTRODUCTION

The centre of Merritt, Foster, Mongowin, and Curtin Townships, an area of about 144 square miles (375 km^2), is approximately 6 miles (10 km) southeast of the town of Espanola and 40 miles (65 km) southwest of Sudbury, Ontario. The map-area is on the North Shore of Lake Huron, north of McGregor Bay and Manitoulin Island.

Highway 68, which connects Highway 17 with Manitoulin Island, crosses the area. A spur line of the Canadian Pacific Railway extends south through the map-area. A gravel road connects Espanola with the West Bay of Lake Panache and branch roads afford access to Deerhound and Hannah Lakes in Curtin Township. Several gravel roads provide access to western and southern Merritt Township. Drainage systems such as Raven and Bass Lakes in Mongowin Township, Lang Lake, the Charlton Lake-Howry Creek system in Curtin Township, and the waters of Lake Huron provide access to much of Mongowin and Curtin Townships.

The map-area is located in the classical Huronian area of the North Shore of Lake Huron in the eastern part of the Southern Province of the Precambrian Shield (Card and Church *et al.* 1972) and consequently has been an area of interest to geologists and prospectors for over 100 years. The earliest discovery of nickel in Canada was made along the North Shore of Lake Huron near Whitefish Falls in Mongowin Township. The present work is part of a program of detailed remapping of the entire North Shore of Lake Huron.

The mapping, on the scale of 1 inch to 1,320 feet (1:15,840) was carried out over a period of about seven months in the summers of 1965 and 1966. In the field, pace and compass traverses were made at irregular intervals, the maximum interval was one quarter of a mile (0.4 km), depending on the geological complexity and the

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[1] Geologist, Ontario Department of Mines, Sudbury, Ontario. This report was submitted in October, 1968 but publication was delayed pending further work in the region. The report was partly revised and updated by the author in 1972. The manuscript was approved for publication by the Chief Geologist 10 December 1973.

amount of outcrop. Data gathered were plotted on perfatrace overlays on 1 inch to 1,320 feet (1:15,840) air photographs, and transferred to base maps of similar scale prepared by the Cartography Section, Surveys and Mapping Branch, Ontario Division of Lands from Forest Resources Inventory Maps.[1] Preliminary geological maps of Merritt (P.322), Foster (P.390), Mongowin (P.391), and Curtin (P.392) Townships were issued by the Ontario Department of Mines in 1966 and 1967 at a scale of 1 inch to 1,320 feet (1:15,840).

During 1965 the author was assisted in the field by C. E. Blackburn, D. Brown, P. A. Palonen, A. Young, and S. Rivett, and in 1966 by P. Kirst, C. Blackburn, R. Palliser, L. Dozzi, and S. Quirt. Blackburn, Brown, and Kirst were responsible for some of the mapping. The writer wishes to thank local residents, especially the owners of Stump and Spry, tourist operators, for the many services rendered. D. C. McKechnie, consultant geologist, provided information on several of the gold occurrences. The manuscript was critically reviewed by E. G. Pye and S. B. Lumbers who offered many suggestions for improvement of the report.

PREVIOUS GEOLOGICAL WORK

Logan and Murray, in the summer of 1848, made a reconnaissance traverse along the North Shore of Lake Huron between Bruce Mines and Killarney. They visited and described the Wallace Mine location just west of Whitefish Falls. Murray (1849, 1857) described sections along the Spanish River and the Lang Lake-Cross Lake-Whitefish River system. Bell (1891) mapped Merritt and Foster Townships. Mapping in the area was carried out by Quirke (1917) and Collins (1925) who established the general sequence of formations and events. Recent mapping in the neighbouring townships has been done by Thomson (1952), Ginn (1961, 1965), Card (1965a, 1968a), Frarey (1967a), and Robertson (1967).

PHYSIOGRAPHY

The area is rugged with a maximum relief of about 800 feet (240 m). The highest point is 1,370 feet (418 m) above mean sea level. Vegetation is generally sparse, especially on the higher hills, and consequently the rock exposures are good to excellent. Bedrock outcrops constitute approximately 50 percent of the area.

The topography is controlled largely by bedrock lithology and unconsolidated surficial deposits. The sandstones are generally resistant to erosion and form high, bare ridges such as the La Cloche hills along the North Shore of Lake Huron. Conglomeratic units such as the Gowganda and Bruce Formations are generally at lower elevations than the sandstones and are well exposed. The calcareous rocks of the Espanola Formation are the least resistant to erosion and are commonly marked by lakes, streams, and swamps. The unconsolidated Quaternary deposits form flat sandplains such as the area around the town of Espanola.

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[1] On 1st April 1972 the Ontario Government was completely reorganized. The Ontario Department of Mines and the Ontario Department of Lands and Forests were restructured within the newly created Ministry of Natural Resources.

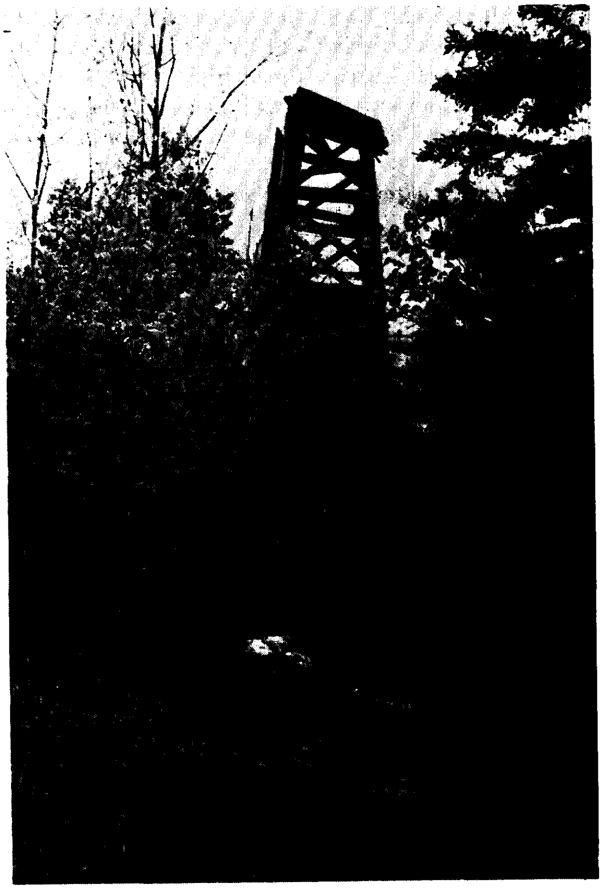

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Photo 1–The headframe of the Majestic Gold Mine, Mongowin Township.

The area is poorly drained by Spanish River, West River, Whitefish River, and Howry Creek. There are numerous lakes present, most of which are elongated east and west parallel to the bedrock trends.

RESOURCES AND DEVELOPMENT

The area is noted mainly for its scenic beauty, and, therefore the hills and lakes are a valuable natural resource.

Tree species are spruce, balsam, cedar and tamarack in swampy areas; maple, birch, poplar and pine in rocky upland areas; and pine, birch and poplar in sandy, soil-covered areas. The high bare hills along the North Shore are covered sparsely with scrubby jackpine and oak. Timber resources are of limited value, although a large tract in central Mongowin Township was exploited for pulpwood in 1966. Lumbering operations were also carried out in the recent past in the Deerhound Lake and Grace Lake areas of Curtin Township. The Brown Paper Company Limited, formerly the KVP Company Limited, operates a pulp and paper mill[1] at Espanola on the Spanish River. The mill is the basic industry supporting this town of about 5,000 people.

Limited dairy farming is carried on in northern and southwestern Merritt Township.

Game and fur-bearing animals present are deer, bear, moose, ruffed grouse, ducks, beaver, and mink. The principal fish species are pike, pickerel, and bass, although trout are present in suitable waters.

There are numerous tourist operators and privately owned summer camps in the area, notably at Whitefish Falls, Willisville, Lake Panache, and on the lakes along Highway 68.

The remains of old gold mining activities are common throughout the district. At the McMillan Mine (Dayjon Explorations and Holdings Limited) in Mongowin Township, the mill and mine building foundations can be seen. Tailings from the operation partly fill House Lake. Just west of Highway 68, the wooden headframe of the Majestic Mine (Gregory, Charles, Estate) is still standing (Photo 1).

The International Nickel Company of Canada Limited operates a quartzite quarry, the Lawson quarry, at Willisville in Curtin Township. This operation employs people from Willisville, a village of about 50 people, and Whitefish Falls, with a population of about 150 people.

GENERAL GEOLOGY

The bedrock in the map-area consists of Precambrian rocks which are partly mantled by unconsolidated Cenozoic deposits. The oldest rocks, metasediments of the Middle Precambrian Huronian Supergroup, can be divided into four groups and ten formations. These are, from oldest to youngest, the McKim Formation of the Elliot Lake Group; the Ramsay Lake, Pecors, and Mississagi Formations of the Hough Lake Group; the Bruce, Espanola, and Serpent Formations of the Quirke Lake Group; and the Gowganda, Lorrain and Gordon Lake Formations of the Cobalt Group.

The rocks were folded, faulted, metamorphosed and intruded by sill-like bodies of Nipissing Diabase, amphibolite dikes, a small composite ultramafic-granophyre pluton, and late diabase dikes. A few miles (kilometres) south of the map-area, Paleozoic limestones and shales unconformably overlap the Precambrian rocks. Pleistocene glaciation scoured and gouged the bedrock, and left behind a thin, discontinuous mantle of sand, gravel, and clay. The foregoing sequence is summarized in the Table of Formations.

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[1] Owned and operated by Eddy Forest Products Limited in 1972.

Table 1 TABLE OF FORMATIONS FOR THE ESPANOLA-WHITEFISH FALLS AREA

- CENOZOIC
  - QUATERNARY
    - PLEISTOCENE AND RECENT
      - Sand, gravel, clay

Unconformity

- PRECAMBRIAN
  - LATE PRECAMBRIAN (Proterozoic)
    - LATE DIABASE INTRUSIONS
      - Diabase, olivine diabase

Intrusive Contact

- MIDDLE PRECAMBRIAN (Proterozoic)
  - MONGOWIN PLUTON
    - Metaperidotite, diorite, granodiorite, trondhjemite

Intrusive Contact

- AMPHIBOLITE INTRUSIONS
  - Amphibolite, porphyritic amphibolite

Intrusive Contact

- NIPISSING DIABASE
  - Gabbro, metagabbro

Intrusive Contact

- HURONIAN SUPERGROUP
  - COBALT GROUP
    - GORDON LAKE FORMATION
      - Argillite, sandstone
    - LORRAIN FORMATION
      - Sandstone, minor conglomerate and argillite
    - GOWGANDA FORMATION
      - Conglomerate, argillite, sandstone

Disconformable Contact

- QUIRKE LAKE GROUP
  - SERPENT FORMATION
    - Sandstone, minor conglomerate, argillite and calcareous metasediments
  - ESPANOLA FORMATION
    - Limestone, calcareous siltstone, argillite, breccia, sandstone, hornfels, amphibolite and skarn
  - BRUCE FORMATION
    - Conglomerate, minor argillite, sandstone

Conformable Contact?

- HOUGH LAKE GROUP
  - MISSISSAGI FORMATION
    - Sandstone, minor argillite and conglomerate
  - PECORS FORMATION
    - Argillite, sandstone
  - RAMSAY LAKE FORMATION
    - Conglomerate, sandstone

Conformable Contact

- ELLIOT LAKE GROUP
  - MCKIM FORMATION
    - Argillite, siltstone, sandstone

DEFINITIONS

Sandstone — a sedimentary rock composed mainly of sand-size (1/16 mm to 2 mm) fragments.

Orthoquartzite — a sandstone composed of more than 95 percent quartz and less than 10 percent matrix. The matrix consists of silt-size quartz (or quartz and feldspar) and phyllosilicate minerals.

Protoquartzite — a sandstone composed mainly of quartz and feldspar with 10 to 20 percent matrix.

Subgreywacke — a sandstone intermediate in composition between orthoquartzite and greywacke composed mainly of quartz, feldspar, and rock fragments with 20 to 30 percent matrix.

Greywacke — a sandstone with more than 30 percent matrix.

Quartz greywacke — greywacke with more than 75 percent quartz in the sand-sized fraction.

Feldspathic (Lithic) subgreywacke — subgreywacke with more than 25 percent feldspar (rock fragments) in the sand-sized fraction.

Feldspathic (Lithic) protoquartzite — protoquartzite with more than 25 percent feldspar (rock fragments).

Feldspathic quartzite — a sandstone with less than 10 percent matrix and 5 to 25 percent feldspar.

Arkose — a sandstone with less than 10 percent matrix and more than 25 percent feldspar.

Coarse-grained sandstone — a sandstone in which most of the sand-sized grains are over 1 mm in diameter.

Medium-grained sandstone — a sandstone in which most of the sand-sized grains range in size from ¼ mm to 1 mm.

Fine-grained sandstone — a sandstone in which most of the sand-sized grains are less than ¼ mm in diameter.

Polymictic conglomerate — a conglomerate with pebbles of more than one rock-type.

Oligomictic conglomerate — a conglomerate with pebbles of a single rock-type.

Paraconglomerate — a conglomerate with a disrupted framework (pebbles do not touch each other). Paraconglomerates generally contain over 50 percent matrix.

Orthoconglomerate — a conglomerate with an intact framework (pebbles touch each other). Orthoconglomerates generally contain over 70 percent pebbles.

Pelite — a metamorphosed, fine-grained (mudstone, siltstone) clastic sedimentary rock.

Thick-bedded — sedimentary bedding over 3 feet (0.9 m) thick.

Medium-bedded — sedimentary bedding 1 to 3 feet (0.3 to 0.9 m) thick.

Thin-bedded — sedimentary bedding less than 1 foot (0.3 m) thick.

Antiform — an upward-closing fold in which the stratigraphic relationships are unknown.

Synform — a downward-closing fold in which the stratigraphic relationships are unknown.

MIDDLE PRECAMBRIAN

Huronian Supergroup

The map-area is underlain mainly by metamorphosed, clastic sedimentary rocks of the Huronian Supergroup which were deposited between 2,150 million years and 2,500 million years ago (Van Schmus 1965). Quirke (1917) considered the lowermost formations to be pre-Huronian, but it has been demonstrated, mainly outside the present map-area, that the various metasedimentary formations of the region are part of a single, unbroken sequence which can be correlated with the Huronian sequence to the west (Card 1965a, 1968a).

The subdivisions of the Huronian sequence are given in the Table of Formations (Table 1), and (Table 2, Chart B, back pocket) compares the various stratigraphic terminologies used by past workers with that of the present report. The Huronian stratigraphic terminology used herein conforms to the recommendations of the Federal-Provincial Committee on Huronian Stratigraphy which are summarized by Robertson *et al.* (1968), Robertson, Card and Frarey (1969) and Robertson, Frarey and Card (1969).

In the following descriptions of the various formations, emphasis is placed on the original lithology and primary structures. These primary features are readily discernible, although they are commonly modified to some extent by metamorphism and deformation. Phenomena caused by metamorphism and deformation are described in later sections.

ELLIOT LAKE GROUP

McKIM FORMATION

Rocks of the McKim Formation are exposed in northwestern Merritt Township. The McKim Formation was originally considered to be of pre-Huronian age (Collins 1936), but it has been demonstrated (Card 1965a) that this formation is part of the Huronian Supergroup, which in this area is uninterrupted by any major erosional break.

The thickness of the McKim Formation cannot be determined in the map-area because of the structural complexity. Nevertheless, to the northeast in the Denison-Waters area, the formation is approximately 5,000 feet (1,500 m) thick (Card 1968a). The formation consists mainly of pelitic metasediments which were originally siltstone, shale, and fine-grained greywacke. In addition, there are lesser amounts (15 to 20 percent) of protoquartzite and subgreywacke. Pelitic rocks are composed mainly of quartz (25 to 50 percent) and muscovite (20 to 40 percent) with variable amounts of plagioclase, biotite, chlorite, and ilmenite. Porphyroblasts of chlorite. chloritoid, and garnet are locally present. Chemically, the metapelites are rich in Al_2O_3 and iron, and poor in Na_2O and CaO (*see* Table 5).

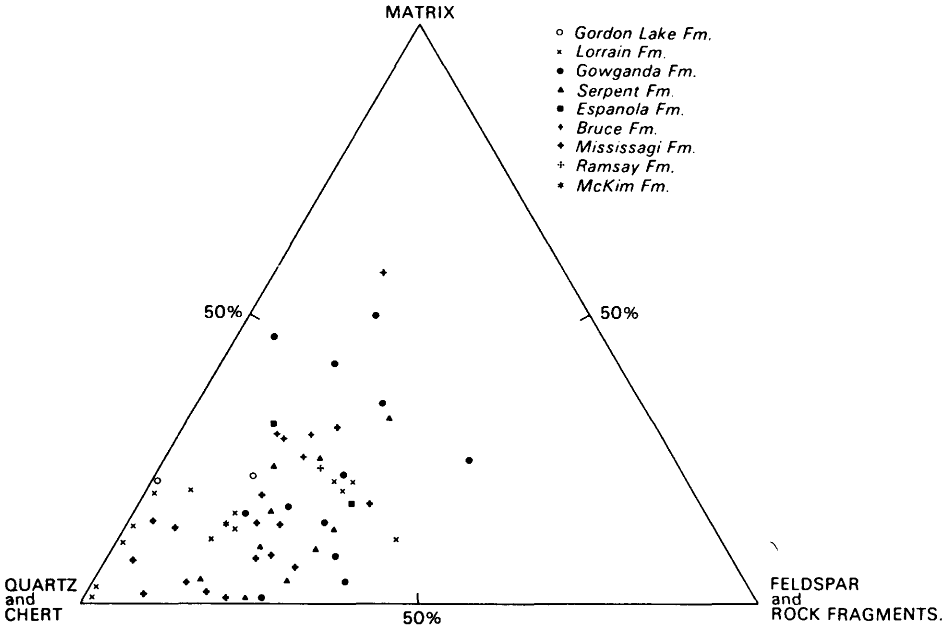

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Figure 2–Mineralogical composition of Huronian sandstones and conglomerate matrices in the Espanola-Whitefish Falls area.

Graded beds, ripples, ripple-drift cross laminations, parallel laminations, ball-and-pillow and flame structures are well preserved. The pelitic metasediments are thin-bedded, and some sections display laminated bedding with alternating light and dark layers about 1 to 20 millimetres thick. Other sections consist of cyclic repetitions of a lower graded greywacke passing upward into cross-laminated or parallel-laminated siltstone. Measurement of the orientation of a few ripples and cross-laminations indicates that the depositional currents flowed generally from north to south. The ball-and-pillow structures show contorted internal layering, are confined to thin stratigraphic zones and were probably formed as a result of soft sediment deformation.

The thin-to medium-bedded metamorphosed sandstones are medium-grained, white to grey rocks composed of subangular grains of quartz, feldspar, and rock fragments in a fine-grained matrix of muscovite, chlorite, biotite, quartz, and feldspar. The sorting is generally poor, and the proportions of matrix and feldspar are high, indicating that the rocks are mineralogically and texturally immature. According to the classification used in this report, most of these rocks are protoquartzites and subgreywackes (Figure 2). A modal analysis of a typical specimen is given in Table 3.

The rocks of the McKim Formation were probably deposited partly under tranquil conditions and partly by turbidity currents. This is indicated by the fine grain-size and regular, parallel laminations of the argillite sequences and by features

Table 3 MODAL ANALYSES OF ROCKS OF THE McKIM AND RAMSAY LAKE AND MISSISSAGI FORMATIONS IN THE ESPANOLA-WHITEFISH FALLS AREA

Sample No.	Stratigraphic Position	Quartz	Feldspar	Rock Frag-ments	Matrix	Accessories	Potassic Feldspar/ Plagioclase Ratio	Grain /Matrix Ratio	Classification
CM-65-57 McKim	Upper	72.0	14.3	x	13.7	x	9/1	86/14	Protoquartzite
CM-65-59A Ramsay Lake	Middle	47.7	4.3	25.4	22.6	x	n.d.	77/23	Lithic subgreywacke (conglomerate matrix)
Mississagi BM-65-27	Lower	79.0	21.0	...	...	x	9/1	98/2	Feldspathic quartzite
BM-65-223	Middle	80.0	5.7	1.0	13.3	x	6/4	87/13	Protoquartzite
CF-66-54	Upper	81.4	17.0	...	1.6	...	9/1	98/2	Feldspathic quartzite
38*	Lower	74.8	7.3	...	14.6	3.3	2/1	82/18	Protoquartzite
534*	Lower	86.0	5.6	1.0	7.3	x	4/1	93/7	Protoquartzite
560*	Lower	63.8	19.2	3.4	12.8	x	6/1	86/14	Feldspathic Protoquartzite
541*	Middle	75.7	9.7	1.3	13.3	...	4/1	87/13	Protoquartzite
583*	Middle	68.7	10.5	2.4	18.5	...	6/4	82/18	Subgreywacke
145*	Middle	82.6	13.1	...	4.3	...	2/1	96/4	Feldspathic quartzite
57*	Upper	67.7	12.4	11.8	6.4	1.7	1/1	92/8	Feldspathic Protoquartzite
593*	Upper	71.2	19.2	1.0	8.2	x	1/2	92/8	Protoquartzite
163*	Upper	89.0	11.0	...	0.0	...	1/3	100	Feldspathic quartzite

* From Casshyap (1967)

Abbreviations

...	Not detected
n.d.	Not determined
x	Present in minor amounts

of turbidity current deposition such as graded beds, ripples, and ripple-drift cross-lamination (Potter and Pettijohn 1964). The chemical composition of the metapelites shows that they are composed of highly weathered material containing a high proportion of ferruginous bauxitic clays.

HOUGH LAKE GROUP

RAMSAY LAKE FORMATION

The Ramsay Lake Formation, which has been traced eastward to the Sudbury area where it is known as the 'Ramsay Lake conglomerate' (Coleman 1914), occurs in the north-central Merritt Township. The nature of the upper and lower contacts of this unit could not be determined satisfactorily in the present map-area, but immediately to the northeast Ginn (1965) describes both contacts as conformable.

The Ramsay Lake Formation consists of approximately 600 feet (180 m) of massive, coarse-grained, pebbly feldspathic sandstone, or polymictic paraconglomerate. Pebbles are mainly granitic, quartz, and mafic igneous types, and compose 5 to 15 percent of the rock and average 1 inch to 3 inches (2.5 cm to 7.6 cm) in diameter. The upper part of the formation contains only rare pebbles and is essentially a coarse-grained feldspathic sandstone.

The paraconglomerate matrix is a poorly sorted sandstone composed of coarse angular grains of quartz, feldspar, and rock fragments with fine-grained interstitial biotite, muscovite, quartz, and feldspar. Plagioclase and potassic feldspar are present in approximately equal proportions. The conglomerate matrix ranges in composition from feldspathic or lithic subgreywacke to lithic greywacke (Table 3).

The Ramsay Lake Formation may represent a glacial or a mudflow deposit. It consists mainly of paraconglomerate with a high proportion of matrix to clasts. Primary sedimentary structures such as bedding are notably absent. The petrography indicates that it was derived from a granitic source and paleocurrent determinations in the area to the northeast (Ginn 1965) indicate that the sediments were deposited by south-flowing currents.

PECORS FORMATION

The Pecors Formation conformably overlies the Ramsay Lake Formation in north-central Merritt Township where it is some 1,500 feet (460 m) thick.

The lower part of the formation consists of several hundred feet (metres) of interbedded feldspathic quartzite, protoquartzite, and argillite at the base which pass gradationally upward into thinly bedded metapelites and greywackes. The upper part of the Pecors Formation is not exposed in the map-area, but to the northeast the formation consists of interbedded subgreywacke, protoquartzite, and argillite which pass gradationally upward into sandstones of the overlying Mississagi Formation.

Crossbedding is present in the lower and upper parts of the formation; graded beds, ripples, cross-laminations, and parallel laminations were observed in the central portion of the formation.

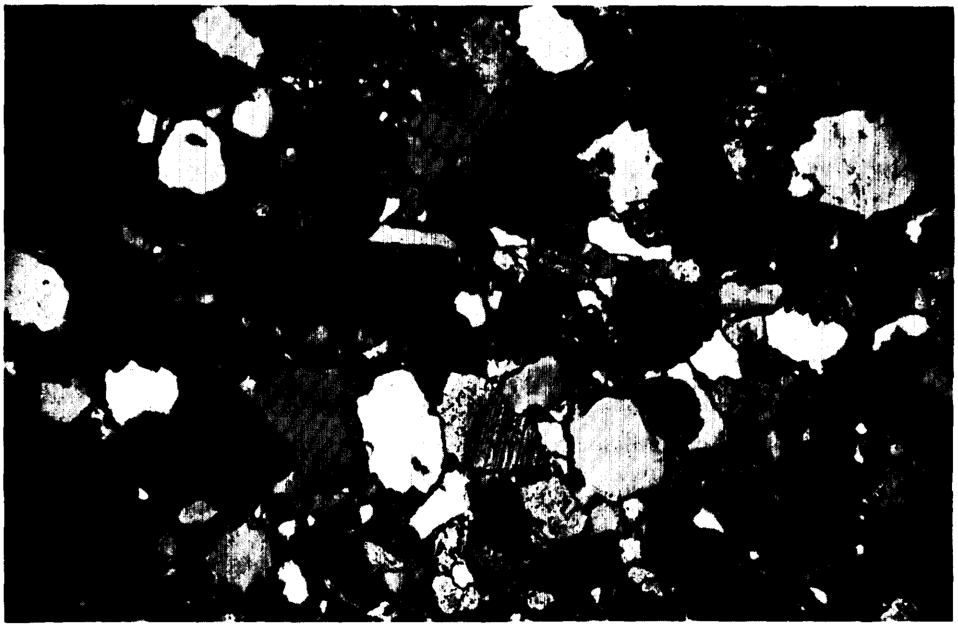
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Photo 2–Photomicrograph of protoquartzite of the Mississagi Formation (about x 30).

MISSISSAGI FORMATION

The Mississagi Formation has previously been called the 'Mississagi quartzite' by Quirke (1917) in the present map-area. The formation correlates with the 'Wanapitei quartzite' (Coleman 1914) of the Sudbury area and with the 'Upper Mississagi Formation' of the Elliot Lake area (Robertson 1967).

The Mississagi Formation is in conformable and gradational contact with the underlying Pecors Formation. The formation is exposed in an east-west trending belt in northern Merritt and Foster Townships, and is repeated by faulting and folding in the central parts of these townships. The sandstones around St. Leonard Lake in Foster Township which were originally assigned to the Serpent Formation (Quirke 1917), have been tentatively assigned to the Mississagi Formation in this report pending further work.

The formation consists of about 5,000 feet (1,500 m) of metamorphosed sandstone, siltstone, argillite, and minor conglomerate. In Merritt Township, the formation is composed almost wholly of sandstone (95 percent) with only minor argillaceous partings and conglomerate lenses, but in Foster Township, pelitic and conglomeratic interbeds constitute about 20 percent of the formation. The lower part of the formation generally contains more pelitic interbeds than the upper part. The top of the formation is marked by thick-bedded, well-sorted arkose.

The sandstones are medium-grained grey protoquartzites and pink or green feldspathic protoquartzites with lesser amounts of pink feldspathic quartzite and arkose. They are composed of subangular to subrounded grains of quartz, feldspar, and minor rock fragments in a sparse matrix of finer grained muscovite, chlorite, biotite, quartz and feldspar (Photo 2). In the samples studied microscopically, the amount of feldspar ranges from less than 5 percent to over 25 percent, the ratio of potassic feldspar to plagioclase feldspar ranges from about 9:1 to 1:3, and the percentage of interstitial detrital matrix material ranges from less than 5 percent to about 20 percent. Sorting is poor to good. In general, fine- to medium-grained, poorly sorted protoquartzite and subgreywacke are dominant in the lower part of the formation, medium-grained protoquartzite and feldspathic quartzite are dominant in the middle portion, and medium- to coarse-grained feldspathic quartzite and arkose form the uppermost unit. Modal analyses are given in Table 3 and the mineralogical composition of several Mississagi sandstones is portrayed in Figure 2.

The sandstones of the Mississagi Formation are characterized by well-developed bedding ranging in thickness from about 6 inches (15 cm) to more than 12 feet (3.7 m). Bedding in the lower half of the formation averages 1 foot to 3 feet (0.3 m to 0.9 m) thick, while it averages 3 feet to 6 feet (0.9 m to 1.8 m) thick in the upper half. Crossbedding occurs throughout the sequence; planar crossbeds are common in the more poorly sorted rocks of the lower part of the formation whereas festoon crossbeds are characteristic of the thick-bedded, better sorted feldspathic quartzite and arkose of the upper part of the formation (Photo 2). Graded crossbeds, with each foreset bed showing grain gradation, are present. The crossbedded units are commonly colour-banded in shades of pink, yellow, green, grey, and white.

Partings, interbeds, and members up to 200 feet (60 m) thick of argillite, siltstone, and fine-grained greywacke occur throughout the formation, but are most common in the lower half of the formation. These rocks are dark grey to dark green, poorly sorted, texturally immature rocks composed essentially of quartz, feldspars, biotite, muscovite, and chlorite with minor sphene, ilmenite, and pyrite. They are thinly bedded, and are commonly laminated with alternating light-coloured, relatively coarse grained, quartz-rich laminae, and dark-coloured, finer grained, micaceous laminae.

Lenses of polymictic paraconglomerate and minor oligomictic quartz-pebble conglomerate occur mainly in the middle and upper parts of the Mississagi Formation. Pebbles of quartz, granite, and greenstone ranging in diameter from 1 inch to 6 inches (2.5 cm to 15 cm) constitute 20 to 60 percent of the polymictic conglomerate. The matrix is poorly sorted protoquartzite or subgreywacke and consists of angular grains of quartz, feldspars, and rock fragments in a detrital matrix of quartz, feldspars, muscovite, biotite, chlorite, sphene, and iron oxide minerals. The oligomictic quartz-pebble conglomerate lenses are thin, commonly only one or two pebbles thick, and generally persist less than 50 feet (15 m) along strike. They consist of rounded quartz pebbles about 1 inch (2.5 cm) in diameter in a feldspathic quartzite or feldspathic protoquartzite matrix.

The sedimentary rocks constituting the Mississagi Formation were probably derived from a predominantly granitic terrain to the north, and were deposited in a shallow-water, turbulent environment by south-flowing currents. The mineralogical and textural immaturity of these sedimentary rocks indicates that they were probably formed under rigorous climatic conditions and were deposited rapidly.

QUIRKE LAKE GROUP

BRUCE FORMATION

Conglomerate of the Bruce Formation overlies sandstone of the Mississagi Formation with an abrupt but apparently conformable contact. The contact is generally sharp, although in lot 7, concession V, Foster Township, there is interbedding of sandstone and conglomerate over an interval of about 10 feet (3.0 m) at the contact. The Bruce Formation is exposed in two east-west trending belts across Merritt and Foster Townships where it is repeated by folding and faulting. Although consisting mainly of conglomerate, the Bruce Formation in Foster Township contains sandstone and argillite. Contrary to Quirke (1917), who correlated the section in Foster Township with the Gowganda Formation, the present work indicates that the section is probably an unusual Bruce sequence.

The Bruce Formation is as much as 1,200 feet (370 m) thick, but averages about 200 feet (60 m) thick. This thickness variability is due in part to original changes in thickness from place to place, but much is caused by faulting, folding, and tectonic thickening. There is a general tendency for the formation to thin southward and westward.

The Bruce Formation consists mainly of polymictic paraconglomerate with a schistose greywacke matrix. Pebbles, cobbles, and boulders of granite, quartz, schist, and greenstone constitute 5 to 50 percent of the rock. The rock fragments, which are angular to subrounded, range in diameter from less than 1 inch (2.5 cm) to several feet (metres) and average 2 inches (5.0 cm). A pebble count of typical conglomerate shows that the rock fragments are approximately 60 percent granitic, 25 percent metasedimentary, and 15 percent volcanic. Over 90 percent of the pebbles are less than 3 inches (7.6 cm) in diameter. The matrix is a poorly sorted greywacke or subgreywacke composed of angular grains of quartz, feldspar, and rock fragments in an abundant, fine-grained matrix of muscovite, chlorite, biotite, quartz, feldspar, epidote, pyrite, and iron oxide (Table 4, Chart B, back pocket). At the top of the formation, and locally at the base, there is abundant calcite in the conglomerate matrix. Also present locally at the base of the formation is a polymictic orthoconglomerate which contains over 70 percent pebbles but is otherwise mineralogically identical to the paraconglomerate.

The unusual sequence on the south limb of the St. Leonard Anticline and north of the Loon Lake Fault, tentatively correlated with the Bruce Formation, consists of conglomerate, argillite, and sandstone. The basal conglomerate member is a sparsely pebbled (10 percent) polymictic paraconglomerate with a subgreywacke matrix, while the upper conglomerate member is typical paraconglomerate with about 30 percent pebbles in a foliated greywacke matrix. The argillaceous rocks are both laminated and massive, and the interbedded sandstones are micaceous protoquartzites and subgreywackes. The various lithologic types are reminiscent of those of the Gowganda Formation.

The rocks display few primary structures. Bedding is poorly developed, except in the atypical section in Foster Township; several narrow (1 to 2 feet; 0.3 m to 0.6 m) north-trending clastic dikes cut the conglomerate in southern Foster Township.

The sedimentary rocks that constitute The Bruce Formation were probably

Table 5 CHEMICAL ANALYSES OF ROCKS OF THE McKIM, ESPANOLA, GOWGANDA, AND GORDON LAKE FORMATIONS IN THE ESPANOLA-WHITEFISH FALLS AREA

	Major Components in percent										
	1*	2*	3*	4	5	6	7	8	9	10	11
1				CG-66-46	CG-66-92	CG-66-82	FCA-68-1	B	A		
SiO_2	62.00	54.60	55.55	26.15	45.50	73.50	59.30	63.60	43.30	59.10	68.60
Al_2O_3	18.90	23.90	22.80	2.71	12.50	9.58	15.60	9.20	11.50	16.50	16.90
Fe_2O_3	1.24	1.32	1.40	1.60	5.82	Nil	1.09	1.36	0.94	4.69	2.79
FeO	4.24	5.20	5.28	2.48	12.55	0.55	3.98	3.38	3.29	5.31	0.83
MgO	3.30	3.60	3.20	3.91	4.65	0.56	6.80	0.88	3.28	3.21	2.42
CaO	1.64	0.82	0.56	31.56	2.13	5.35	2.42	13.20	18.30	1.55	<0.10
Na_2O	2.17	0.90	0.72	0.84	0.57	4.10	1.70	Nil	1.47	2.91	0.40
K_2O	1.88	4.12	4.65	0.80	2.34	0.80	4.92	0.07	1.83	2.98	5.56
H_2O^+	3.56	3.78	4.31	0.66	5.53	0.18	1.11	0.52	1.71	2.63	1.51
H_2O^-	0.05	0.04	0.07	0.01	0.70	0.06	0.05	Nil	0.05	0.15	0.16
CO_2	...	...	...	28.25	2.22	4.40	0.82	1.45	10.52	0.25	0.05
TiO_2	0.64	0.96	0.84	0.11	3.65	0.14	0.53	0.06	0.23	0.82	0.63
P_2O_5	0.11	0.18	0.15	0.06	0.15	0.03	0.12	0.05	0.23	0.15	0.06
S	...	...	...	0.05	0.02	0.02	0.27	1.04	0.39	0.04	0.02
MnO	0.05	0.04	0.09	0.22	0.17	0.08	0.03	2.14	2.51	0.13	<0.01
Cr_2O_3	...	...	...	0.02	...	...	...	...	...	...	...

ZnO	...	...	...	...	...	...	...	1.81	...	...	...
V_2O_3	...	...	...	0.01	...	...	...	...	...	...	...
S.G.	...	...	...	2.79	2.68	2.64	n.d.	3.01	2.82	2.80	2.73
Total	99.78	99.46	99.62	99.39	98.50	99.35	98.70	98.70	99.60	100.40	99.90

1, 2, 3. Metapelite: Quartz – muscovite – plagioclase – chlorite – Fe-Ti oxides ± chloritoid ± garnet. McKim Formation.
4. Silty limestone: Quartz – calcite – biotite – pyrite. Espanola Formation.
5. Calcareous siltstone: Dolomite – calcite – quartz – biotite – chlorite – iron oxide – sphene. Espanola Formation.
6. Calcareous sandstone: Quartz – calcite – plagioclase – muscovite – biotite. Espanola Formation.
7. Scapolite hornfels: Quartz – scapolite – muscovite – biotite – chlorite – calcite – iron oxide – pyrite. Espanola Formation.
8. Idocrase-diopside-garnet skarn: Quartz – plagioclase – idocrase – diopside – garnet – calcite – eipdote – scheelite – pyrrhotite – sphalerite. Espanola Formation.
9. Idocrase-diopside-garnet skarn: Quartz – plagioclase – potassic feldspar – idocrase – diopside – garnet – calcite – scheelite – apatite – pyrrhotite. Espanola Formation.
10. Argillite: Quartz – plagioclase – chlorite – muscovite – epidote – magnetite. Gowganda Formation.
11. Siltstone: Quartz – plagioclase – muscovite – chlorite – iron oxides. Gordon Lake Formation.

[1] Sample Number, where given
* From Blackburn 1967
Remainder of analyses by Mineral Research Laboratory, Ontario Division of Mines.

Abbreviations
... Not detected
n.d. Not determined
S.G. Specific Gravity

derived from a granitic terrain to the north. Paleocurrent studies (Casshyap 1967) show that they were deposited by south-flowing currents.

ESPANOLA FORMATION

The Espanola greywacke and Espanola limestone were first recognized and named in the area south of Espanola by Collins (1925) who subdivided the rocks into three units, the Bruce Limestone, the Espanola Greywacke, and the Espanola Limestone. These three members, in addition to a thick sequence of calcareous sandstone in the upper part of the formation, form the Espanola Formation of this report.

The contact between the Espanola Formation and the underlying Bruce conglomerate is conformable and gradational over a few feet (metres). The formation is exposed north and south of the Apsey Fault in Merritt Township, and in northern Curtin Township. In Foster Township, it is found north of Elizabeth and Augusta Lakes, on the limbs of the St. Leonard Anticline, between Stratton and Panache Lakes and in the southeast corner of the township. The Espanola Formation is about 800 feet to 1,300 feet (240 m to 400 m) thick in Merritt Township, and 1,000 feet to 1,600 feet (300 m to 490 m) thick in Foster and Curtin Townships. The Espanola Formation comprises a discontinuous basal limestone and calcareous siltstone member about 100 feet to 200 feet (30 m to 60 m) thick; a calcareous siltstone, argillite, and fine-grained greywacke member approximately 400 feet to 800 feet (120 m to 240 m) thick; a calcareous sandstone member 300 feet to 700 feet (90 m to 200 m) thick; and a discontinuous upper calcareous siltstone and limestone member that can be as much as 100 feet (30 m) thick.

The basal member consists of interbedded impure dolomitic limestone and calcareous siltstone. The limestone is a fine-grained, white to light grey rock composed mainly of calcite and dolomite, with lesser amounts of detrital quartz, feldspar, biotite, epidote, and chlorite (Table 4). The siliceous varieties are grey to black in colour. There are a few beds of brown-weathering dolomite in the basal member. A chemical analysis of a white Espanola limestone is given in Table 5 (analysis 4) and a mode from the same sample (CG-66-46) appears in Table 4. The bedding in this member ranges from less than one inch (2.5 cm) to as much as several feet (metres). The limestones are massive, or laminated, with alternating light, calcite-rich laminae, and dark, biotite-rich laminae about 1 millimetre thick.

The Espanola siltstones, argillites, and fine-grained greywacke are dark grey to black rocks composed of variable amounts of quartz, feldspar, calcite, dolomite, biotite, muscovite, clinozoisite, chlorite, scapolite, sphene, iron oxides, and sulphides. The Espanola rocks are generally fine-grained, and sorting in them is poor to fair. There appears to be a complete gradation in them from silty limestone to siltstone with minor carbonate. The interbedded siltstones and argillites are characteristically thinly bedded and, owing to differences in composition of the beds, the weathered surface is strongly etched and pitted.

Light green, laminated, cherty siltstone interbeds composed of fine-grained quartz, chlorite, and biotite are present in the Foster Township section. Cherty siltstone beds have been broken up locally to form a breccia consisting of angular chips and blocks of green chert in a dark grey calcareous siltstone matrix.

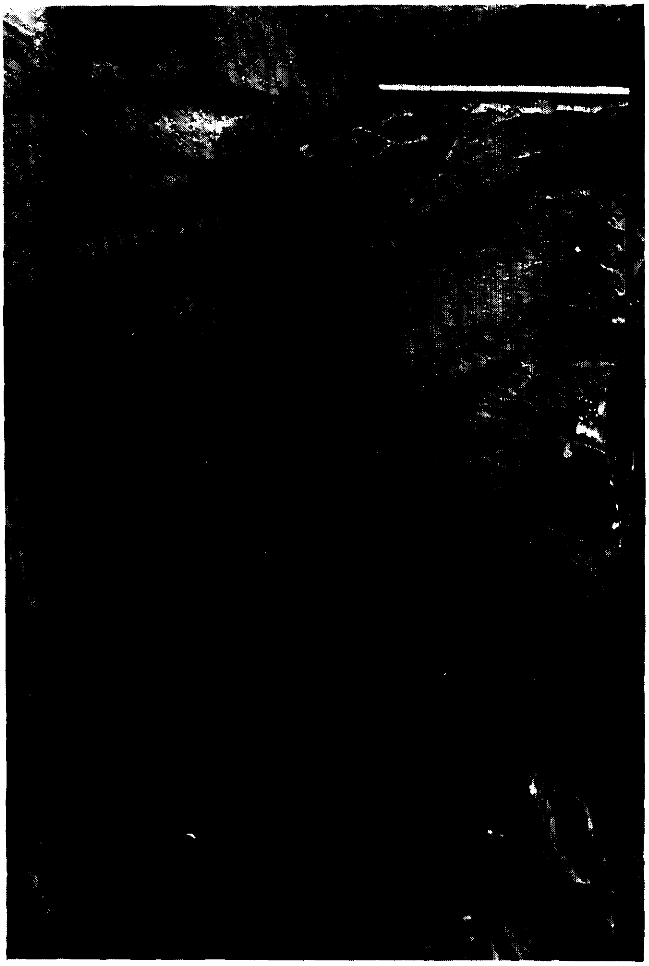

Photo 3–Espanola calcareous siltstone and sandstone. Note the crossbedding, ball-and-pillow structures, and desiccation cracks.

The calcareous sandstones are white to buff-weathering, medium-bedded, fine- to coarse-grained, and are composed of subangular to rounded grains of quartz and feldspar in a matrix of calcite, dolomite, biotite, muscovite, chlorite, epidote, quartz, and feldspar. The sorting is poor to fair; the coarser sandstones typically display a bimodal grain size distribution with coarse (up to 1 centimetre) grains of quartz and feldspar in a fine- to medium-grained matrix. Most of the calcareous sandstone samples examined microscopically are protoquartzites and subgreywackes although calcareous feldspathic quartzites are also present (Figure 2).

The upper calcareous siltstone-limestone member (Collins' 'Espanola Limestone') is similar to the basal member except that siltstone is dominant and the limestone is mainly of the brown-weathering, dolomitic type.


ODM9151

Photo 4—Clastic dike intruding scapolitic metasediments of the Espanola Formation. Note the pebbles in the centre of the dike and the weathering of the thinly bedded metasediments.

Calcite and dolomite analyses given by Casshyap (1967) show that the carbonate content is highly variable from bed to bed. The lower part of the formation is approximately twice as rich in carbonate as the middle and upper parts. Calcite is the dominant carbonate mineral in the lower and upper parts of the formation; calcite and dolomite are present in approximately equal proportions in the middle part.

Primary sedimentary structures are well developed in the Espanola Formation. Graded beds, ripples, parallel laminations, and cross-laminations are characteristic of the siltstones, argillites, and limestones, while planar and festoon crossbeds are common in the calcareous sandstones. In lot 3, concession IV, Merritt Township, there is a spectacular outcrop of calcareous siltstone, sandstone, and impure limestone in the railway cut immediately east of Tulloch Lake with excellent examples of ripples, crossbedding, graded bedding, ball-and-pillow structures, flame structures, desiccation cracks, and sandstone dikelets (Photo 3). In lot 6, concessions III and IV, Merritt Township, several sedimentary dikes cut rocks of the Espanola Formation. One of the best examples is a dike about 2 feet (0.6 m) wide on a small rocky point extending out into Griffin Lake on Highway 68 in Merritt Township (Photo 4). The dike is a poorly sorted pebbly greywacke with medium-grained, angular fragments of quartz, feldspar, and rock in a fine-grained matrix of quartz, feldspar, chlorite, biotite, muscovite, calcite, clinozoisite, sphene, and leucoxene. There is a weak alignment of micaceous minerals parallel to the walls of the dike. The pebbles are mainly granitic and quartzitic types, average about 1 inch (2.5 cm) in diameter, are not uniformly distributed throughout, but occur as rafted aggregates or concentrations in the central part of the dike. The dike, like most other sedimentary dikes seen in the area, strikes approximately north-south and trends sharply across the bedding of the Espanola rocks. The sandstone dikes were apparently emplaced in a fluid condition into consolidated or semi-consolidated Espanola siltstone. Quirke (1917) postulated that the sandstone dikes were formed by filling of fissures from above during a long period of emergence. Nevertheless, the petrography of the dikes indicates that they were probably derived from below; from the Bruce Formation. The consistent orientation of the dikes suggests that they were emplaced under the influence of a regional stress-system; possibly during the earliest folding movements as injections of water soaked, conglomeratic sediments into semi-consolidated rocks.

Paleocurrent determinations of crossbed and ripple orientations show that the Espanola sediments were deposited by southwest-flowing currents. The Espanola sediments were probably deposited under shallow-water conditions as is indicated by sedimentary structures such as laminated bedding, ripples, and crossbedding. The desiccation cracks indicate periodic emergence and subaerial exposure. Other structures, such as the ball-and-pillow and flame structures, were probably formed by slumping and soft-sediment deformation. The interbedded silty and calcareous layers probably represent periodic influxes of fine sediment alternating with periods of clearer water and carbonate deposition. The coarser crossbedded sandstones of the upper part of the Espanola Formation probably represent a return to more turbulent depositional conditions. These rocks commonly display a bimodal grain-size distribution typical of beach sands.

SERPENT FORMATION

The Serpent Formation is exposed in Merritt Township north and south of the Apsey Fault, in west-central Foster Township, in central Mongowin Township, and in northern Curtin Township.

The Espanola Formation grades upward into the Serpent Formation and there is interbedding of calcareous and biotitic sandstone and argillite over a stratigraphic interval of several hundred feet (metres). Consequently, during the mapping, the contact was placed arbitrarily where the proportion of non-calcareous sandstone is greater than calcareous sandstone and pelite.

North of the Apsey Fault in Merritt and Foster Townships the Serpent Formation consists of calcareous sandstone, protoquartzite, subgreywacke, and argillite near the base; and feldspathic quartzite and arkose in the upper part. Several thick sections of interbedded argillite, subgreywacke and protoquartzite occur around Anderson and Wood Lakes. South of the Apsey Fault the formation consists of about 700 feet (200 m) of biotitic protoquartzite, subgreywacke and argillite, followed by approximately 900 feet (270 m) of feldspathic quartzite and arkose. In Curtin and Mongowin Townships, the formation consists of 1,000 feet to 2,000 feet (300 m to 600 m) of quartzite and arkose with minor calcareous and biotitic protoquartzite and argillite at the base.

ODM9152

Photo 5–Photomicrograph of subgreywacke of the Serpent Formation (about x 30).

ODM9153

Photo 6–Photomicrograph of arkose of the Serpent Formation (about x 30).

The basal calcareous sandstones are light grey to white, medium-grained, poorly sorted rocks with numerous brownish pits on weathered surfaces caused by weathering of carbonate crystals. These rocks are composed of subangular to subrounded grains of quartz, plagioclase, and potassic feldspar, with interstitial carbonate, biotite, muscovite, sphene, and iron oxides. The carbonate minerals, which are calcite, dolomite, and possibly ankerite, form interstitial patches and euhedral porphyroblasts with inclusions of quartz, feldspar, and micas. These porphyroblasts cut across the foliation and include oriented quartz and mica grains and consequently their formation or recrystallization is post-tectonic. The calcareous sandstones are mainly protoquartzites and subgreywackes, although calcareous greywackes and arkose are also present. The interbedded biotitic sandstones are feldspathic protoquartzites and subgreywackes composed of quartz, feldspar, biotite, muscovite, and chlorite (Photo 5). Modes of the typical specimens are given in Table 4.

The upper feldspathic sandstones are medium- to coarse-grained, pink, grey, or greenish rocks composed of subrounded to rounded grains of quartz, and plagioclase. The potassic feldspar/plagioclase ratio averages about 3:1, and plagioclase, which is albite or oligoclase, is commonly sericitized. The sorting is fair to good (Photo 6). Most of the upper Serpent sandstones are feldspathic quartzite, feldspathic protoquartzite, and arkose (Table 4).

The Serpent argillites are dark green to black, laminated or massive, thinly bedded rocks containing quartz, feldspar, biotite, muscovite, calcite, epidote, and iron oxide minerals. The sorting is fair, and the grain size is in the silt to fine sand range. Thin 1 inch to 2-inch (2.5 cm to 5 cm) thick partings of green argillite in the upper part of the formation in Merritt Township are commonly broken up, and the chips are scattered through the feldspathic sandstones.

Numerous lenses of sparsely pebbled sandstone and a few polymictic orthoconglomerate lenses occur in the formation. The pebbly sandstone consists of small quartz and granite pebbles and granules scattered through an arkosic or feldspathic protoquartzite matrix. The orthoconglomerate lenses are composed of granite, quartz, quartzite, greenstone, and jasperoid pebbles in a feldspathic greywacke or subgreywacke matrix.

Bedding and crossbedding is well developed in the Serpent Formation. Bedding thickness in the lower part of the section averages 1½ feet (0.5 m), but in the upper part it averages 3 feet (0.9 m) and ranges up to 10 feet (3.0 m). The thicker beds generally display crossbedding of the planar and tangential tabular type. The crossbeds are rarely cross-laminated. Graded crossbeds are present in the upper part of the Serpent Formation, and, normal graded bedding occurs in argillite. Argillite also displays ripple marks, small-scale crossbedding, and small sandstone dikes in central Merritt Township.

Measurement of crossbed and ripple mark orientation shows that the Serpent sediments were deposited by south-flowing currents. The petrography indicates that the Serpent rocks are mineralogically immature, but reasonably well sorted, especially in the upper half of the formation. The crossbedding, graded crossbedding, and ripple marks indicate that the rocks were deposited under shallow-water conditions. The rocks were probably derived from a granitic terrain to the north and were deposited in a turbulent, deltaic-type environment.

COBALT GROUP

GOWGANDA FORMATION

The Gowganda Formation overlies the Serpent quartzite in northern, central, and southern Mongowin and Curtin Townships and southern Merritt Township. The contact between the basal Gowganda conglomerate and the underlying Serpent sandstone is conformable and disconformable. In lot 8, concession IV, Mongowin Township, the contact is disconformable and the Gowganda conglomerate locally truncates the bedding of the underlying Serpent sandstones. Fragments of quartzite similar to the underlying Serpent quartzite are present in the basal conglomerate. However, in most other localities where the contact is exposed there is structural conformity between the two formations and the contact is generally sharp, and only slightly irregular or wavy. For example in lot 5, concession V, Mongowin Township, there is interbedding of conglomerate and sandstone along the contact.

The thickness of the Gowganda Formation ranges from about 3,000 feet (900 m) in southeastern Curtin Township to 5,500 feet (1,700 m) in central Curtin Township, and averages 4,000 feet (1,200 m). The Gowganda Formation is divisible into eight members. These are, from bottom to top:

MEMBER	THICKNESS	LITHOLOGY
Lower Conglomerate	300-1,400 ft. (90-430 m)	Polymictic paraconglomerate with lenses of orthoconglomerate, argillite, and sandstone.
Lower Argillite	200-800 ft. (60-240 m)	Laminated argillite.
Middle Conglomerate	100-800 ft. (30-240 m)	Polymictic paraconglomerate with lenses of orthoconglomerate, sandstone, and argillite.
Middle Argillite	100-800 ft. (30-240 m)	Laminated argillite and, in the thicker sections, interbedded argillite, siltstone, and sandstone.
Upper Conglomerate	Ranges to 800 ft. (240 m)	Polymictic paraconglomerate with lenses of sandstone, argillite, and orthoconglomerate.
Mixed Member	600-1,300 ft. (180-400 m)	Interbedded argillite, siltstone, sandstone, and orthoconglomerate with minor calcareous siltstone in the upper part in southern Mongowin and Curtin Townships.
Sandstone Member	600-1,100 ft. (180-340 m)	Interbedded sandstone and argillite in the lower half grading into feldspathic sandstone in northern and central Mongowin and Curtin Townships; mainly inter-

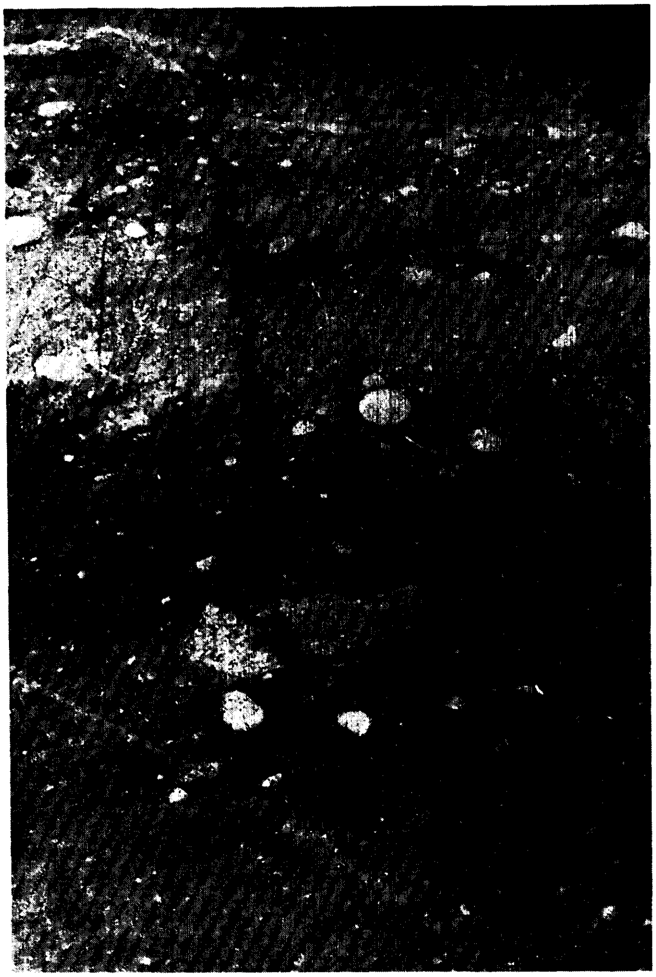

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Photo 7–Orthoconglomerate and paraconglomerate of the Gowganda Formation. Note the crude stratification, the poor sorting, and extreme differences in rounding of pebbles.

		bedded sandstone and argillite in southern Mongowin and Curtin Townships.
Upper Argillite	200-450 ft. (60-140 m)	Laminated argillite with polymictic orthoconglomerate and greywacke lenses in northern Mongowin Township.

The stratigraphic sequence is portrayed diagrammatically in Figure 4 (Chart A, back pocket).

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Photo 8–Bedded conglomerate of the Gowganda Formation. Note the crossbedding parallel to the marking pen.

There are several types of conglomerate present in the Gowganda Formation (Photo 7). The most common type is a polymictic paraconglomerate, or pebbly mudstone, with a grey or green greywacke or subgreywacke matrix. Pebbles commonly constitute only 10 to 20 percent of the rock and are dominantly pink granitic types ranging in size from less than 1 inch to 3 feet (2.5 cm to 0.9 m) and averaging 1½ inches (3.8 cm). Approximately 75 percent of the pebbles are granitic, 20 percent are fine-grained mafic and felsic types, and the remainder are chert and schist. The matrix is generally unstratified, although locally, as in Section 39, Curtin Township, bedding and crossbedding are present (Photo 8). The poorly sorted matrix is composed of medium- to coarse-grained angular grains of quartz, feldspars, and rock fragments in a fine-grained matrix of muscovite, biotite, quartz, feldspar, epidote, calcite, and iron oxide minerals (Table 6, Chart B, back pocket). Feldspar is generally abundant, and the proportion of potassic feldspar to plagioclase ranges from 1:1 to 5:1. The ratio of clastic grains to interstitial detrital material in the conglomerate matrix ranges from 4:1 to 1:1.

Tilloid-type conglomerates, which are polymictic paraconglomerates with laminated argillite matrices, are also present. Pebbles forming 10 to 15 percent of the rock, are mainly granitoid types averaging 1 to 2 inches (2.5 to 5 cm) in diameter. The laminations of the matrix are commonly interrupted by the pebbles, and are draped over the pebbles, indicating that the pebbles were dropped into the fine silt and mud. The pebbles were probably dropped from floating ice.

Polymictic orthoconglomerate lenses occur locally at the base of the lower conglomerate member and in the middle and upper conglomerate members, but are most abundant near the top of the sequence in the axial zone of the Bass Lake syncline in northern Mongowin Township. The lenses are commonly a few feet to a few tens of feet (metres to tens of metres) thick, and consist of abundant (60 to 70 percent) granitic, quartzitic, and mafic pebbles in a feldspathic greywacke or subgreywacke matrix. The pebbles are subangular to subrounded and average 1 inch (2.5 cm) in diameter. The orthoconglomerate lenses in northern Mongowin Township are interbedded with sandstone and argillite.

There are several types of pelitic rock in the Gowganda Formation. The most common in the lower part and at the top of the section is laminated argillite, a dark grey to black, fine-grained, poorly sorted rock composed of silt- and clay-sized grains of quartz, feldspar, biotite, muscovite, chlorite, epidote, and iron oxide minerals. The chlorite is typically an iron-rich ripidolite, and the muscovite, a greenish ferri-muscovite. Magnetite is abundant, notably in the lower argillite, and this unit gives rise to pronounced magnetic anomalies (GSC 1965a, Aeromagnetic Map 1522G, Whitefish Falls, Ont.). A chemical analysis of an iron-rich, laminated argillite is given in Table 5. The laminations are approximately 0.25 to 1 millimetre thick, consist of alternating, light-coloured quartzose layers and dark-coloured micaceous layers, and are persistent along strike. The grain-size of the light laminae averages about 0.03 millimetres and ranges up to fine-sand size, while the grain-size of the dark laminae averages less than 0.01 millimetre. The light laminae are approximately 0.5 to 1 millimetre thick, but the dark laminae are 0.25 to 0.5 millimetre thick.

Thinly bedded, massive argillites and siltstones are characteristic of the mixed member where they are interbedded with impure sandstones. The bedding ranges in thickness from less than 1 inch to 6 inches (2.5 to 15 cm), and commonly is graded. The argillites and siltstones are composed of the same minerals as the laminated argillites, but are coarser grained on the average (silt- to fine-sand range), and generally have a distinctive greywacke texture with angular quartz and feldspar grains set in an abundant, fine-grained, micaceous matrix. Fine- to medium-grained greywackes are present near the top of the section, and a modal analysis of one is given in Table 6 (Chart B, back pocket).

Sandstones are present as thin lenses in the lower part of the Gowganda section, and also as persistent members in the upper part. They are mainly feldspathic protoquartzites and subgreywackes, although micaceous feldspathic greywackes are present in the lower part of the section, and arkose in the upper part (Table 6).

Noteworthy primary sedimentary features of the Gowganda Formation are: the lensoid character of the lithostratigraphic units, the rapid facies changes along strike (especially in the lower half of the formation), the laminated bedding of the argillites, and the poor stratification of the conglomerates. Other primary sedimentary structures present include crossbedding, especially in the upper half of the formation, ripples (Photo 9), cross-laminations, graded beds, and ball-and-pillow structures (Photo 10); especially in the mixed member.

Numerous quartz-calcite-chlorite veins cut the Gowganda rocks, and the veins locally contain pyrite, arsenopyrite, and gold. There are also areas in which the rocks are extensively replaced by albite and carbonates.

The orientation of ripple marks, crossbeds, and long axes of pebbles indicates that the Gowganda sedimentary rocks were deposited by south-flowing currents.

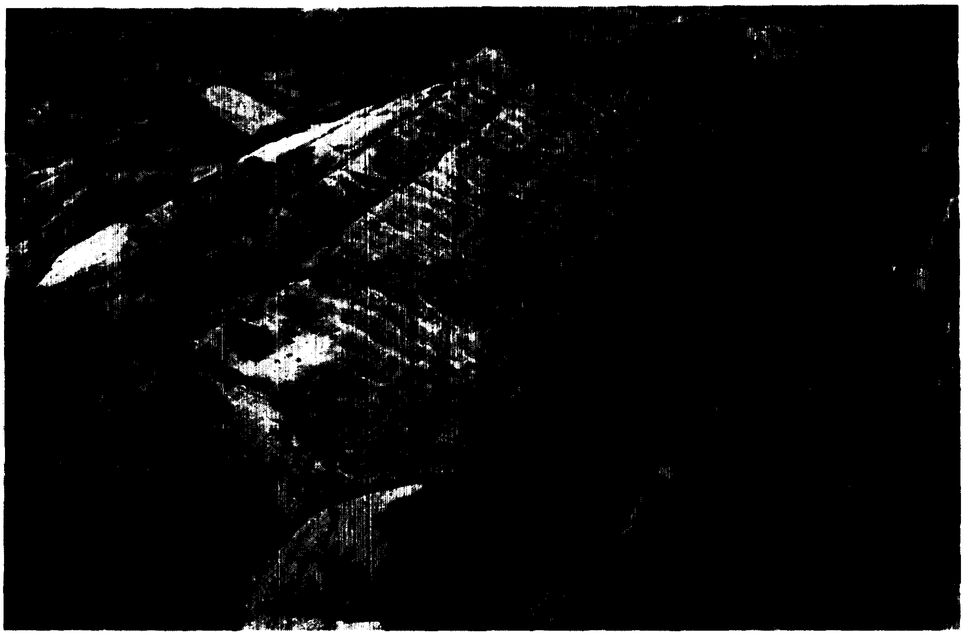

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Photo 9–Ripple marks in the Gowganda Formation.

Photo 10–Ball-and-pillow structures in rocks of the Gowganda Formation.

These sedimentary rocks were deposited in water, possibly by glacial agencies (Coleman 1908).

LORRAIN FORMATION

Sandstones of the Lorrain Formation underlie the southern parts of Mongowin and Curtin Townships forming the La Cloche hills. The contact with the underlying Gowganda Formation is conformable and gradational.

The Lorrain Formation is approximately 5,500 to 6,000 feet (1,700 to 1,800 m) thick and consists of six lithostratigraphic members. These are, from oldest to youngest:

MEMBER	THICKNESS	LITHOLOGY
Grey Sandstone	150-300 ft. (46-90 m)	Grey micaceous sandstone with minor interbedded argillite at the base and pink feldspathic sandstone at the top.
Pink Sandstone	250-650 ft. (76-200 m)	Pink feldspathic sandstone.
Green Sandstone	1,650-3,000 ft. (503-900 m)	Green micaceous sandstone with very minor oligomictic quartz pebble conglomerate.
Ferruginous Sandstone	As much as 700 ft. (200 m)	Buff hematitic sandstone with aluminosilicate minerals and minor quartz and jasperoid conglomerate.
White Sandstone	700-2,600 ft. (200-790 m)	White sandstone with aluminosilicate minerals and minor quartz pebble conglomerate.
Cherty Sandstone	650-1,000 ft. (200-300 m)	White and red, fine-grained sandstone.

Contacts between the various units are gradational and consequently the placing of contacts between them is somewhat subjective. For example, the ferruginous sandstones are identical to the white sandstones except for very minor amounts of hematite staining the grains. The distinction between the white sandstone member and the cherty member is very subtle, and is further complicated by a general increase in grain-size of the cherty sandstones as they are traced eastward. However, the subdivision of the formation is important because uppermost cherty sandstones can be used for industrial purposes.

The basal grey Lorrain sandstones are medium-bedded, light grey rocks composed of medium-grained subangular grains of quartz, feldspar, and rock fragments in a fine-grained matrix of muscovite, biotite, chlorite, quartz, and feldspar (Table 6). The potassic feldspar-plagioclase ratio ranges from 3:1 to 1:4, the sorting is fair, and the rocks are feldspathic protoquartzite and subgreywacke (Figure 2).

The pink feldspathic sandstones are coarse-grained, thick-bedded rocks com-

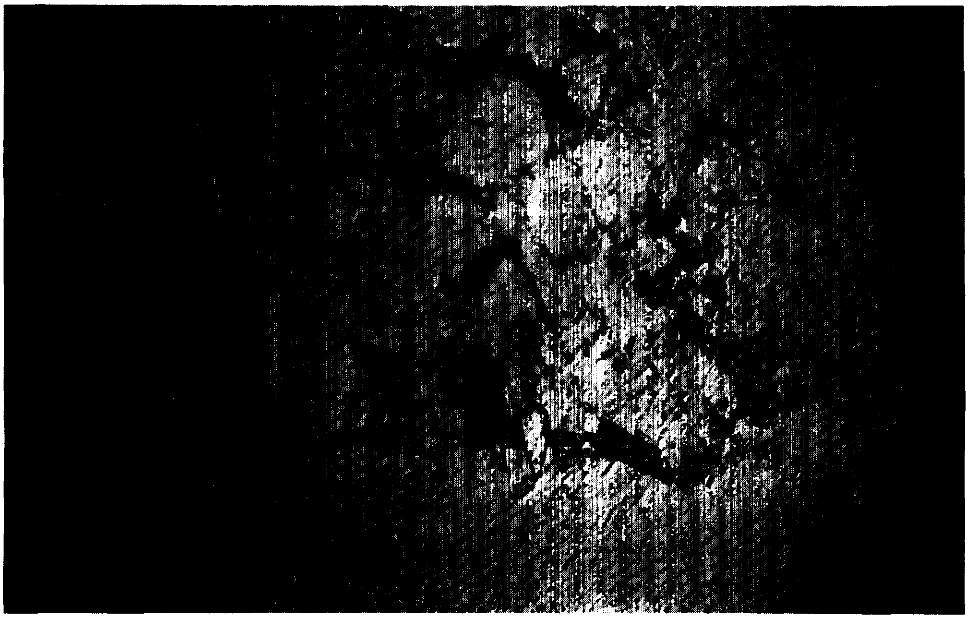

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Photo 11–Photomicrograph showing the development of kyanite from interstitial kaolinite in sandstone of the Lorrain Formation (about x 30).

posed of quartz, feldspars, and rock fragments in a matrix of biotite, muscovite, quartz, feldspar, and minor sphene and iron oxides. The potassic feldspar/plagioclose ratio ranges from about 2:1 to 1:10 in the samples studied, the sorting is poor to fair, and the rocks are mainly feldspathic protoquartzites with some arkose and feldspathic subgreywacke.

The green sandstones are medium-bedded, medium- to coarse-grained rocks composed mainly of quartz, feldspar, and muscovite. The potassic feldspar/plagioclase ratio ranges from 3:1 to 9:1. The muscovite is green ferri-muscovite. The rock owes its colour to this mineral and to greenish altered feldspars. In addition, the green chrome mica, fuchsite, is locally present. Sorting is fair and most of the green sandstones are feldspathic protoquartzites. Near the top of this unit, the original feldspars are replaced by kaolinite and muscovite.

The ferruginous and white sandstones are medium- to thick-bedded, medium-grained rocks composed primarily of quartz and muscovite. Hematite, a very minor constituent, coats mineral grains and is concentrated along joint planes. The ferruginous and white sandstones are moderately well sorted muscovitic protoquartzites. Kaolinite is commonly found as interstitial patches and veinlets. Microscopic porphyroblasts of kyanite, andalusite, and pyrophyllite are developed in these aluminous sandstones (Photo 11).

The cherty sandstone (orthoquartzite) is a thinly bedded, fine-grained rock composed mainly of quartz with very minor muscovite and hematite staining (Table 6).

Chemically, the cherty sandstone is pure and consists of more than 95 percent silica. The sandstone has a distinct bimodal grain size distribution and consists of well-sorted quartz grains about 0.5 millimetre in diameter in a mosaic of fine-grained (0.03 to 0.01 millimetre) quartz. The fine-grained quartz probably represents chemically precipitated silica cement which has been recrystallized.

The conglomerate lenses in the green, ferruginous, and white members consist of small (½ to 1 inch; 12.7 mm to 2.5 cm) rounded pebbles of quartz, chert, and jasper in a poorly sorted matrix of quartz, feldspar, muscovite, and iron oxides. Pebbles compose 30 to 70 percent of the lenses and both ortho- and paraconglomerates are present.

Primary sedimentary structures in the formation include crossbedding, graded bedding, and graded crossbeds. The average bedding thickness generally decreases from the base to the top of the formation. Planar crossbeds, graded crossbeds, and graded beds are common in the pink and green members, while festoon crossbeds marked by concentrations of specular hematite on the foreset surfaces occur in the ferruginous and white sandstone members.

Breccia occurs in southern Curtin Township in sandstones of the white and cherty members. The breccia consists of angular fragments of sandstone ranging from less than one inch (2.5 cm) up to several feet (metres) in a matrix of quartz, muscovite, chlorite, and epidote. It is probably of tectonic origin, because there are poorly defined minor folds traced out by the orientation of quartzite chips. There has also been significant hydrothermal activity, with the introduction of water, potassium, aluminium, magnesium, calcium and iron to form abundant chlorite and epidote.

The Lorrain sandstones were probably deposited in a turbulent shallow-water, littoral environment during a repeated series of marine transgressions and regressions. The mineralogical and textural maturity of the rocks increases from the base to the top, but this is accompanied by a general decrease in grain size and bedding thickness. The upper member, the cherty sandstone, probably contains a significant amount of chemically precipitated silica. These trends indicate an increase in the maturity of the detritus supplied, and probably an increased amount of sorting. The source of the large amounts of quartz is not known, but crossbedding studies show that the depositional currents flowed generally from north to south. If the quartz was derived from granitic rocks to the north, the Lorrain Formation must represent a very extended interval of erosion and deposition.

GORDON LAKE FORMATION

Rocks of the Gordon Lake Formation, originally termed 'Banded Cherty Quartzite' by Collins (1925), occur in the axial zone of the La Cloche Syncline in southern Mongowin and Curtin Townships. The formation is herein termed the "Gordon Lake Formation" on the basis of correlation with the Gordon Lake Formation of the type area near Sault Ste. Marie (Frarey 1967b). The fine-grained argillites and sandstones of the formation are in conformable and gradational contact with the underlying Lorrain sandstones.

The Gordon Lake Formation is probably 600 feet (180 m) thick. Because of deformation and erosion, this figure is only approximate. It consists of thinly bedded argillite, siliceous argillite, fine-grained greywacke, and subgreywacke. The transitional rocks between the Lorrain and Gordon Lake Formations are light green, fine-grained protoquartzites which consist of fine-grained quartz and feldspar grains (0.1 millimetre) in a sparse matrix of muscovite and quartz. The argillites are laminated and distinctly colour-banded in shades of grey, green, and buff. The light-coloured laminae are rich in quartz and feldspar grains averaging 0.03 millimetre in diameter while the dark laminae are rich in muscovite and chlorite. Calcite, sphene, iron oxides, and pyrite are present in variable amounts.

A chemical analysis of a laminated argillite is given in Table 5, Analysis 11. The sandstones are grey, fine-grained rocks consisting of variable proportions of quartz, feldspar, muscovite, chlorite, and iron oxides. The specimen examined is a feldspathic subgreywacke but protoquartzite and greywacke are also present (Table 6, Chart B, back pocket).

Sedimentary structures present include laminated bedding, graded bedding, convolute bedding, desiccation cracks and ball-and-pillow structures in the argillites. The sandstones display cross-laminations and graded bedding.

The sedimentary structures present in the formation indicate that these rocks were deposited under non-turbulent conditions. The rhythmic laminations indicate cyclic depositional processes while the mud cracks indicate periodic exposure to subaerial conditions.

CORRELATION OF HURONIAN ROCKS

Correlation of the rocks between Sudbury and Blind River has been controversial and the problems involved have been discussed by Collins (1936), Thomson (1952, 1962), Ginn (1965), Card (1965a, 1968a), and Young and Church (1966). Work by Ginn (1965) and the writer in the area between Sudbury and Espanola has shown that there is a general conformity throughout the metasedimentary sequence and consequently, the division of the metasediments into a pre-Huronian 'Sudbury Series' and a Huronian Series is not valid. The metasedimentary units previously assigned to the 'Sudbury Series', the McKim, the Ramsay Lake, and the 'Wanapitei' (Mississagi) Formations, are of Huronian age.

In Figures 3 and 4 (Chart A, back pocket), the lithostratigraphic units of the Sudbury-Whitefish Falls area are compared with those of the Elliot Lake district. The major differences between the succession of the two are as follows:

(a) The eastern section is thicker than the western, and this thickening occurs abruptly as the Murray Fault is crossed.
(b) Individual formations are thicker in the east than in the west, particularly the pelitic units.
(c) There are numerous disconformities in the Elliot Lake area; there are relatively few in the Espanola-Whitefish Falls section.

Nonetheless, the similarity between the sequences of the two areas is most notable. The lithostratigraphic units are remarkably persistent along strike and there is apparently little facies change. This lateral lithologic uniformity provides a sound basis for correlation throughout the district.

A comparison of the Espanola-Whitefish Falls and Sudbury-Espanola sections is given in Figure 4. The formations and the section as a whole thicken markedly from northwest to southeast, and the thickening occurs abruptly in the northern part of the area as the formations are traced away from the exposed basement rocks.

Table 7 MEAN PALEOCURRENT DIRECTIONS FOR THE HURONIAN FORMATIONS IN THE ESPANOLA-WHITEFISH FALLS AREA

Formation	Casshyap (1967) (Vector Mean)	This Report
McKim		160°
Mississagi	179° ± 63°	Polymodal – south, west to southwest
Bruce	192° or 12° ± 39°	
Espanola	180° ± 52°	Polymodal – southwest, east, west (mean – 200°)
Serpent	187° ± 54°	Polymodal – southwest, southeast (mean – 190°)
Gowganda (Lower)	156° or 336° ± 44°	
Gowganda (Upper)	158° or 338° ± 39°	Polymodal – southeast, west (mean – 180°)
Lorrain	161° ± 54°	Polymodal – south to southeast, southwest, minor north.

The thicknesses remain relatively constant throughout the Espanola-Whitefish Falls area.

PALEOGEOGRAPHY AND PROVENANCE

Measurements of the attitudes of crossbeds, and ripples, in the Espanola-Whitefish Falls area by the writer and by Casshyap (1967) show that the paleocurrent patterns for most of the Huronian formations are distinctly polymodal (Table 7). Most formations display two paleocurrent maxima, one south to southeast, the other southwest to west. This bimodal pattern has been attributed to sampling bias caused by preferential measurement of the proximal crossbed classes, to the exclusion of the modal class in steeply dipping beds (Pettijohn 1957b).

It is probable, however, that the paleocurrent polymodal distribution is due to variable current directions, rather than to sampling bias. Measurement of several crossbeds in any one outcrop or outcrop group generally produces a polymodal distribution pattern, even where the beds dip at angles of 30 degrees or less. The south- to southeast-trending maximum would represent the main paleocurrents which flowed down the regional paleoslope and contributed sediment to the depositional basin. The southwest- to west-trending maximum, and other maxima would represent reworking of these sediments by long-shore and on-shore currents.

The paleocurrent patterns indicate that the source area for the Huronian sediments lay to the north. The petrography of the sandstones and conglomerates indicates that the main source rocks were plutonic granitoid rocks in the quartz monzonite-granodiorite range, but that some of the sediments were also derived from volcanic and metasedimentary sources. The source rocks for the Huronian sedimentary rocks must have been similar to those exposed in the Superior Province to the north.

ENVIRONMENT OF DEPOSITION

The Huronian formations comprise three main lithological types. The commonest type includes the sandstone units, the Mississagi, Upper Espanola, Serpent, Upper Gowganda, and Lorrain Formations. The second type includes the dominantly pelitic units, the McKim, Pecors, Lower Espanola, and Gordon Lake Formations. The third is the conglomeratic type, and into this category fall the Ramsay Lake, Bruce, and lower part of the Gowganda Formations.

The sandstones of the Mississagi, Serpent, Espanola, and the Lower Lorrain Formations are generally immature to submature texturally and mineralogically, indicating little winnowing action, and, probably, rapid deposition. The sedimentary rocks of the upper parts of these formations are generally submature, and in the case of Lorrain Formation, mature to supermature. They were probably deposited in high energy environments where winnowing action was moderate to strong. In the case of the Mississagi and Serpent Formations, some of the fine detritus winnowed out was deposited locally in the form of argillaceous intercalations.

According to Potter and Pettijohn (1964), the crossbedding variance (a statistical measure of the variability of orientation of the crossbedding) of fluvial-deltaic deposits is in the 4,000 to 6,000 range but that of marine deposits is generally higher. Casshyap (1967) gives the following variance figures and concludes that a fluvial environment is indicated as follows:

Mississagi Fm — 4863, 3876
Espanola Fm — 2730
Serpent Fm — 3897, 1310
Lorrain Fm — 2927

He also states that the depositional currents were locally variable but regionally uniform, also indicating a fluvial mode of deposition. The Mississagi, Espanola, Serpent, and Lower Lorrain Formations were probably deposited in a deltaic coastal plain environment. The upper part of the Lorrain Formation was deposited in a high energy, shallow-water, marine, littoral, or neritic environment. Winnowing and reworking of the sediments were effected by repeated transgressions and regressions of the seas. The almost complete lack of detrital feldspars, and the appearance of abundant hematite and clay minerals in the upper part of the Lorrain Formation may indicate a change from cold, rigorous climatic conditions to tropical conditions.

The pelitic formations have characteristics such as laminated bedding that indicate deposition in low energy environments. Mud cracks are also common, indicating periodic exposure. They also contain features indicative of deposition by turbidity currents. The rocks are texturally and mineralogically immature although the chemistry of the McKim metapelites indicates a high proportion of bauxitic clays that would be provided by highly weathered detritus. The high proportion of calcite and dolomite in the Espanola Formation indicates marine conditions existed. It is probable that the McKim, Lower Espanola, and Gordon Lake Formations were deposited in a near shore, shallow-water, marine environment where periodic regressions exposed the tidal flat areas from time to time.

The conglomeratic units, the Ramsay Lake, Bruce, and Lower Gowganda Formations, are typical pebbly mudstones texturally and mineralogically immature, and have great lateral extent in relation to their thickness. Three general modes of origin are possible; marine turbidity current deposits, terrestrial mudflow deposits, or glaciofluvial deposits.

Evidence of a glacial origin for these deposits is their extensive, sheet-like form, their homogeneous nature, and their lithology (Ovenshine 1965). The tilloid-type conglomerates and argillites are similar to Pleistocene glaciofluvial deposits. The pebbles of the conglomerates are mainly plutonic varieties which have been transported over long distances. Dropped pebbles in laminated argillites could be due to ice-rafting. The textural immaturity of the sedimentary rocks indicates transportation, and deposition by a high density medium such as ice. The mineralogical and chemical immaturity of the rocks indicates rigorous climatic conditions. Finally, studies by Lindsey (1966, 1967) indicate a regional north-south preferred orientation of pebbles in the formations. The crude bedding and crossbedding in the conglomerates, and the laminated bedding and ripple marks in the argillites show that the lower part of the Gowganda Formation was deposited probably in a marine environment.

The lower part of the Gowganda, and possibly also the Ramsay Lake and Bruce Formations, may be of marine glacial origin. If this hypothesis is valid, the Ramsay Lake and Bruce Formations would record single glacial events, whereas the lower part of the Gowganda Formation would represent two or three glacial advances and retreats; the main conglomerate units represent glacial advances, and the argillites, interglacial periods.

The possibility that the Huronian conglomeratic formations represent large-scale mudflow or turbidite (debris flow) deposits has not been fully assessed on a regional basis.

Nipissing Diabase

Several sill-like bodies of pyroxene gabbro and metagabbro in the area are tentatively correlated with the Nipissing Diabase of the Blind River and Cobalt areas. According to geochronological studies (rubidium-strontium whole-rock isochron analyses) by Van Schmus (1965), these intrusions are 2,155±80 million years old. The sills are as much as 1,500 feet (460 m) thick, and are generally parallel to the regional structural-stratigraphic trends. Apparently emplaced early in the sequence of tectonic and metamorphic events, the gabbros are massive, but commonly display weak foliations near their contacts with other rocks.

The pyroxene gabbro is a brown- to black-weathering, medium-grained rock composed essentially of plagioclase (An70±4), orthopyroxene (bronzite), and clinopyroxene (augite) with minor amounts of quartz, granophyre, biotite, and ilmenite (Table 8). The pyroxene gabbro is extensively altered to metagabbro and alteration begins along narrow veins in the gabbro and spreads outward. The mineralogical changes consist of alteration of the pyroxenes to talc and chlorite, then to actinolitic amphibole. Reactions between actinolite and plagioclase, if they go to completion, result in assemblages consisting mainly of hornblende, albite, epidote, and quartz with minor amounts of biotite, chlorite, muscovite, sphene, iron-titanium oxides, and sulphides. Reactions are commonly incomplete, resulting in a partly altered gabbro consisting of the original calcic plagioclase, and actinolite pseudomorphic after pyroxene. Modal and chemical analyses of gabbroic rocks are given in Table 8.

Table 8 | MODAL AND CHEMICAL ANALYSES OF MAFIC INTRUSIVE ROCKS IN ESPANOLA-WHITEFISH FALLS AREA*

Modal Analyses; Major Components in percent

Rock Unit	Nipissing Diabase	Nipissing Diabase	Nipissing Diabase	Amphibolite Dike	Late Diabase Dike
Rock Type	Pyroxene Gabbro	Metagabbro	Metagabbro		Olivine Diabase
Sample Number	CG-66-125a	CG-66-126	CG-66-107a[1]	CG-66-106a	BM-65-175
Plagioclase	52.4	49.2	...	23.7	61.6
Quartz	x	3.8	...	3.3	...
Pyroxene	37.7	...	...	...	19.0
Olivine	...	...	...	...	8.0
Actinolite	5.0	44.9	...	...	...
Hornblende	...	x	...	58.4	...
Biotite	3.7	0.5	...	x	1.3
Chlorite	...	...	...	x	x
Muscovite	...	...	...	x	...
Epidote	...	x	...	3.0	...
Sphene	...	...	...	11.6	...
Iron Oxides	1.2	1.6	...	x	8.1
Sulphide	...	...	...	x	
Apatite	...	...	...	...	2.0
Plagioclase Composition	$An_{70\pm5}$ zoned to $An_{50\pm5}$	An_{70+5}, minor albite		Albite	

Chemical Analyses; Major Components in percent

	CG-66-125a	CG-66-126	CG-66-107a	CG-66-106a	BM-65-175
SiO_2	49.97	48.34	50.89	47.44	
Al_2O_3	17.44	18.03	14.60	15.70	
Fe_2O_3	2.19	1.28	1.52	3.19	
FeO	6.90	8.15	8.08	13.11	
MgO	7.79	8.45	8.38	4.50	
CaO	11.05	9.82	9.94	8.19	
Na_2O	1.96	2.08	1.65	2.54	
K_2O	0.48	0.60	0.55	0.97	
H_2O^+	0.53	1.52	1.76	1.89	
H_2O^-	0.22	0.23	0.28	0.20	
CO_2	0.39	0.33	0.27	0.19	
TiO_2	0.30	0.28	0.19	0.50	
P_2O_5	0.07	0.07	0.03	0.29	
S	0.08	0.09	0.08	0.16	
MnO	0.12	0.14	0.14	0.18	
Cr_2O_3	0.09	0.03	0.05	0.01	
V_2O_3	0.07	0.04	0.09	0.10	
Total	99.57	99.39	98.42	99.00	
S.G.	2.99	2.96	2.98	2.90	

Abbreviations

x	Present in minor amounts
...	Not detected
S.G.	Specific Gravity

*Chemical Analyses by Mineral Research Branch, Ontario Division of Mines.

[1] No modal analysis carried out on this sample.

Comparison of chemical analyses No. 1 and No. 2 indicates that the alteration of the gabbro to metagabbro has resulted in relatively little change in bulk chemistry except for a three-fold increase in water and a change in the Fe_2O_3/FeO ratio from approximately 1:3 to 1:7.

The gabbros are of intrusive, magmatic origin and were emplaced during an early orogenic stage. Their alteration was effected mainly by hydrous fluids produced by the elevated temperature and pressure of regional metamorphism (Card 1964).

Amphibolite Intrusions

A system of northwest- to west-striking amphibolite dikes younger than the Nipissing Diabase occurs in the area. Individual dikes range in width from a few feet (2 m) to about 100 feet (30 m). They are fine-grained, black-weathered, equigranular to porphyritic rocks composed of hornblende, actinolite, saussuritized plagioclase, epidote, chlorite, biotite, calcite, apatite, iron-titanium oxides, and sphene. The zoned plagioclase phenocrysts are as much as ¼ inch (0.65 cm) long, and are almost completely saussuritized. Modal and chemical analyses are given in Table 8.

In the earlier mapping in this region (for example, Collins 1925) the amphibolite dikes were ignored, or were included with either the Nipissing or the Late Diabase Intrusions. The amphibolite intrusions clearly represent a separate series of intrusions. The amphibolite dikes are younger than the Nipissing Diabase and in lot 9, concession II, Mongowin Township, a fine-grained amphibolite dike intrudes medium-grained Nipissing Diabase. The gabbro and amphibolite are distinctly different in mineralogy and bulk chemistry as is demonstrated by comparative modes and chemical analyses (Table 8). The dikes transect the major fold axes and are consequently younger than the major folding. The dike rocks are metamorphosed, and are consequently older than the unmetamorphosed late diabases. The absolute age of the amphibolites is not known, but they are younger than the gabbros (2,155 million years) and older than the regional metamorphism (1,800±100 million years) (Van Schmus 1965; Fairbairn and Hurley *et al.* 1969; Fairbairn and Knight *et al.* 1967).

Mongowin Pluton

The Mongowin Pluton is described in a separate paper (Card 1968b), and will only be dealt with briefly here.

The elliptical pluton, which measures 1,450 feet by 2,600 feet (440 m by 780 m), is in lots 11 and 12, concession VI, Mongowin Township. It is a composite intrusion comprising a northern ultramafic portion, a middle dioritic portion, and a southern trondhjemitic portion. The ultramafic rock is an altered peridotite composed of serpentinized olivine, pyroxenes, and the amphiboles anthophyllite, cummingtonite, and hornblende. The dioritic rocks consist essentially of plagioclase (An30±3), quartz, hornblende, biotite, chlorite, and epidote. The trondhjemite consists of a granophyric intergrowth of quartz and albite, with muscovite, and chlorite. The rocks of the pluton, especially the ultramafics, contain abundant magnetite; consequently the body gives rise to a circular aeromagnetic anomaly (GSC 1965a, Aeromagnetic Map 1522G, Whitefish Falls, Ontario).

Investigation of the chemistry and mineralogy of the pluton shows that it was probably derived from a single magmatic source, and represents two successive injections of magma followed by minor differentiation.

Alteration of the femic minerals has produced serpentine, magnetite, and possibly sulphides. The magnetite is generally disseminated throughout the ultramafic rocks. An unusual vein of colloform magnetite is in the ultramafic rocks in the central part of the body. Sulphides which have been identified are pyrrhotite, chalcopyrite, and pyrite.

The Mongowin Pluton intrudes rocks of the Gowganda Formation, apparently cuts amphibolite dikes, and was emplaced 1,770±75 million years ago according to rubidium-strontium isochron age determinations by Van Schmus (1971).

LATE PRECAMBRIAN

Late Diabase Intrusions

Late diabase dikes striking northwest and east-west are the youngest rocks in the area. Potassium-argon radiometric age determinations by Leech *et al.* (1963) and others on similar late dikes throughout the region have yielded results ranging in age from approximately 1,000 million years to 1,400 million years. Recently, Gates and Hurley (1973) have determined a rubidium-strontium isochron age of 1,460±130(?) million years for these dikes.

The dikes range in width from a few feet (metres) to several hundred feet (metres), dip vertically, and are generally very long relative to their width. One dike, 600 feet (180 m) wide, has been traced from the present area to the east of Killarney (Frarey, personal communication). Study of the aeromagnetic maps (GSC 1965a and 1965b Aeromagnetic Maps 1522G and 1523G) shows that the dike continues to the northwest, and that it is more than 100 miles (160 km) long.

The diabase is a dark grey, brown-weathering, medium-grained rock with a sub-ophitic texture and comprises zoned plagioclase laths (An70±5 to An50±5), olivine, titaniferous augite, magnetite-ilmenite, and minor apatite, biotite, and chlorite. The high magnetite content accounts for the high magnetic response of the dikes.

The diabase dikes post-date the major tectonic and metamorphic events in the region, cut sharply across the trends of the country-rocks, and are unmetamorphosed. They have been displaced by late fault movements and their constant regional orientation indicates that they were emplaced under a regionally imposed tectonic stress system. Possibly they were intruded into tensional zones produced by broad, regional flexuring at a high angle to the earlier regional structural trends.

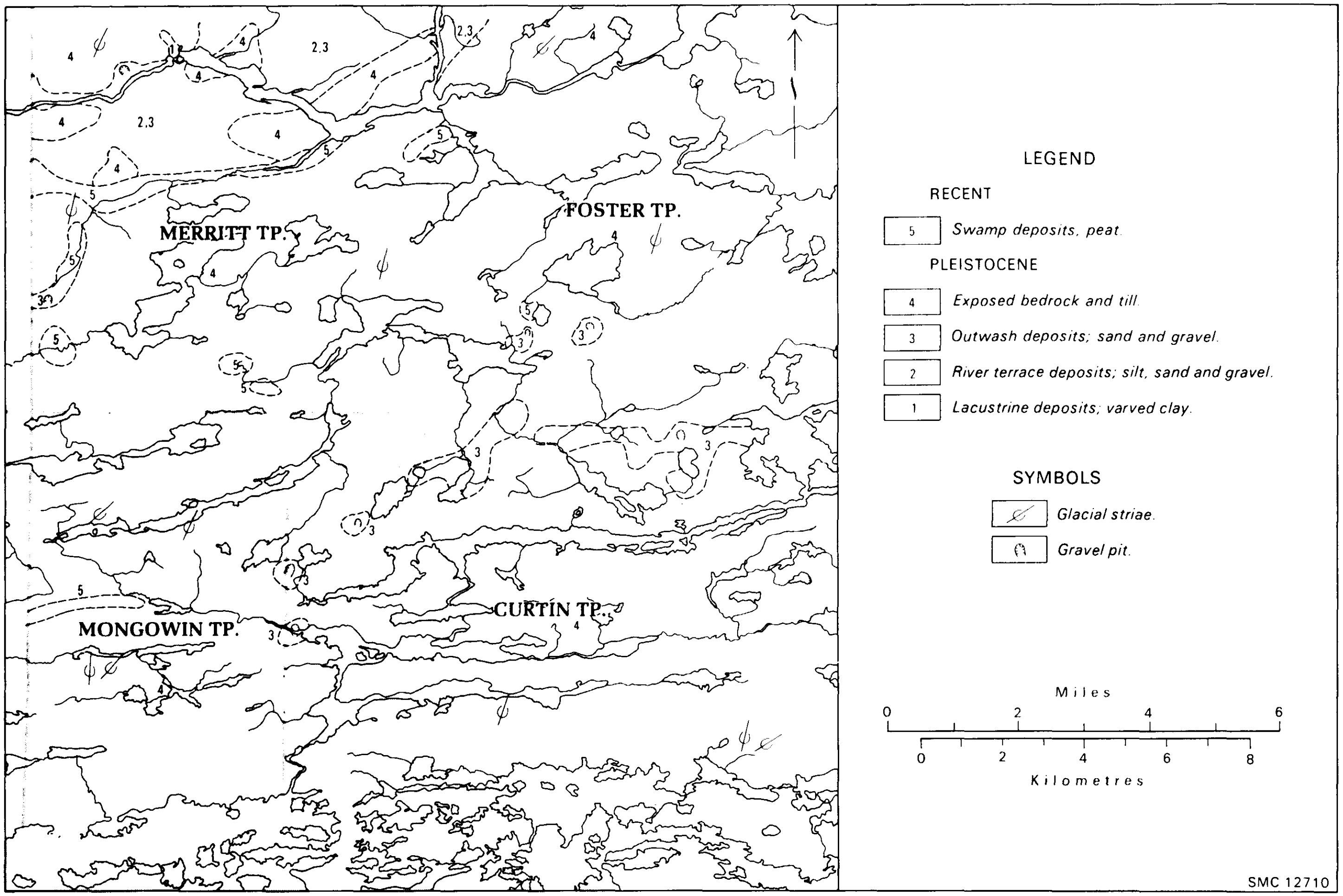

Figure 5–Quaternary Geology of the Espanola-Whitefish Falls area.

CENOZOIC

Quaternary Geology

PLEISTOCENE AND RECENT

The map-area was subjected to glaciation during the Pleistocene. Measurements of glacial striae show that the last direction of ice movement was approximately S20°W but at several localities, older striations striking about S45°W also were measured (Figure 5).

Throughout most of the area, glacial deposition is represented by a thin, discontinuous veneer of ground moraine which consists of coarse, unsorted boulder till. There are locally thick accumulations of unsorted till and sand which possibly represent glacier bottom load materials.

Glaciofluvial outwash deposits display bedding and crossbedding throughout the area. These deposits provide most of the workable gravel deposits. Thick glaciofluvial deposits occur in the northern part of the area along the Spanish River. These sediments consist of silt, sand, gravel, and varved clay and probably represent river terrace deposits marking the course of a major Pleistocene drainage system (Boissonneau 1965, 1968). Varved clays containing clay stone nodules, are exposed on the north shore of the Spanish River north of the town of Espanola.

Recent deposits of sand, gravel, and peat accumulation occur along the streams and in the swamps.

STRUCTURAL GEOLOGY

The Espanola-Whitefish Falls map-area lies in the 'Penokean fold-belt' of the Southern Province. The deformation and metamorphism affecting these rocks have been assigned to the Penokean orogeny by Gill (1949) and to the Hudsonian orogeny by Stockwell (1965). Recent work on the structure, metamorphism, and radiometric ages by Card (1964), Blackburn (1967), Church (1966), Fairbairn and Hurley *et al.* (1969), and Fairbairn and Knight *et al.* (1967), and Van Schmus (1965), has shown that the sequence of orogenic events is complex. The region was affected by a series of deformational-metamorphic events which began prior to the emplacement of Nipissing Gabbro 2,150 million years ago, and essentially ended before emplacement of the late olivine diabase dikes 1,120 million years ago. The main orogenic events probably fall in the interval between 2,200 million years and 1,600 million years as bracketed by the Nipissing Diabase age and K/Ar dating of metamorphic micas (Leech *et al.* 1963). The radiometric age dating also indicates the possibility of two main metamorphic culminations, one about 1,900 million years ago, the other about 1,700 million years ago. Although more than one orogeny could have affected the region, it is possible to view the orogenic history as a series of deformational-metamorphic events belonging to a protracted orogeny.

The major regional structure consists of an *en echelon* series of domes and basins which are major synclinoria and anticlinoria. The Espanola-Whitefish Falls area extending southward from the Baldwin Anticlinorium includes such major structures as the Bass Lake and La Cloche Synclines.

The present structural analysis shows that the rocks have been affected by at least three superimposed deformations:

(1) Early deformation which resulted in major folding about east-west axes;
(2) Second deformation, which varied in intensity from low to moderate, and resulted in refolding about east-west to northeast-trending axes;
(3) A third deformation resulted in strain-slip cleavage and minor refolding about northwest- to northeast-trending axes.

Structural Domains

The map-area can be divided into nine structural areas or domains. Each is relatively homogeneous structurally, contains one or two dominant structural elements, and has generally constant orientation of major and minor structures. The structural subdivisions and orientations of major and minor structural elements are shown in Figure 6 (Chart A, back pocket). Within each domain, the early foliations and lineations are generally parallel to early fold structures, but they have been locally deformed and rotated by later deformational events. Foliations associated with the second deformation, where they can be distinguished from the early foliations, transect the early structures at a low angle. Lineations associated with the first and second deformations plunge east and west and commonly form a girdle trending parallel to the axial planes of associated folds. Minor structures associated with the third deformation transect the earlier structural trends at high angles.

Folds

In Domain I, rocks of the McKim Formation are folded into a series of doubly plunging anticlines and synclines whose axes strike about N75°E to N80°E and plunge from 10° to 35° both east and west. The folds are non-cylindrical, are upright, and their limbs are tightly appressed to open (Photo 12). In Domain III, there is a similar series of folds whose axes strike about N75°E and plunge both east and west at angles of 10° to 40°.

The St. Leonard Anticline in Domain IV is an upright, approximately cylindrical fold whose axis strikes about N70°E and plunges 50° west. The adjacent West Bay Syncline in Domain V is a poorly defined structure whose axis strikes N60°E to N70°E and apparently plunges about 30° east.

In Domain VI, the major structures are the Bass Lake Syncline, the Fox Lake Anticline, and the Carson Cross-Fold. The Bass Lake Syncline is a non-cylindrical, doubly plunging fold with an upright axial plane. The axis of this fold strikes about N80°E and plunges both east and west at angles of 20° to 25°. The plunge of the axis in the centre of the trough varies from about 5° east to 5° west and averages 0°. The Fox Lake Anticline is an upright fold whose axis strikes N80°E and is approximately horizontal. The axis of this anticline is deformed by the Carson Cross-Fold, an antiformal structure, the axial plane of which strikes approximately N40°W and whose axis apparently plunges vertically.

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Photo 12–An open, gently plunging anticline in the McKim Formation.

The Deerhound Lake Syncline and the Deerhound Lake Anticline in Domain VII are upright, approximately cylindrical folds whose axes are warped but trend approximately N80°E and are horizontal. The Lang Lake Cross-Fold, which deforms the earlier east-west folds, appears to be both antiformal and synformal and is crudely 'eye-shaped' in plan. Its axial plane strikes about N70°W and its axis plunges both northwest and southeast at angles of 30° to 40°.

The La Cloche Syncline in Domain IX is an upright, isoclinal fold whose axis strikes N85°E and is horizontal. The Frood Lake Cross-Fold is an antiform whose axis strikes N85°W and plunges 40° west.

Faults

Faults in the area trend in three main directions, east-west, northeast, and northwest. Probably the east-west faults are part of the Murray system which extends along the North Shore of Lake Huron.

The major faults were probably active intermittently for more than 1,000 million years. The main Murray fault system north of the map-area was apparently active during Huronian sedimentation. Faults constitute the boundaries between structural domains and were consequently active before, during, and after the various Penokean orogenic events. Movement occurred on many of the faults after emplacement of the late diabase dikes, and there was probably renewed activity during the various events that occurred in the Grenville Province to the south.

EAST-WEST FAULTS

The main east-west faults, which apparently dip steeply south, are the Espanola, Tulloch Lake, Apsey Lake, Loon Lake, Charlton Lake and the La Cloche Faults. Movement on several, notably the Apsey Lake, Loon Lake, and Charlton Lake Faults, has produced major vertical and horizontal displacements of rock units: some of several thousands of feet (metres) are indicated.

The east-west faults are probably major reverse faults on which the dominant sense of movement is south side up and to the west with respect to the north side. These faults are 'tectonic slides' because they were probably formed in close connection to folding, are approximately conformable in strike to the fold axial surfaces, and have produced major omissions and repetitions of stratigraphic units.

NORTHWEST AND NORTHEAST FAULTS

The northwest and northeast faults are probably part of a conjugate set. They are probably older than the east-west faults, although there has been late movement on several of them. The more important northeast faults are the Fox Lake, Elizabeth Lake, and St. Leonard Faults. Northwest faults include the Webbwood, Lang Lake, and Deerhound Lake Faults. Apparent horizontal displacement of stratigraphic units on most of these faults amounts to no more than a few hundred feet (metres). But several, notably the Fox Lake Fault, have produced apparent displacements of stratigraphic units of several thousand feet (metres). The dominant movement was probably dip-slip.

Breccia

All rock-types older than the amphibolite intrusions have been brecciated. The brecciation is similar to that which affects the Huronian and older rocks near Sudbury (Card 1968a). In the map-area, irregular breccia bodies ranging in maximum dimension from a few feet (metres) to several miles (kilometres) are in northern Merritt Township, at the nose of Bass Lake Syncline, in central Curtin Township, and near the Lang Lake Cross-Fold.

The breccia consists of angular to rounded fragments of country-rock ranging from less than 1 inch (2.5 cm) to about ten feet (3 m) in maximum dimension in a fine-grained matrix consisting of comminuted rock-flour. Commonly only one or two lithologies are represented in the fragments, and these are derived from nearby formations. The composition of the matrix corresponds to the composition of the fragments. For example the breccias in northern Merritt Township in the McKim Formation comprise blocks of pelitic metasediments with minor sandstone and gabbro in a pelitic matrix. Those breccias in the Serpent Formation in southern

Merritt Township comprise sandstone fragments in a quartzose matrix. The breccia fragments are commonly bleached and some have alteration haloes. Locally, breccias are silicified and albitized, demonstrating the existence of hydrothermal activity in the breccia zones.

Breccia bodies cut the early formed fold structures, but are affected by the second and third deformational events and are regionally metamorphosed. They were probably formed by slumping, by deformation in the axial zones of folds, by boudinage caused by competency differences between different rocks, and by faulting. However, for many of the larger breccia bodies, there is no obvious explanation for them.

Shatter Cones

Shatter cones similar to those of the Sudbury area (Bray *et al.* 1966) occur in northern Foster Township in micaceous sandstones of the Mississagi Formation. They are spatially related to the Espanola Fault and all the shatter cones found in the area have their apices pointing downward at angles of 45 degrees to 65 degrees.

Dietz (1964) attributes the formation of shatter cones in the Sudbury area to shock-induced overpressures caused by meteorite impact. Because of the close association of the Foster Township shatter cones with a fault, and their orientation, shock-induced overpressures generated by fault movements seem a possible alternative mode of origin.

Tectonic Synthesis

The axial planes of the major folds, the east-west foliations, and the major east-west faults are approximately parallel. The major folds are non-cylindrical, although fold segments are approximately cylindrical.

Folds were formed mainly by a combination of flexural slip on bedding planes, flexural slip on foliation planes, and flexural flow (Donath and Parker 1964). Folding of the sandstone units was probably effected mainly by flexure slip on bedding and flexure slip on foliation planes with flexural flow as a subordinate mechanism. Folding of the pelitic units was probably accomplished mainly by flexural planes and flexural flow. The late strain-slip cleavage folds were probably formed by passive slip on cleavage planes.

The early foliations may be compressive phenomena formed perpendicular to the axis of maximum compression. If so, the axis of maximum compression producing the major deformation was oriented north-south, perpendicular to the major fold-axial planes, the foliations, and the east-west faults. The late strain-slip cleavages could have formed parallel to the shear planes of the theoretical strain ellipsoid.

The doubly plunging folds of the Espanola-Whitefish Falls area are part of the major *en echelon* dome and basin pattern of the region. This pattern may have formed as a result of a single deformational event, the first major folding, or may represent an interference pattern developed by the superimposition of secondary deformational structures on the primary major folds.

Study of the relationships between the time of formation of various structures and time of events or emplacement of lithologic units shows the following sequence of events.

(1) First deformation-major folding about approximately east-west axes.
(2) Intrusion of Nipissing Diabase, probably during later stages of the first event.
(3) Formation of the Sudbury-type breccia.
(4) Second deformation-refolding about east-west to northwest-southeast axes, preceded or accompanied by the intrusion of the amphibolite dikes.
(5) Third deformation-minor folding about northwest to northeast axes and formation of strain-slip cleavage.

METAMORPHISM

Except for the late diabase dikes and possibly the Mongowin Pluton, the rocks have been regionally metamorphosed under conditions corresponding to the greenschist and almandine amphibolite facies of regional metamorphism. Metamorphism accompanied each of the deformational events and its intensity varied in time and space.

The map-area can be divided into four zones on the basis of the metamorphic mineral assemblages developed in the rocks of each zone (Figure 7). Zone 1 is underlain mainly by pelitic rocks containing porphyroblasts of garnet, chloritoid, chlorite, and plagioclase, and mafic igneous rocks which are composed of actinolite, hornblende, and plagioclase. Chemical analyses (Table 5) of pelitic metasediments show that the development of chloritoid and garnet is dependent on total rock composition. The chloritoid- and garnet-bearing rocks have higher FeO/MgO ratios and alumina contents than nearby rocks which do not have these minerals. The metamorphic mineral assemblages in Zone 1 indicate that the grade of regional metamorphism is the same as the quartz-albite-epidote-almandine subfacies of the greenschist facies (Fyfe, Turner, and Verhoogen 1958).

In Zone 2, the widest metamorphic zone in the area, porphyroblasts of chlorite and biotite are in the quartzo-feldspathic and pelitic metasediments; actinolite, hornblende, and albite are in the metagabbros; and chlorite, phlogopite, biotite, and scapolite are in the calcareous metasediments. The mineral assemblages of Zone 2 correspond to the quartz-albite-epidote-biotite subfacies of the greenschist facies of regional metamorphism. The origin of the scapolite, abundant in calcareous metasediments of the Espanola Formation (Photo 13), is problematic. Scapolite probably developed in response to regional metamorphism, but is sodic (marialite-rich); the source of this soda is unknown. Chemical analyses show that the scapolitic rocks contain nearly twice as much Na_2O as the non-scapolitic rocks (compare analyses 4, 5, and 7 in Table 5). The soda required for scapolite formation may have been originally present in the rocks as soda-rich minerals, such as halite, or may have been the result of metasomatism from gabbroic intrusions.

Zone 3 is underlain partly by calcareous metasediments of the Espanola Formation. The metamorphic minerals include biotite, scapolite, actinolite, garnet, idocrase (Photo 14), wollastonite, and diopside. Scheelite, powellite, pyrrhotite, sphalerite, and molybdenite are locally abundant. The mineral assemblages of this zone are diagnostic of the staurolite-almandine subfacies of the almandine-amphib-

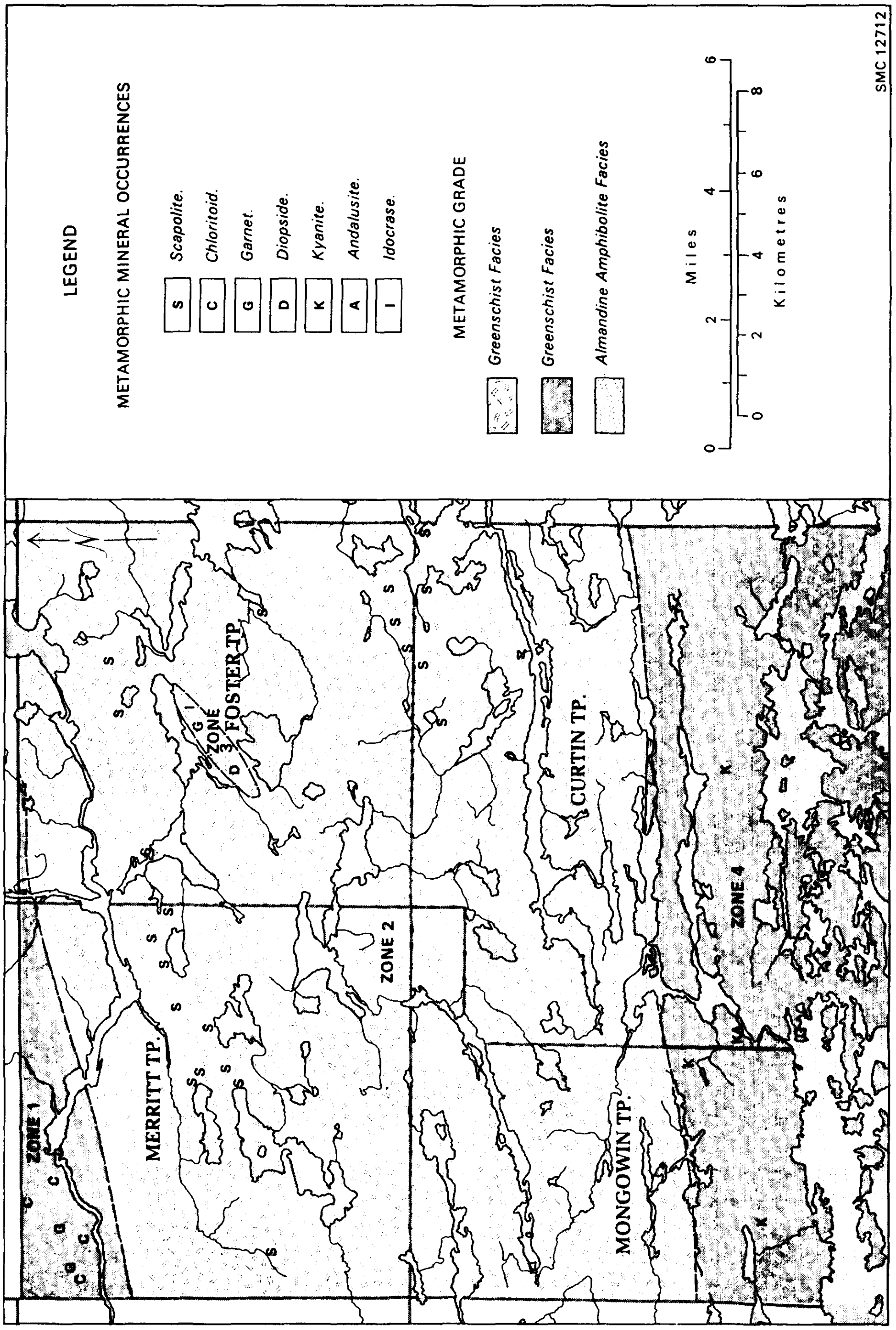

Figure 7–Metamorphic zones and metamorphic mineral occurrences. Zones 1 and 4 – middle to upper greenschist facies; Zone 2 – lower to middle greenschist facies; Zone 3 – lower almandine – amphibolite facies.

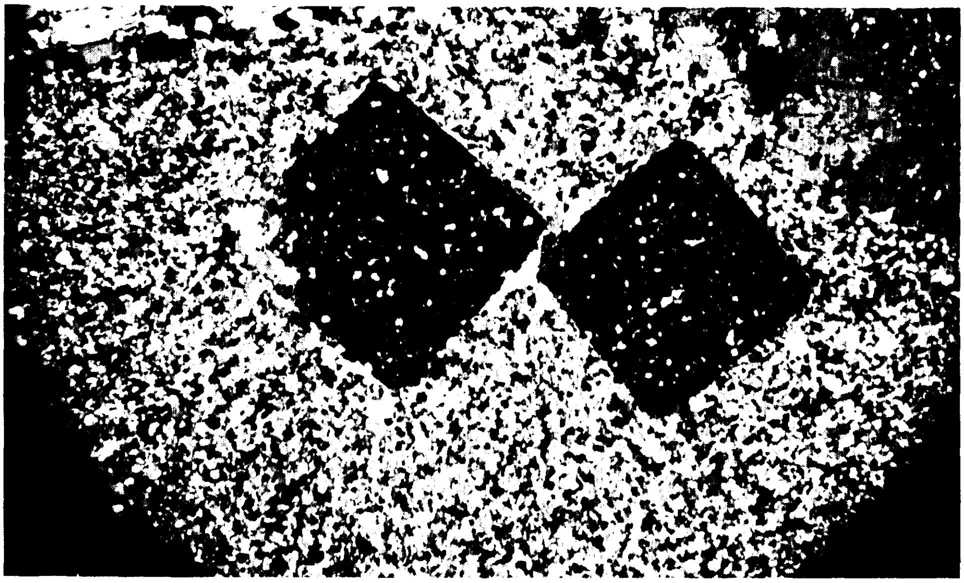

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Photo 13–Photomicrograph of euhedral scapolite porphyroblasts in calcareous metasediments of the Espanola Formation.

ODM9161

Photo 14–Photomicrograph of idocrase porphyroblasts developed in Espanola skarn. Note the zoning and the ameboid growth pattern of the crystals (about x 30).

olite facies of regional metamorphism. The presence of abundant sulphides, tungsten minerals, and idocrase indicates the probable metasomatic addition of material to the rocks of Zone 3.

Zone 4 is dominated by the La Cloche Syncline, and is underlain by sandstones and pelitic metasediments. The pelites contain porphyroblasts of muscovite, chlorite, biotite, and garnet. One of the sandstone units contains abundant interstitial kaolinite which was either sedimentary in origin, or was formed by alteration of potassic feldspar. Kyanite, and, rarely, andalusite have partly replaced the kaolinite. According to Church (1967), the kyanite was formed early during dynamothermal metamorphism, probably under conditions of ultra-high pressure that existed in the axial zone of the La Cloche Syncline. Andalusite was probably formed after stress release at the same time as post-kinematic biotite-garnet assemblages in the pelitic rocks to the south. If this interpretation is correct, kyanite probably formed under conditions of high pressure and intermediate temperature corresponding to the quartz-albite-epidote-almandine sub-facies of the greenschist facies of the Barrovian-type facies series. Andalusite, on the other hand, formed under intermediate pressure-temperature conditions corresponding to the quartz-andalusite-plagioclase subfacies of the green schist facies of the Abukuma-type facies series (Winkler 1967).

Study of the relationships between porphyroblasts and deformational structures such as cleavage shows that each of the deformational events was accompanied by low-grade metamorphism and growth or recrystallization of minerals such as muscovite and chlorite. Metamorphism, higher in grade than the low-grade metamorphism, occurred in the intervals between deformational events in some localities. During the first period of high-grade metamorphism minerals such as garnet and kyanite formed. During the second period of high-grade metamorphism in the southern part of the area, there was a metamorphic culmination with the formation of andalusite and almandine garnet.

ECONOMIC GEOLOGY

EXPLORATION AND MINING HISTORY

In the 1840s, Alexander Murray, Sir William Logan's assistant, made a survey along the North Shore of Lake Huron between Bruce Mines and Killarney and visited the Wallace Mine of the Upper Canada Mining Company (Murray 1847). The Wallace Mine (27); Map 2312 (back pocket) was the site of the first discovery of nickel in Canada, and foreshadowed the discovery of the great nickel deposits of Sudbury, some 40 miles (65 km) to the northeast.

The Wallace Mine location was explored later by Thomas Frood who discovered specular hematite north of the sulphide occurrence (Report of the Royal Ontario Nickel Commission 1917, p.24 to 26). In recent years, the sulphide occurrence has been diamond drilled and sampled, principally by Falconbridge Nickel Mines Limited and Jolloco Explorations Limited, but no mineralization of commercial importance has been discovered (Resident Geologist's Files, Ontario Ministry of Natural Resources, Sudbury).

In the early 1900s, copper-nickel mineralization was discovered in a small ultramafic-granophyre intrusion in northern Mongowin Township which is called in this report, the Mongowin Pluton. At this occurrence, known as the Owen property, colloform magnetite and Iceland spar also are found.

In the 1920s and 1930s, gold showings were discovered in the map-area and the Tough brothers who acquired fame in the Kirkland Lake gold camp lived and prospected in the area for several years. Some gold was produced from the McMillan and Bousquet Mines during the 1930s and in more recent years attempts were made to recover gold at the Upsala Mine (*see* "White, S. J. (Upsala Mine)") in Curtin Township, cobalt from a cobaltite occurrence (*see* Map 2311) in northern Foster Township, and quartz for pre-cast concrete facing from veins in Merritt Township.

In the mid-1960s, two local prospectors, T. Tamminen and V. Piispanen, staked a group of claims north of St. Leonard Lake in Foster Township on the strength of the discovery of minor amounts of scheelite, molybdenite, and chalcopyrite in an old pit. Texas Gulf Sulphur Company Incorporated tested this mineralization by diamond drilling and surface mapping in 1966 and 1967; and in 1970 Cerro Mining Company of Canada Limited carried out further surface exploration and diamond drilling.

The only present producer in the area is the Lawson Quarry of The International Nickel Company of Canada Limited in Curtin Township (*see* Map 2312 for location). The quarry was opened in 1924 and the crushed orthoquartzite produced is shipped to Sudbury for use as flux in the company's smelter operations.

Table 9 (Chart B, back pocket) lists assessment work reports which are on file at the Resident Geologist's office, Ontario Ministry of Natural Resources, Sudbury, to the end of 1971.

DESCRIPTION OF PROPERTIES AND OCCURRENCES[1]

Copper, Nickel and Cobalt

APSEY LAKE OCCURRENCE (1)[2]

Sulphides are found in Mississagi quartzite and Bruce conglomerate in lot 11, concession I, Merritt Township. Disseminated pyrrhotite, pyrite, and minor chalcopyrite, generally constituting less than 5 per cent of the rock, are in an area measuring approximately 100 feet by 300 feet (30 m by 90 m). Graphite veinlets are closely associated with the sulphide mineralization.

KARL OCCURRENCE (6)

There are numerous shallow pits in lot 12, concession V, and lot 12, concession IV, Foster Township, blasted into small north-striking veins in rocks of the Espanola

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[1] Only those properties and occurrences for which geological information is available are described in this report.

[2] The number in brackets refers to property number on Geological Maps 2311 and 2312, back pocket.

Formation. The veins contain minor amounts of disseminated pyrrhotite, chalcopyrite, and pyrite. In 1957, Prosco Limited examined the property by geological and geophysical methods. Assays by Prosco Limited of chip samples across and along several of the veins are as follows:

Sample No.	Width (Feet)	Copper percent	Nickel percent	Nickel	Lead	Gold	Silver
15	4.0 [1.2 m]	0.10	0.05	...	...	...	...
16	3.2 [1.0 m]	0.13	0.07	nil	nil	tr.	tr.
20	10 (along vein) [3 m]	0.13	0.13	...	...	...	...

Assays from Resident Geologist's Files, Ontario Ministry of Natural Resources, Sudbury)

E. MAKI (7)

In lot 10, concession V, Foster Township, cobaltite, pyrrhotite, and chalcopyrite occur near the contact between a partly altered Nipissing-type gabbro body and hornfelsed calcareous siltstones of the Espanola Formation. The sulphides are in, and close to an east-west-trending quartz-carbonate vein which is as much as 40 feet (12 m) wide and can be traced for several hundred feet (metres). An equally large north-trending vein barren of sulphides is exposed to the north. Pyrrhotite and chalcopyrite are found mainly within the quartz-carbonate vein whereas cobaltite occurs as euhedral crystals up to 1 inch (2.5 cm) in diameter in actinolite amphibolite along the walls of the vein. Both calcite and brown-weathering ankerite are present in the vein.

Stripping, trenching, and diamond drilling has been carried out on the occurrence. An adit 100 feet (30 m) long has been driven into a hill underlain by metagabbro. Local prospectors report that a magnetometer survey over the drift-covered area south of the adit disclosed nothing of interest. In 1969, E. J. Rivers carried out stripping and trenching in lot 10, concession V, and in 1971 Dauphin Iron Mines Limited tested the main occurrence with 12 diamond-drill holes totalling 3,177 feet (968.3 m). Assays of core yielded 0.10 percent copper and 0.14 percent nickel over a length of about 2 feet (0.6 m) (Resident Geologist's Files, Ontario Ministry of Natural Resources, Sudbury).

A high-grade grab sample, taken by the author, consisting mainly of pyrrhotite and cobaltite gave upon assay by the Mineral Research Branch, Ontario Division of Mines, 9.16 percent cobalt and 3.56 percent nickel.

J. F. OWEN (23)

Copper-nickel sulphides occur at the Owen property in lots 9, 10, 11, and 12, concession VI, Mongowin Township in the ultramafic portion of a small composite intrusion. The petrology of this intrusion, the Mongowin Pluton, is discussed in another report (Card 1968b). The body also contains an unusual colloform magnetite vein and iceland spar.

The sulphides form sparse disseminations and massive patches in altered peridotite. The main occurrence is near the northeast contact of the body and it has been tested by several small pits and diamond drilling. Minor amounts of pyrrhotite and chalcopyrite occur in a small pit near the southern contact of the ultramafic rocks. In 1951, Falconbridge Nickel Mines Limited diamond drilled 4 holes on the showings, and in 1952, Ontario Nickel Mines Limited put down 2 diamond-drill holes (Thomson *et al.* 1957, p.98-99). The grade of mineralization in the holes ranged from 0.21 percent nickel and 0.44 percent copper in very disseminated material, to 3.82 percent nickel and 2.38 percent copper in massive sulphides.

Polished section examination of the disseminated sulphides, which generally constitute less than 10 percent of the rock, shows that they consist mainly of pyrrhotite (80 percent) and chalcopyrite (20 percent) with very minor pyrite. The sulphides replace silicates and chalcopyrite appears to replace pyrrhotite. It is possible that the sulphides formed by alteration of silicate minerals which originally contained copper and nickel in solid solution. Assay data from the Owen Property given by Phemister (1939) as well as an assay of one grab sample taken by the author are as follows:

Sample No.	Type	Nickel percent	Copper percent	Cobalt percent	Ounce of Gold per ton
	Disseminated	1.04	0.07	...	0.01 (0.34 g/t)
		1.05	0.07	...	0.01 (0.34 g/t)
		0.55	3.00	...	tr.
		0.21	0.44	...	...
	Disseminated, massive patches	0.28	0.89	...	...
	Heavily disseminated, coarse-grained	0.84	0.39	...	...
	Massive, fine-grained	3.82	2.28	...	...
	Massive pyrrhotite	2.43	tr.	...	0.01 (0.34 g/t)
R-9	Grab sample-disseminated sulphides	0.47	0.26	tr.	...

Assays by Mineral Research Branch, Ontario Division of Mines.

TEXAS GULF SULPHUR COMPANY INCORPORATED (12)

Three small zones of sulphide mineralization occur at intervals over a length of about 3,600 feet (1,100 m) in a northeast-trending Nipissing Diabase dike in lot 8, concession III, and lots 6 and 7, concession IV, Foster Township. The sulphides consist of sparsely disseminated (less than 5 percent) pyrrhotite with minor chalcopyrite. The dike is highly altered, and it intrudes intensely metamorphosed rocks of the Espanola Formation. A major fault, the St. Leonard Fault, occurs in the area. In 1966, the occurrences were examined by Bellechase Mining Corporation Limited who performed geological and ground magnetometer surveys which failed to disclose economically significant mineralization. In 1967, this area was tested by diamond drilling by Texas Gulf Sulphur Company Incorporated during their search for tungsten (Resident Geologist's Files, Ontario Ministry of Natural Resources, Sudbury).

WALLACE MINE (27)

Nickel and copper were discovered at the Wallace Mine on the North Shore of Lake Huron approximately 3/4 mile (1.2 km) west of Whitefish Falls in the mid-1800s. The original discovery was made by Alexander Murray and early exploration work was carried out by Thomas Frood.

Hespanola Mines Limited examined the occurrence in 1956, and in 1962 Falconbridge Nickel Mines Limited and Huron Nickel Basin Mining Limited diamond drilled 10 holes totalling 2,360 feet ((720 m) on 2 claims (Table 9). In 1964, Ivan Tulgestke diamond drilled 9 short holes totalling 837 feet (255.1 m) to test the mineralization (Table 9). In 1969 to 1970, Jolloco Explorations Limited carried out geological, magnetometer, electromagnetic, and scintillometer surveys in the area and diamond drilled five holes totalling 1,480 feet (450 m). In 1971, Viva Explorations Limited held claims west of the Wallace Mine at Locations 2 and 3, but there is no report of work done on these claims (Table 9). The work done to date in the area has failed to disclose the presence of economical amounts of sulphide mineralization.

The country rocks consist of argillite and sandstone of the Gowganda Formation which are intruded by Nipissing Diabase and amphibolite dikes near the sulphide occurrences. The country rocks are sheared, silicified, and intruded by quartz veins, and a northeast-trending fault is interpreted to extend through the area.

The sulphides, mainly in the metasediments and to a lesser extent in the amphibolite and Nipissing Diabase consist of disseminated pyrrhotite, and pyrite with minor chalcopyrite. Numerous, small, a few square inches (mm^2) to 2 square feet (0.19 m^2), patches generally containing less than 5 percent disseminated sulphides are found throughout the area. But at the main occurrence, up to 10 percent sulphides are erratically distributed over a zone approximately 125 feet (38 m) long and up to 3 feet (0.9 m) wide. This mineralization has been tested by three pits some 20 feet to 40 feet (6 to 12 m) deep. Pieces of massive pyrrhotite are present in the dump material from these pits.

Assays of grab samples taken from the dump by Hespanola Mines Limited and the writer are as follows:

Sample No.	Copper percent	Nickel percent	Cobalt percent
1	0.94	0.23	trace
2	0.52	0.18	nil
3	0.70	1.04	nil
CG-66-129	0.58	2.22	nil

Assays by Hespanola Mines Limited and Mineral Research Branch, Ontario Division of Mines.

Gold

BOUSQUET MINE (29)

The Bousquet Mine is located in central Curtin Township about ½ mile (0.8 km) north of Howry Creek. The occurrence is described by Rickaby (1935) and Phemister (1939). The mine and a 50-ton (45 tonnes) per day mill were operated during the period 1936-38 and gold (4,672 ounces; 145,299.2 gm) and silver (196 ounces; 6,095.6 gm) was produced from 17,129 tons (15,549 tonnes) of ore.

Rickaby (1935, p.60) describes the general geology of the occurrence:

> The property of Bousquet Gold Mines, Limited, is situated near the centre of township 11 at the east end of Charlton lake. The showing, which occurs near the north side of claim No. 54,782, consists of a quartz vein lying along the contact between diabase and quartzite of the Cobalt series, with the diabase on the north side. The vein strikes almost due east and west and stands nearly vertical. It is traceable on the surface for 120 feet [36 m] west and 300 feet [90 m] east of the shaft, showing widths up to 4 feet [1.2 m]. West of the shaft a distance of 150 feet [46 m] the diabase appears to be displaced to the southeast, probably owing to a fault, and the shear zone in which the vein occurs passes into the diabase.
>
> At the time the property was visited in July, 1934, a shaft had been sunk to 160 feet [49 m] and drifting done on the 150-foot [46 m] horizon. The vein was visible most of the way down the manway, showing widths from 18 inches [45.0 cm] to 42 inches [105.0 cm]. On the 150-foot [46 m] level the vein showed good widths for a length of 45 feet [13.7 m] west of the shaft. Beyond this point it passes into the diabase, where it is represented by narrow stringers of quartz without much mineralization. To the east the vein had been followed for 340 feet [103 m], at which point the quartz appeared to pinch out. The quartz is mineralized with pyrite and arsenopyrite, and grab samples of this material showed high values in gold.
>
> The shaft was later deepened to 450 feet [137 m] and lateral work done on the 300- [90 m] and 450-foot [137 m] levels. The vein on the 300-foot [90 m] level showed a length of 315 feet [96 m] with widths somewhat narrower than on the 300-foot [90 m] level. On the 450-foot [137 m] level the vein was narrow and below commercial grade. From the surface down to the 450-foot [137 m] level the ore had an apparent rake of about 60°E in conformity with the plane of the fault. On this level diamond-drilling into the diabase north of the shaft indicated a strong quartz vein lying along the shear zone in the diabase. The quartz in the diabase was drifted on and is reported to have shown values[1] of $6.00 across a width of 5½ feet [1.7 m].

Phemister (1939, p.16-17) provides further details:

> The veins occur associated with the elongated intrusion of diabase, presumably a sill, which runs roughly east-west through the Cobalt series about a mile and a half [2.4 km] south of Long Lake, and they appear to be restricted to the small area where there is a sharp offset on the southern boundary of the outcrop of the igneous rock. This relation is shown clearly in the accompanying map of the surface in the vicinity of the mine. There is considerable doubt regarding the structural significance of this feature, whether it is only a primary irregularity of the outcrop or whether it has been brought about by faulting. The outcrops of diabase and quartzite are not sufficiently continuous to afford positive evidence on this matter, and it is not clear whether the sharp break of the southern boundary appears also on the northern side. The diabase exposed at this point does not show the evidence of cross-shearing that might be expected in the vicinity of a cross-fault.
>
> The vein occurrences fall into two classes: (1) those formed along the contact of the diabase and the quartzite and (2) those formed within the igneous rock itself. Only the first of these has proved to be of commercial value, and to it belongs the main vein of the property, which is located on the southern contact immediately to the east of the break in the diabase outcrop.
>
> The mineralogy of the veins is relatively simple. All are quartz veins, and the metallic minerals occurring in variable amounts are arsenopyrite, pyrite, chalcopyrite and, in some cases, visible gold. Siderite, ankerite, and calcite are abundant in some sections of the veins, and chloritized diabase appears as relic fragments in the vein in the igneous rock.

The Main Vein

The main vein has been explored by three levels at 150, 300, and 450 feet [46, 90 and 137 m], and the general nature of its occurrence on the 150- [46 m] and the 450-foot [137 m] levels is shown in the accompanying plan. It follows the contact of the sill and the quartzite and is always on the east side of the nose of diabase, which pitches eastwards, being thus intersected by the shaft not far below the 150-foot [46 m] level. The ore shoot has a width of 16 to 30 inches [40.0 to 75.0 cm], and its length ranges from 384 feet [117.1 m] at the surface to 344 feet [104.9 m] on the 300-foot [90 m] level, its westerly limit in all cases being but a few feet from the diabase nose. The dip is steep but changes from south to north twice in the vertical extent of the vein, though there does not appear to be any constant relation between this feature and the value of the ore.

Generally speaking, the arsenopyrite and siderite tend to occur most abundantly in the eastern parts of the upper levels and in the lower workings, the vein consisting elsewhere either of quartz alone or quartz with pyrite. It is this latter facies of the mineralization that is the richer, and the most valuable ore was taken out in a series of sublevels below the 300-foot [90 m] level. Here the values are said to have ranged from 0.34 to 0.55 ounces [11.6 to 18.7 g/t] of gold per ton over widths of 34.3 [85.8 cm] and 34.5 inches [86.3 cm], respectively. According to the management, sampling of a 110-foot [39 m] vein section on the 300-foot [90 m] level yielded an average of $40.20[1] across an average width of 28 inches [70.0 cm].

At 450 feet [137 m], the vein became too small both in width and in value to be mined at a profit and, as drilling did not disclose any valuable prolongation of the vein, the mine was closed. An interesting feature of the undertaking was the accidental circumstance, which became evident as mining progressed, that the levels and the shaft itself had been cut through the richest parts of the vein.

The Diabase Vein

Though the main contact vein itself does not continue at the surface into the diabase west of the nose, on the 150-foot [46 m] level it is represented in this rock by a thin irregular quartz vein in sheared material. This occurrence was not further explored on the 300-foot [90 m] level, but on the 450-foot [137 m] level it was picked up again as a much wider vein, about 4 inches [10.0 cm] across, with somewhat indefinite walls and consisting of almost pure quartz, bluish-black in colour and containing visible gold in its fractures. Assays are said to have indicated a grade of about 0.09 ounce [3.06 g/t] per ton across its width. Exploration at greater depths by drilling showed that, though the vein continued downwards, its values were too low for mining.

The other diabase vein is exposed at the surface, and its position is shown on the surface plan. Its occurrence is clearly controlled by a sheared zone in the diabase, along which replacement by quartz has taken place to give an irregularly defined quartz vein with a maximum width of 7 inches [17.5 cm]. As assays showed values ranging from nil to 70 cents per ton it has not been further explored.

BRIDGER OCCURRENCE (32)

The Bridger occurrence is approximately mid-way between Howry Creek and the Whitefish River in eastern Curtin Township. Metasediments of the Gowganda Formation are faulted and silicified in this area and an east-west silicified shear zone has been tested over a length of about 400 feet (120 m) by a shallow shaft, and several pits. There are several small pits about ½ mile (0.8 km) to the east that are on strike with the main showing.

The metasediments are cut by east-west and northeast faults in this area. The Gowganda conglomerates, argillites, and sandstones are silicified and intruded by numerous small quartz-carbonate veins along a vertical, east-west zone which can be traced for about 600 feet (180 m). The veins are generally less than 1 inch (2.5 cm)

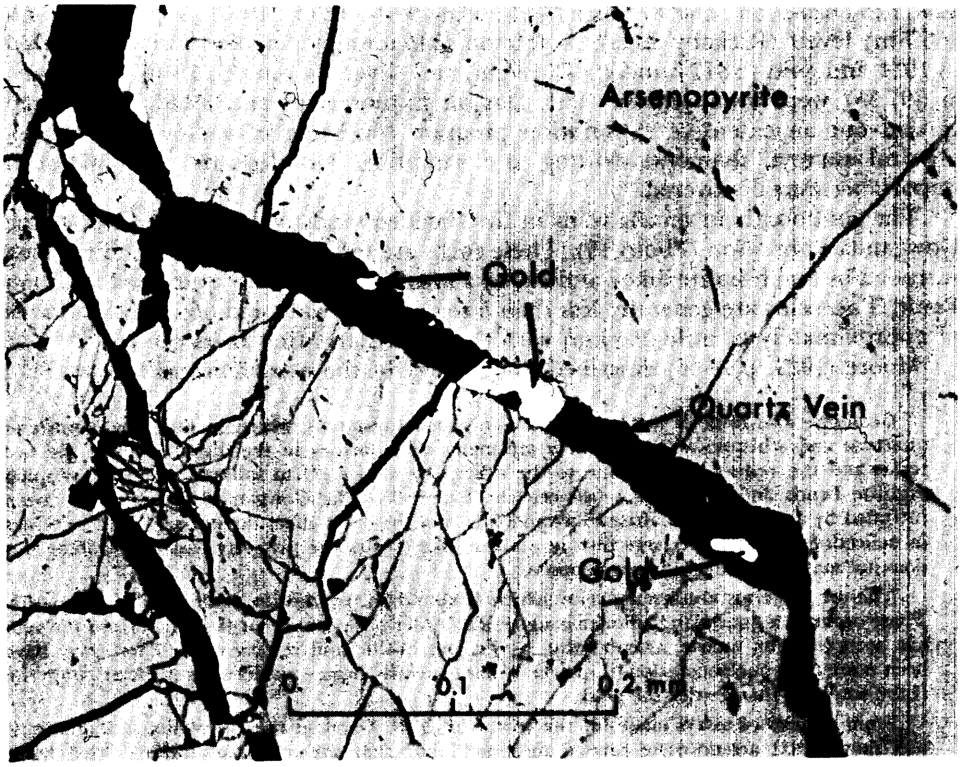

Photo 15–Photomicrograph of gold in quartz veinlets in arsenopyrite from the McMillan Mine.

but a few are up to 6 inches (15 cm) in width, and the carbonate is mainly ankerite. Pyrite and arsenopyrite are locally and sparsely disseminated in the veins and in the surrounding silicified country-rock; gold occurs with these minerals.

In 1953, H. E. Martin drilled four diamond-drill holes totalling 1,071 feet (326.4 m) to test the silicified zone over a strike length of about 400 feet (120 m). In 1959, F. H. Mylrea drilled one diamond-drill hole 103 feet (31.4 m) long at the west end of the silicified zone. Only low gold values were found, and a grab sample taken by the writer of the most heavily mineralized material gave an assay of 0.07 ounce of gold per ton (2.4 g/t) (Assay by Mineral Research Branch, Ontario Division of Mines).

DAYJON EXPLORATIONS AND HOLDINGS LIMITED (McMILLAN MINE) (15)

The McMillan Mine in lot 11, concession III, Mongowin Township, was discovered in the 1920s and was operated periodically from 1934 to 1937. A shaft was sunk to a depth of 900 feet (274 m) and drifting was done on the 125-, 225-, 325-, 425-, 525-, 625-, 750-, and 875-foot (38.1-, 68.6-, 99.1-, 129.5-, 100.0-, 190.5-, 230-, and 266.7-m) levels (Rickaby 1935). A 150-ton (145 tonnes) per day mill was erected in 1934 and gold (2,817 ounces; 87,618 gm) and silver (84 ounces; 2,613 gm) valued at $97,357 were produced. In 1961, Dayjon Explorations and Holdings Limited carried out an extensive exploration program consisting of geological and geophysical surveys, diamond drilling and sampling. No deposits of commercial importance were discovered.

The gold occurs in quartz veins in interbedded sandstones and argillites of the Gowganda Formation (Photo 15). These rocks are folded about east-trending axes, intruded by amphibolite dikes, and cut by a northwest-trending fault, the McMillan Fault. The veins are generally less than 5 feet (1.5 m) wide and occur over an area of approximately ¼ mile (0.4 km) with the McMillan Mine at its centre.

Moore (1929, p.43-46) described the geology of the occurrence as follows:

> *Geology.*—The mine is located on the Gowganda formation, which in this area consists of quartzite and schistose argillite. There are many irregularities in the distribution of the two rocks, and the veins run from one to the other, but they tend to follow the steeply dipping argillite bands and the contact between the two rocks. The Gowganda formation has been intruded by a number of diabase dikes and sills, and the dikes affect the underground workings in deflecting the veins. A large olivine diabase dike crosses the property east of the mine but does not materially affect the ore deposits.
>
> The ore minerals are arsenopyrite, which is abundant, pyrrhotite, chalcopyrite, and pyrite. These occur in a quartz and chlorite gangue. The order of formation of the minerals in the vein has been chlorite, quartz, arsenopyrite, pyrite, pyrrhotite, and chalcopyrite. There may have been more than one generation of quartz. It has generally been considered that the arsenopyrite is the sulphide that carries the gold.
>
> From a series of assays made for the writer by D. R. Derry at the University of Toronto, it was shown that arsenopyrite carried most gold but that the other sulphides carried lesser quantities. Gold was found in all the sulphides, but the coarsely crystallized pyrite found in vugs in the mine was barren. The gold values per ton of sulphide obtained by Mr. Derry were as follows: arsenopyrite, $32.00 to $39.00; pyrrhotite, $23.25; chalcopyrite, $27.40.
>
> It was difficult to get a complete separation of the chalcopyrite from all the other sulphides, but the sample assayed was practically free from them. Native gold is associated with arsenopyrite and was observed by the writer in several spots on the 500-foot [150 m] level. On this level east of the shaft there is one lens 35 feet [10.7 m] wide which carries commercial ore across 24 feet [7.3 m]. East of this lens the vein becomes very narrow and then widens out again. No attempt was made by the writer to sample the whole mine, but a sample taken across 4 feet [1.2 m] at the end of the drift, where it swings south on the 3rd level, assayed $12.80 to the ton in gold. The ore on the whole is heavily mineralized with sulphides.
>
> The veins were traced as far as possible on the surface. Beginning at the west end of Moyle lake stringers of quartz are found for about 450 feet [137 m] along the edge of the hill west of the lake, and just north of the west end of the lake there is a pit showing a vein 4 feet [1.2 m] wide in quartzite. This quartz vein is well mineralized with arsenopyrite, chalcopyrite, and pyrite. From this pit eastward there are stringers of quartz in quartzite for 460 feet [140 m], and then no further sign of the vein is seen for some distance. It would appear that a fault runs up the little ravine past the powder magazine and shifts the vein northward on the east side. Greywacke or argillite lies opposite quartzite on the side of the ravine, but this rock would have to move in the opposite direction from the apparent displacement of the vein. Further, the diabase dike crossing the ravine at the magazine is not displaced, so if a fault exists it must be earlier than the diabase and quartz vein. It is probable that the vein west of the shaft has been deflected northward by the diabase dike that rises from the lake just southwest of the shaft and sluice-box to concentrate the gold, which was in a very fine state.
>
> South and southwest of the shaft there are several pits exposing two well-mineralized veins, which are found in the underground workings. Very little underground work has been done west of the shaft. East of the shaft there are few exposures on the surface, but the veins have been followed in the drifts dipping steeply southward and pitching a little eastward. They make a

> sudden bend southward and even curve around to the west, apparently because of the diabase dike which is seen on the lake shore about 260 feet [79 m] east of the shaft. This intrusion has quite a different shape underground from that on the surface. There is a question as to whether it runs beneath the lake to connect with the diabase exposed on the south shore. It seems more probable that the mass on the south shore is a continuation of that seen at the west end of the lake, and it is possible that the two dikes exposed on the opposite sides of the shaft are connected beneath the lake; this would explain the curving of the vein around to the west under the lake. From information lately received, the company has apparently driven eastward through the dike and picked up the ore on the east side of it beneath a small ravine, in which a branch of the diabase disappears.
>
> The only sign of a vein on the surface to the east of the shaft is found on the east side of the bay, and from the strike of the formation there it seems probable that the vein will follow the argillite band eastward beneath the lake. There is little evidence of mineralization at the east end of Moyle lake. A pit has also been made on well-mineralized quartz on the north shore about halfway down the lake, but the vein here runs northwestward and there does not seem to be any chance of it continuing toward the shaft. If the main vein runs under the lake this may be a branch running along the north side of a diabase dike which appears to underlie the lake in this section and emerges at the pit.

Polished section examination of specimens by the writer shows that the gold is in late quartz veinlets in the arsenopyrite (Photo 15). Some of these veinlets fill hairline fractures, and consequently, the gold is very fine grained.

Dayjon Explorations and Holdings Limited obtained surface gold assays of 0.10 to 0.40 ounce per ton (3.4 to 13.7 g/t) over widths of up to 5 feet (1.5 m) in the immediate vicinity of the mine. Assays from pits to the east and west ranged from 0.01 to 0.06 ounce of gold per ton (0.34 to 2.1 g/t) over 2- to 5-foot (0.6 to 1.5 m) long widths. Four diamond-drill holes totalling 1,300 feet (400 m) on a claim about ½ mile (0.8 km) east of the mine failed to disclose economically significant amounts of gold. A massive arsenopyrite sample taken from the mine dump by the writer assayed 0.57 ounce of gold per ton (19.5 g/t).

D. EWING (HOWRY CREEK MINE) (35)

The Howry Creek Mine is approximately 1,000 feet (300 m) north of Howry Creek in eastern Curtin Township. Gold occurs in an erratically mineralized quartz vein in brecciated, sheared, silicified sandstones and argillites of the Gowganda Formation. The main east-west vein ranges in width from 1 to 6 feet (0.3 to 1.8 m) on the surface and is about 600 feet (180 m) long. The vein dies out to the west, and is cut off by a fault on the east. Arsenopyrite and pyrite are irregularly and sparsely disseminated throughout the vein although some of the material on the dump is massive arsenopyrite.

The occurrence has been tested by a shaft about 70 feet (20 m) deep, an adit 528 feet (161 m) long driven into the hill below the vein, and trenching along the vein. A sample of arsenopyrite taken by the writer and analyzed by the Mineral Research Branch, Ontario Division of Mines, gave upon assay gold values of 0.54 ounce of gold per ton (18.5 g/t).

FOX LAKE OCCURRENCES (18, 26, 28)

There are several gold occurrences along the Fox Lake Fault. They are in lots 5 and 6, concession IV, Mongowin Township (numbers 18 and 26 on Map 2312 in back pocket); and section 33, Curtin Township extending into lot 5, concession V, Mongowin Township (numbered 28 on Map 2312 in back pocket). The fault brings brecciated, sheared rocks of the Gowganda and Serpent Formations into juxtaposition in this area, and adjacent rocks are quartz veined, silicified, and replaced by carbonates. Rickaby (1935, p.60-61) describes the Fox Lake Gold Mines Limited occurrence in lots 5 and 6, concession IV, Mongowin Township as follows:

> The country rock consists mainly of quartzite, both Serpent quartzite and quartzite of Cobalt age being represented. These are intruded by diabase dikes. Within the Cobalt series there is a brecciated zone replaced by carbonates and quartz carrying some sulphide mineralization. The zone is irregular in shape, showing widths up to 25 feet [7.6 m] and a length of 200 feet [60 m]. Oxidation of the carbonates has produced a rusty capping of honey-combed material with a thickness of 20 feet [6 m] or more. At the time the property was visited some pits had been sunk in this gossan, but in only one instance had the pits got below the oxidized material. Grab samples of the quartz and carbonates with some sulphides from this pit showed low values in gold. There appeared to be some enrichment of gold values in the oxidized zone, and at the time the property was visited some of this oxidized material was being treated in a sluice-box to concentrate the gold, which was in a very fine state.

The occurrence in lot 5, concession IV, (number 18 on Map 2312) is in similar brecciated rocks which have been silicified and replaced by carbonate and sulphide minerals. The mineralization had been tested by pitting and trenching.

In lot 5, concession V, Mongowin Township, a large pit has been blasted into an east-west trending quartz vein (number 28 on Map 2312 in back pocket) about 500 feet (150 m) long and up to 20 feet (6 m) wide which straddles the Mongowin-Curtin township boundary north of Fox Lake. This vein contains minor amounts of pyrite sporadically distributed along its length.

CHARLES GREGORY ESTATE (MAJESTIC MINE) (19)

Moore (1929, p.46) describes the Majestic Mine occurrence as follows:

> The Majestic mine lies east of the McMillan property and close to the Algoma Eastern railroad. It is owned by Majestic Gold Mines, Limited, and has been idle for a number of years, but several reports have been circulated that it is to be reopened. The shaft, which is said to be 200 feet [60 m] deep, is full of water, and most of the buildings are in a decaying condition. There is a spectacular quartz vein on this property, much larger but less mineralized than the vein at the McMillan mine, and is not, as has been believed by some persons, the same vein. Commencing at the west end as stringers, it widens rapidly into a solid quartz vein about 30 feet [9 m] wide cutting quartzite. In one place there is 18 feet [5.5 m] of solid quartz with 32 feet [9.8 m] of stringers running into the quartzite walls. It runs southeast for a short distance and then bends around so that at the shaft it strikes nearly east. It can be traced to the eastern border of the property where it gradually dies out. This large vein may connect with the small vein exposed to the west near the centre of the eastern half of lot 9, concession III. The quartz is

not heavily mineralized and some of it has a barren, vitreous appearance. The sulphides found are chalcopyrite, pyrite, and arsenopyrite. The vein is of sufficient size to be of considerable economic importance if it carried higher values, but apparently these do not increase greatly at depth.

G. L. KIRWAN (JO-AMI OCCURRENCE) (21)

Gold occurs in several small quartz-carbonate veins in sandstone and siltstone of the Gowganda Formation in lot 7, concession III, Mongowin Township. The Fox Lake Fault is interpreted to be located immediately east of the occurrences.

The occurrences were investigated by Cogo Grubstake Syndicate in 1958 who carried out surface sampling, and reported gold values of 1.44 ounces per ton (49.4 g/t). Jo-Ami Gold Mines Limited acquired the property, and in 1959-1960 diamond drilled 17 holes totalling 3,742 feet (1,141 m) to test a northeast-trending zone of quartz veining over a length of about 300 feet (90 m). The diamond drilling disclosed only minor amounts of gold; surface sampling yielded gold assays of 0.21 ounce gold per ton (7.2 g/t) over 4 feet (1.2 m) and 0.20 ounce gold per ton (6.9 g/t) over 1½ feet (0.5 m) (Table 9).

Further exploration work by G. L. Kirwan and Accra Explorations Limited in 1967-1968 revealed that the gold mineralization occurred in a zone parallel to and on the hanging wall of an amphibolite dike. A magnetometer survey conducted over the area indicated the possibility that this dike and the associated gold mineralization extended eastward from the main occurrences. Six diamond-drill holes totalling 2,422 feet (738.2 m) were drilled to test this structure over a strike length of about 100 feet (30 m) to a depth of about 400 feet (120 m). The amphibolite dike was encountered in all six diamond-drill holes, but only the first three intersected the gold-bearing structure. Assays of 0.52 to 14.1 ounces of gold per ton (17.8 to 48.3 g/t) over core lengths of 1 to 3 feet (0.3 to 0.9 m) were obtained.

S. J. WHITE (UPSALA MINE) (38)

The Upsala Mine, in central Curtin Township north of Miller Bay on Charlton Lake, was discovered by the Tough brothers in the 1930s or 1940s. In the early 1960s the occurrence was taken over by Upsala Mines Limited who erected several small mills on the property. There is no record of any gold production.

The east-west trending vein, which occurs in a faulted and sheared section of interbedded sandstones and argillites of the Gowganda Formation, is 400 feet (120 m) long and as much as 8 feet (2.4 m) wide. It has been explored with a trench about 300 feet (90 m) long and a shallow shaft. The vein material consists mainly of white quartz, but there are several carbonate-rich zones with minor disseminated chalcopyrite, pyrite, and galena. The carbonates are calcite and ankerite. In 1960 and 1961, nine diamond-drill holes totalling 900 feet (270 m) were drilled along the length of the vein and disclosed only minor gold values. A grab sample taken by the author of the best-looking material on the dump gave upon assay 0.11 ounce of gold per ton (3.77 g/t) and 0.4 percent copper.

Other Gold Occurrences

PETER J. ROCHE (5)

The Roche property in lot 4, concession III, Merritt Township, consists of a rusty, silicified shear zone in Serpent sandstone. Several narrow quartz veins, which strike east-west, are sparsely mineralized with pyrite and minor chalcopyrite. The occurrence was tested by P. J. Roche in 1956 by trenching and two shallow diamond-drill holes totalling 74 feet (22.6 m).

STRATTON LAKE OCCURRENCE (10)

There are numerous quartz veins north of the east end of Stratton Lake, mainly in lot 10, concession I, Foster Township which are sparsely and erratically mineralized with pyrite, pyrrhotite, chalcopyrite, and arsenopyrite.

VEIN QUARTZ; (W. LACELLE), AND K. SCOTT (9)

There are several mineralized quartz veins a few inches (cm) to about 2 feet (0.6 m) wide on the south shore of the narrows between Loon Lake and Stratton Lake in lot 1, concession II, Merritt Township (Vein Quartz Property), and lot 12, concession II, Foster Township, Scott K. (9).

The Vein Quartz Property (W. Lacelle Property) is in highly weathered mineralized quartz veins in silicified Serpent sandstone. The sulphides, present in amounts up to 15 percent, are mainly pyrrhotite, with minor pyrite and chalcopyrite.

The Scott property consists of a system of east-striking quartz veins which is exposed for several hundred feet (metres) along the shore of Stratton Lake. The veins are about 2 feet (0.6 m) wide and are sparsely mineralized with pyrite and pyrrhotite. They have been tested by S. J. White in 1954 and W. D. Sutherland in 1961 with a shallow shaft, several pits, and one diamond-drill hole totalling 165 feet (50.3 m) in length. A grab sample of vein material containing about 10 percent sulphides was taken by the writer and upon assay by the Mineral Research Branch, Ontario Division of Mines, yielded values of 0.04 ounce of gold per ton (1.37 g/t) and 0.3 percent nickel.

Quartz and Quartzite

THE INTERNATIONAL NICKEL COMPANY OF CANADA LIMITED (LAWSON QUARRY) (36)

The Lawson quarry of the International Nickel Company of Canada Limited is near the village of Whitefish Falls in southwestern Curtin Township. The quarry is on the Canadian Pacific Railway line from Espanola to Little Current and the rail haul to Sudbury is approximately 65 miles (105 km).

The rock quarried is the uppermost 'cherty sandstone' member of the Lorrain Formation. The quarry is located immediately south of the axis of the La Cloche Syncline and the rock is highly sheared at this locality and breaks easily into small fragments. Analyses of the orthoquartzite given by Hewitt (1963, p.11) are as follows:

Sample	SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	TiO_2	Na_2O	K_2O
59-4	98.86	0.51	0.08	0.02	0.03	0.04	0.16	0.50
59-5	98.78	1.64	0.10	0.02	0.02	0.04	0.10	0.50
59-7	98.35	1.04	0.09	0.03	0.02	0.05	0.12	0.50

Analyses are by the Mineral Research Branch, Ontario Division of Mines.

The crushed orthoquartzite is shipped to Sudbury where it is used in the company's smelting operations. Production amounts to about 1,400 tons (1,270 metric tons) per 8-hour shift, approximately 363,713 tons (329,887 metric tons) were shipped during 1968, the last year for which production figures are available (Ontario Department of Mines Ann. Rept. on Mining 1968, p.137).

QUARTZ VEINS, MERRITT TOWNSHIP

There are three large quartz veins located in lot 5, concession I, lot 11, concession IV, and lot 11, concession V, Merritt Township which have been tested for production of quartz chips for pre-cast concrete facings. All are essentially similar consisting mainly of white quartz, with minor amounts of carbonates, sulphides, and wall-rock inclusions. The vein in lot 5, concession I, strikes east-west, is about 300 feet (90 m) long and up to 100 feet (30 m) wide, and is at the contact of the Espanola and Serpent Formations. The vein has been extensively stripped, and in the winter of 1965, several tons of quartz were blasted out and hauled to Highway 17 at Loon Lake.

If a market should develop for vein quartz aggregate, there are several other lodes in the area. The large vein at the Majestic Mine in Mongowin Township may be suitable and it is readily accessible to the railroad. The veins in lot 10, concession V, Foster Township, also appear to be of high purity.

Tungsten

T. TAMMINEN, (11)

Minor amounts of sulphide and scheelite mineralization were discovered by T. Tamminen and V. Piispanen in the mid-1960s in an old pit in lot 9, concession III, Foster Township. They staked a group of six claims which they optioned to Texas Gulf Sulphur Company Incorporated in 1965. R. M. Ginn, company geologist, found mineralization over a wide area and subsequently extended the group to 22 claims in lots 6, 7, 8, and 9, concessions III and IV, Foster Township.

Work by Texas Gulf Sulphur Company Incorporated consisted of geological mapping, diamond drilling, surface and core sampling for assay purposes, and a magnetometer survey. In 1966 and 1967, the company diamond drilled six holes totalling 3,079 feet (938.5 m) to explore the mineralization over a strike length of about 4,000 feet (1,200 m). This work showed that the distribution of the mineralization is very erratic. Assays of over 1 percent WO_3 were obtained but only over short sections.

In 1970, Cerro Mining Company of Canada Limited optioned the property and carried out surface trenching and, according to a company plan, some 1,783 feet (543.5 m) of diamond drilling for which no core logs were submitted. Some 298 core and surface chip samples were assayed. The chip samples (Resident Geologist's Files, Ontario Ministry of Natural Resources, Sudbury), representing sections 5 to 20 feet (1.5 to 6 m) in length, yielded upon assay the following:

W — trace to 0.38 percent
MoS_2 — trace to 0.27 percent
Bi — trace to 0.11 percent
Cu — 0.01 to 0.29 percent
Ag — trace to 0.36 ounce per ton (12.3 g/t)
Sn — trace to 0.01 percent
Zn — nil to 0.18 percent

Samples of diamond drill core (lengths sampled not stated) yielded the following upon assay:

WO_3 — nil to 0.51 percent
MoS_2 — nil to 0.05 percent
Bi — nil to 0.08 percent
Ag — trace to 0.36 ounce per ton (12.3 g/t)

Most samples yielded only trace amounts of the various elements.

Assays of selected, relatively high grade material taken by the writer yielded the following results upon assay by the Mineral Research Branch, Ontario Division of Mines:

Sample	Percent Wolfram	Percent Zinc	Percent Copper	Percent Gold
B	...	1.81	...	...
C	0.39	...	...	...
5	0.13	...	0.06	Trace
6	0.20	...	0.06	Trace

The general geology of the area is shown on ODM Map 2311 (in back pocket). Disseminated tungsten and sulphide mineralization occurs erratically over an area approximately 1,400 feet (430 m) wide and 4,800 feet (1,500 m) long on the faulted north limb of the St. Leonard Anticline. The mineralization occurs mainly in skarns in the Espanola Formation and in sandstone and argillite of the Mississagi Formation. Mineralization occurs near the faults of the St. Leonard System and the intensely altered gabbroic intrusions. Detailed mapping by Texas Gulf Sulphur Company Incorporated has defined six *en echelon* zones of mineralization which trend northeast-southwest and are generally parallel to the strike of the metasediments. These zones range in width from a few inches (cm) to about 30 feet (9 m) and in length from about 1,200 to 2,500 feet (370 to 760 m).

Mineralization occurs as disseminated grains in the highly altered metasediments, and in quartz veins. Sulphides are generally present in minor (less than 5 percent) amounts, although small pods containing up to 20 percent sulphides occur locally. Minerals recognized include scheelite, powellite, pyrrhotite, pyrite, chalcopyrite, sphalerite, molybdenite, and arsenopyrite which are closely associated with skarn minerals such as idocrase, diopside, wollastonite, and garnet. Scheelite, the dominant tungsten mineral, and powellite, the other tungsten mineral identified, occur as ½ to 2 mm subhedral grains that are disseminated through the rock, and as small veinlets with quartz.

The origin of the mineralization is not known, but there is apparently a close relationship between mineralization, gabbroic intrusion, faulting, and high grade metamorphism. The mineralization is stratabound for the most part, but this is probably caused by hydrothermal introduction of materials into chemically favourable beds. In the Sudbury region, there are several small deposits of scheelite in quartz-carbonate veins associated with Nipissing Diabase. Possibly the Foster Township deposit is of similar origin.

Sand, Gravel, and Clay

Several sand and gravel deposits in the area have been worked as a source of road metal. Deposits close to Highway 68, such as those in lot 8, concession VI, Merritt Township, Section 38, Curtin Township, and Section 33, Curtin Township, were depleted during construction of this highway. A large gravel deposit on the north shore of Charlton Lake, Section 19, Curtin Township and several small pits in Merritt and Foster Townships were worked periodically during 1966 and 1967 to provide road metal for secondary gravel roads in the area.

Rainbow Cement Limited operates a cement plant south of Espanola. They use local sand, but haul gravel in by truck from outside localities. It is possible that good quality gravel underlies the sand in this area and this possibility should be investigated.

Varved clays occur on the north bank of the Spanish River immediately north of the town of Espanola in lot 8, concession VI, Merritt Township. The quality and size of this deposit has not been ascertained, but some beds appear to be suitable for pottery manufacture.

SUGGESTIONS FOR FUTURE EXPLORATION

Further exploration in the Espanola-Whitefish Falls area for tungsten, base metals, silica, and gold is warranted. The tungsten occurrence in Foster Township should be investigated further and there is the possibility of finding similar deposits in the district. Sulphides are common in the Bruce and Espanola Formations, and in the Nipissing Diabase intrusions; and these rock units should be regarded as possible hosts for large, low grade base-metal deposits. The upper part of the Lorrain Formation contains very large amounts of chemically pure silica. Much of this material is readily accessible and could be easily transported by water to markets around the Great Lakes or overseas. The gold deposits discovered and mined in the 1930s were generally small and of marginal grade but several of these, notably, Dayjon Explorations and Holdings Limited, Ewing, D., and Kirwan, G. L., properties warrant further exploration, especially if gold prices increase in the future above present-day values.

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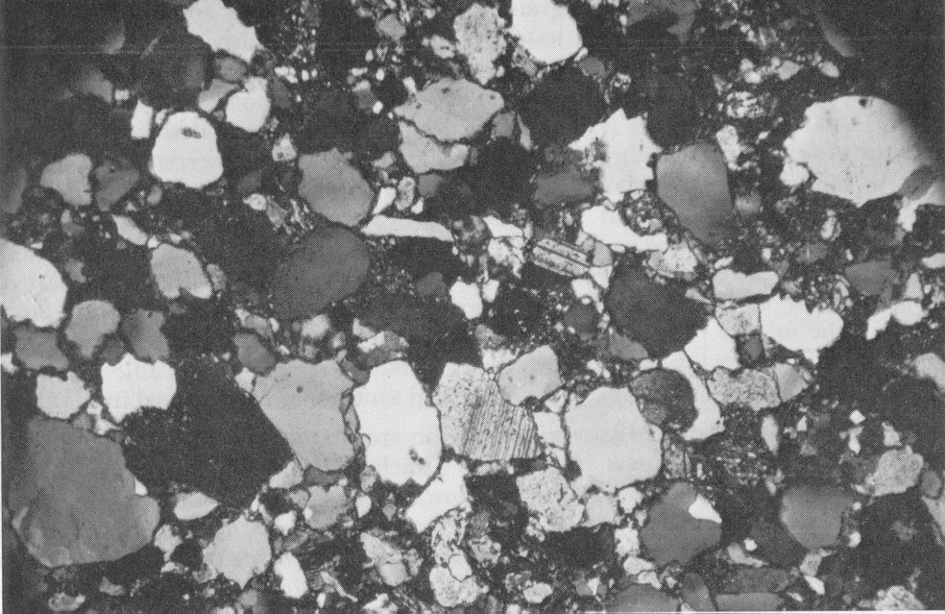

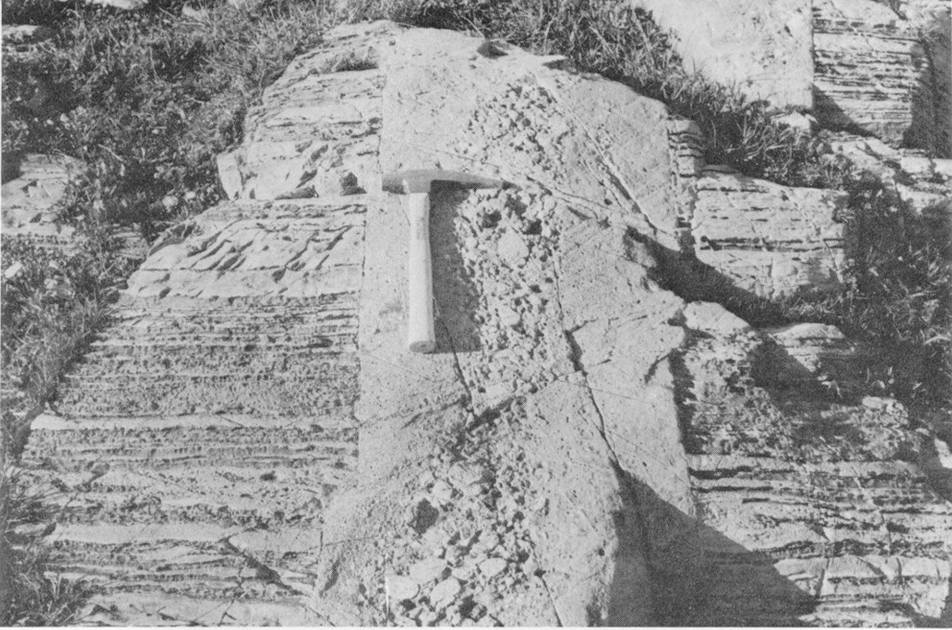

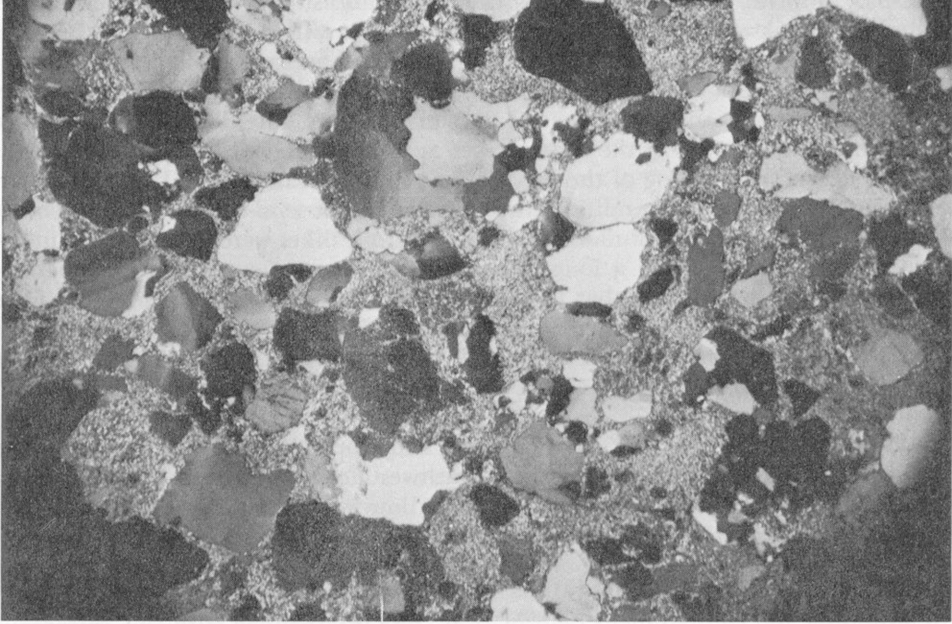

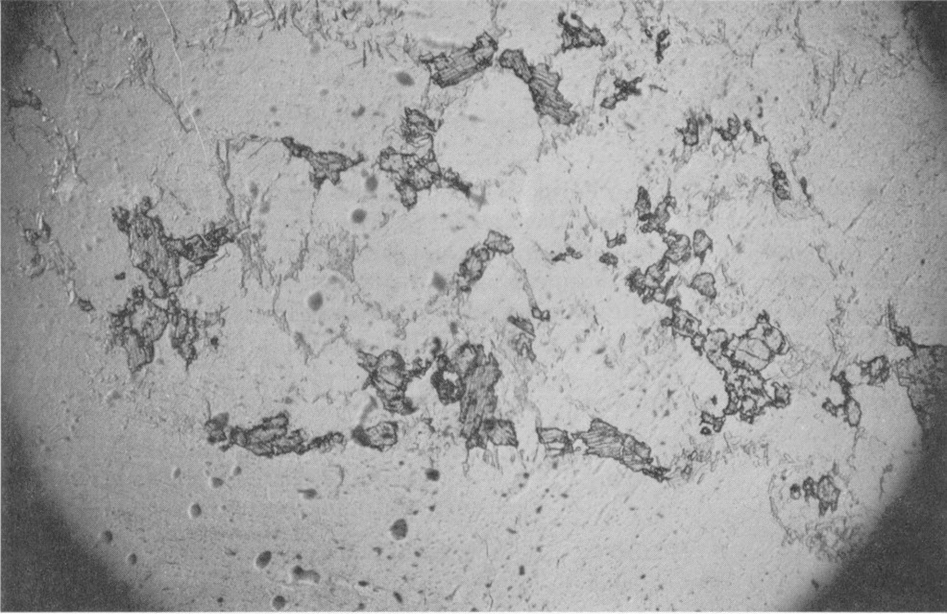

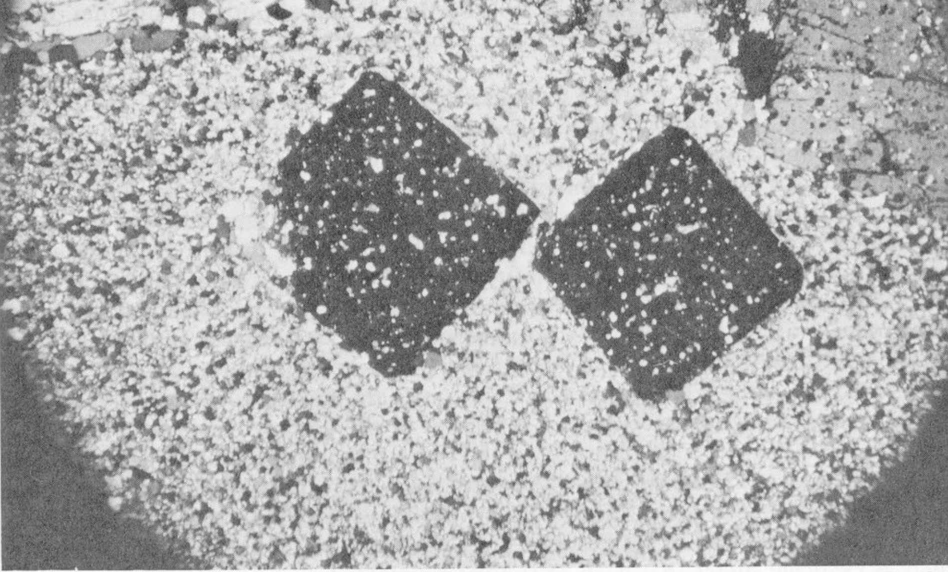

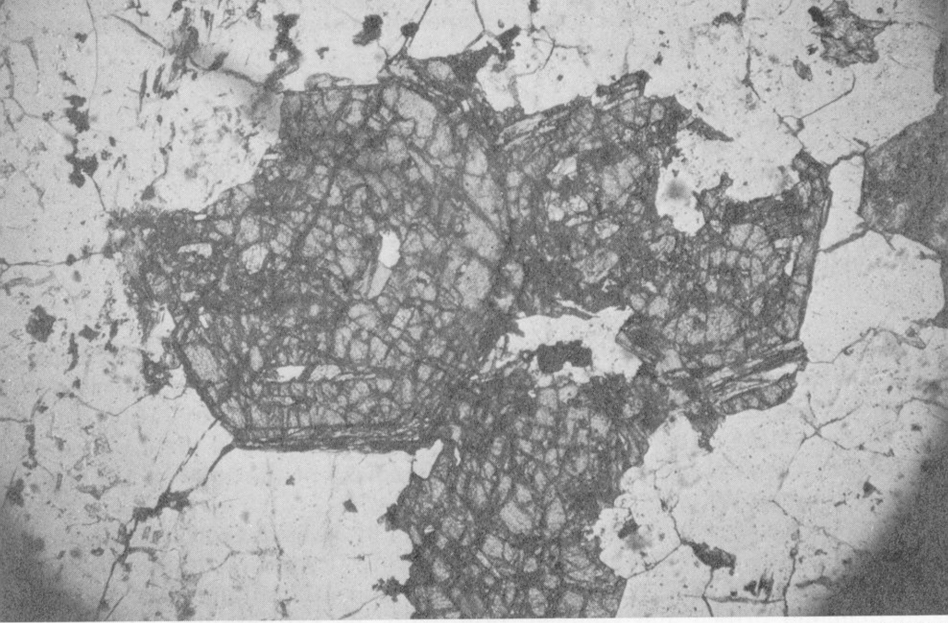

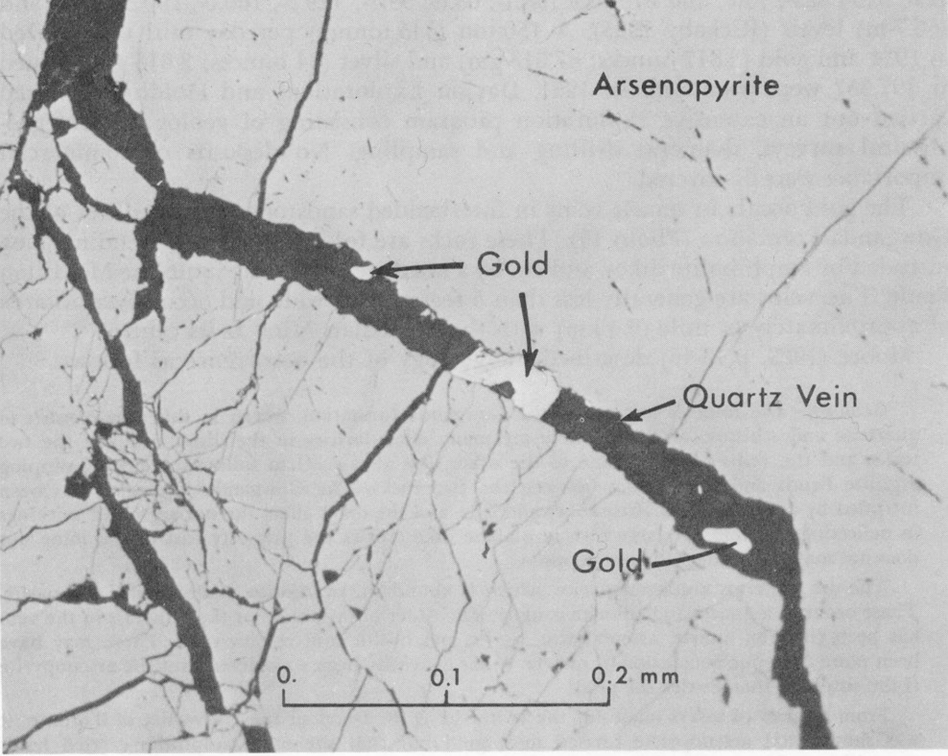
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Gold
Quartz Vein
Gold
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0.1
0.2 mm

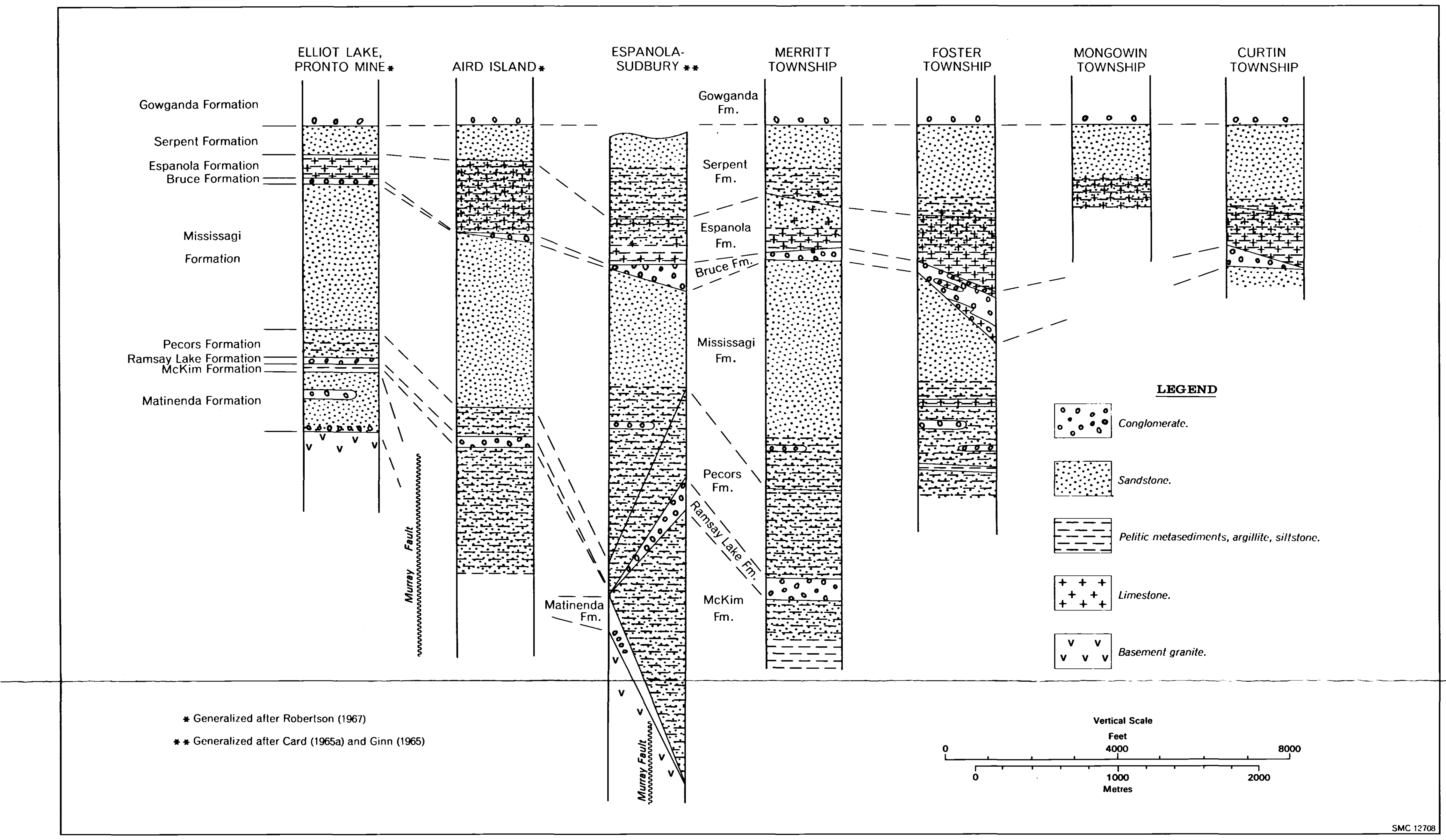


FIGURE 3 Lateral variation and generalized stratigraphy of the Elliot Lake, Hough Lake, and Quirke Lake Groups.

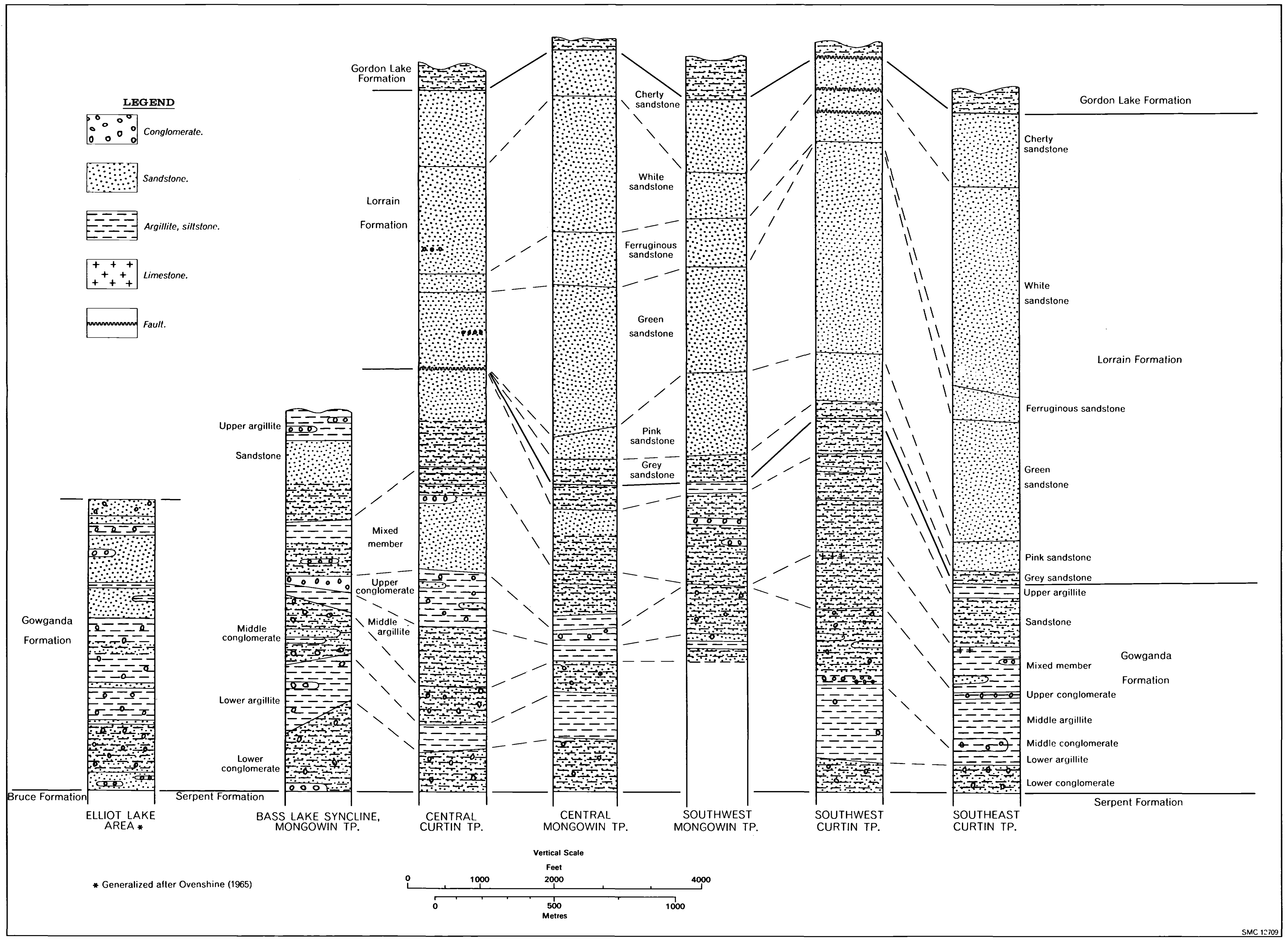


FIGURE 4 Lateral variation and generalized stratigraphy of the Cobalt Group.

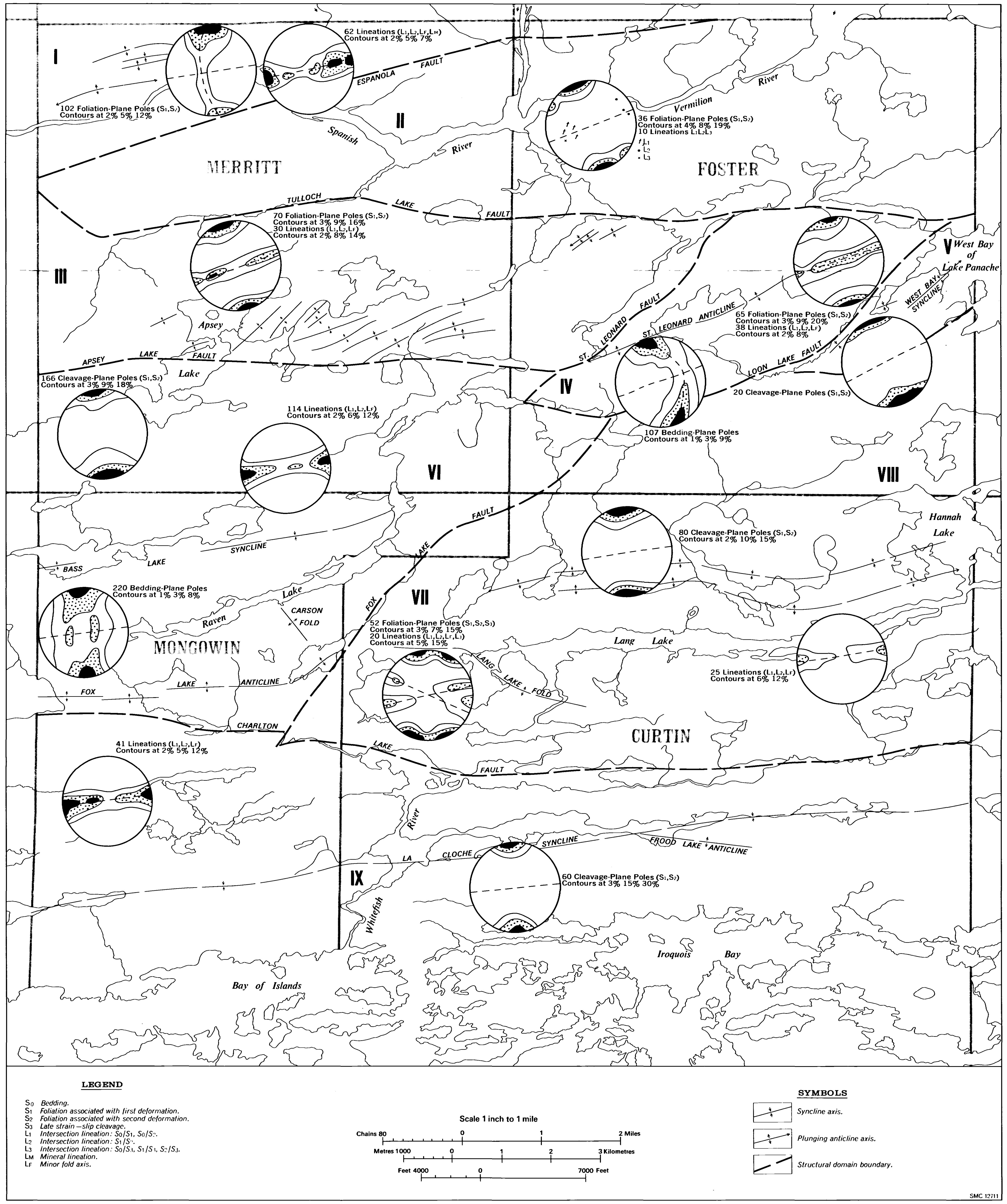


FIGURE 6 Structural domains and orientation of major and minor structures. Equal area projections of minor structural elements, Domains I to IX.

ESPANOLA-WHITEFISH FALLS

Chart B

Tables 2, 4, 6 and 9

Table 2 HURONIAN STRATIGRAPHIC TERMINOLOGY

North Shore Collins (1925)	Sudbury-Espanola Collins (1938)	Sudbury Coleman (1914)	Espanola Quirke (1917)	Sudbury Area Thomson (1962)	Elliot Lake Area Robertson (1965)*	Elliot Lake Area Roscoe (1956)*	Denison-Waters Area Card (1967)	This Report
Cobalt Series Upper White and Cherty Quartzite Banded Cherty Quartzite Lorrain Quartzite Gowganda Formation	Cobalt Series Gowganda Formation		Cobalt Series Gowganda Formation		Cobalt Group Upper Formation Gowganda Formation	Cobalt Group Upper Formation Gowganda Formation		Cobalt Group Gordon Lake Formation Lorrain Formation Gowganda Formation
Bruce Series	Bruce Series		Bruce Series		Bruce Group	Quirke Lake Group		Quirke Lake Group
Serpent Quartzite	Serpent Quartzite		Serpent Quartzite	Serpent	Serpent Formation	Serpent Formation		Serpent Formation
Espanola Limestone Espanola Greywacke Bruce Limestone	Espanola Formation Siliceous Limestone, Siltstone		Espanola Limestone Espanola Greywacke Bruce Limestone	Espanola	Espanola Bruce Limestone	Espanola Bruce Limestone		Espanola Formation
Bruce Conglomerate	Bruce Conglomerate		Bruce Conglomerate	Bruce	Bruce Conglomerate	Bruce Conglomerate		Bruce Formation
Mississagi Quartzite	Mississagi Quartzite		Mississagi Quartzite	Mississagi	Upper Mississagi Formation	Hough Lake Group Mississagi Formation	Upper Quartzite	Hough Lake Group Mississagi Formation
	Ramsay Lake Conglomerate	Ramsay Lake Conglomerate			Middle Mississagi Formation	Pecors Formation	Upper Metapelite	Pecors Formation
						Whiskey Formation	Conglomerate	Ramsay Lake Formation
					Lower Mississagi Formation	Elliot Lake Group Nordic Formation	Lower Metapelite	Elliot Lake Group McKim Formation
						Matinenda Formation	Lower Quartzite	
Pre-Huronian Algoman Granite Sudbury Series	Pre-Huronian Sudbury Series McKim Greywacke Volcanics, granites	Pre-Huronian Sudbury Series Wanapitei Quartzites McKim Greywacke Copper Cliff Arkose Sudburite	Pre-Huronian Schistified sediments (McKim) basic intrusions, granites	Pre-Huronian Wanapitei Quartzite Ramsay Lake Conglomerate McKim Greywacke Volcanic Group Copper Cliff Rhyolite Frood-Stobie Series	Pre-Huronian Algoman Granite Keewatin	Pre-Huronian Algoman Granite Greenstone	Pre-Huronian (?) Felsic Metavolcanics Mafic Metavolcanics	

*As given in Robertson (1967)

Table 4 MODAL ANALYSES OF ROCKS OF THE BRUCE, ESPANOLA, AND SERPENT FORMATIONS IN ESPANOLA-WHITEFISH FALLS AREA

Sample No.	Stratigraphic Position	Quartz	Feldspars	Rock Frag-ments	Calcite Dolomite	Matrix Phyllo-silicates	Accessories	Potassic Feldspar/ Plagiocase Ratio	Grain/ Matrix Ratio	Classification
Bruce Formation										
BM-65-134	Lower	28.7	6.3	8.6	...	56.4	x	9/1	44/56	Lithic greywacke conglomerate matrix
8b*	Lower	59.4	6.1	1.7	...	32.8	x	1/9	77/33	Quartz greywacke conglomerate matrix
8*	Middle	56.7	8.2	5.7	...	29.3	x	6/1	70/30	Subgreywacke conglomerate matrix
KF-66-76	Upper	55.0	19.3	0.8	...	24.9	x	4/1	75/25	Feldspathic subgreywacke conglomerate matrix
552*	Upper	50.3	8.0	11.2	...	28.5	x	7/1	71/29	Lithic subgreywacke conglomerate matrix
Espanola Formation										
CG-66-46	Lower	10.7	...	...	87.0	2.0	0.3	n.d.	n.d.	Silty Limestone
CM-65-6	Lower	13.3	...	...	86.0	...	0.7	n.d.	n.d.	Silty Limestone
436*	Lower	33.0	4.8	2.5	39.7	14.6	...	n.d.	n.d.	Calcareous Siltstone
CF-66-75	Middle	56.3	12.2	...	22.0	9.5	x	n.d.	n.d.	Calcareous Siltstone
554*	Middle	43.2	26.3	...	8.1	16.2	6.1	n.d.	n.d.	Calcareous Siltstone
60*	Upper	57.2	12.2	...	15.9	10.9	3.7	10/1	70/30	Calcareous Greywacke
506*	Upper	51.3	29.1	4.3	9.3	4.6	3.0	3/1	83/17	Calcareous Feldspathic Subgreywacke
Serpent Formation										
CF-66-77	Lower	39.0	28.6	x	...	32.4	x	3/2	68/32	Feldspathic Greywacke
A	Lower	60.1	29.9	...	8.6	0.9	0.5	1/2	90/10	Calcareous Feldspathic Protoquartzite
34*	Lower	62.6	19.9	1.7	8.4	7.4	...	5/1	84/16	Calcareous Protoquartzite
526*	Lower	52.2	24.1	0.6	...	23.2	...	2/1	77/23	Feldspathic Subgreywacke
CM-65-59	Middle	68.0	22.3	...	2.0	7.7	x	4/1	90/10	Protoquartzite
BM-65-182	Middle	55.4	14.6	...	6.4	23.6	...	7/3	70/30	Quartz Greywacke
522*	Middle	75.0	21.7	1.7	...	1.7	1.7	1/1	97/3	Feldspathic Quartzite
CM-65-7	Upper	69.0	27.5	...	3.2	0.3	...	9/1	96/4	Arkose
491a*	Upper	56.1	23.3	7.9	...	12.7	...	1.6/1	87/13	Feldspathic Protoquartzite
87	Upper	80.6	16.7	1.7	...	1.0	...	1.5/1	99/1	Feldspathic Quartzite

* From Casshyap (1967)

Abbreviations

x	Present in minor amounts
n.d.	Not determined
...	Not detected

Table 6 MODAL ANALYSES OF ROCKS OF THE GOWGANDA, LORRAIN, AND GORDON LAKE FORMATIONS IN THE ESPANOLA-WHITEFISH FALLS AREA

Sample No.	Stratigraphic Location	Quartz	Feldspars	Rock Frag-ments	Matrix	Accessories	Potassic Feldspar/ Plagioclase Ratio	Grain/Matrix Ratio	Classification
Gowganda Formation									
CG-66-26	Lower	32.7	15.0	x	52.3	x	2/1	48/52	Feldspathic greywacke paraconglomerate matrix
278*	Lower	39.7	10.1	6.2	44.0	x	3/1	66/44	Greywacke-paraconglomerate matrix
400*	Lower	30.6	11.9	21.7	24.8	1.7	5/1	75/25	Lithic subgreywacke paraconglomerate matrix
BM-65-197	Lower	49.0	28.3	...	18.0	4.7	1/1	77/23	Feldspathic Subgreywacke
CG-66-11	Middle	56.5	19.0	11.0	13.5	x	3/2	86/14	Feldspathic protoquartzite orthoconglomerate matrix
292*	Middle	43.1	8.4	1.0	47.5		5/1	52/48	Quartz greywacke-paraconglomerate matrix
CG-66-16	Upper	59.0	37.7	...	3.3	x	1/1	96/4	Arkose
CG-66-136	Upper	39.2	20.7	4.9	35.2	x	4/1	65/35	Greywacke
666*	Upper	58.8	22.4	11.2	7.5		100/1	92/8	Feldspathic Protoquartzite
289*	Upper	60.2	13.4	3.1	13.3	2.4	5/1	84/16	Feldspathic Subgreywacke
640*	Upper	65.3	26.4	8.5	0.0	...	3/1	n.d.	Arkose
Lorrain Formation									
CG-66-48	Grey sandstone member	45.8	42.6	...	11.6	x	1/4	88/12	Feldspathic protoquartzite
261a*	Lower	50.0	20.6	6.9	20.1	2.4	3/1	80/20	Feldspathic Subgreywacke
CR-66-25	Pink sandstone member	74.6	15.0	x	10.0	x	3/2	90/10	Protoquartzite
253*	Lower	50.6	21.3	8.0	9.6	10.5	n.d.	80/20	Feldspathic Subgreywacke
CG-66-62	Green sandstone member	73.6	13.7	...	12.0	0.7	9/1	87/13	Protoquartzite
371*	Middle	75.0	6.0	1.3	17.3	0.4	100/1	82/18	Subgreywacke
CG-66-119	Ferruginous sandstone member	81.0	...	...	15.5	3.5	n.d.	81/19	Subgreywacke
CG-66-68	White sandstone member	87.0	...	...	11.0	2.0	n.d.	87/13	Protoquartzite
CG-66-117	Cherty sandstone member	97.6	...	...	2.4	...	n.d.	98/2	Orthoquartzite
385*	Upper	97.0	...	...	3.0	...	n.d.	97/3	Orthoquartzite
Gordon Lake Formation									
CG-66-14	Middle	62.6	13.7	...	22.0	1.7	n.d.	78/22	Subgreywacke

* From Casshyap (1967)

Abbreviations

x	Present in minor amounts
...	Not detected
n.d.	Not determined

Table 9 ASSESSMENT WORK DATA, ON FILE AT RESIDENT GEOLOGIST'S OFFICE, ONTARIO MINISTRY OF NATURAL RESOURCES, SUDBURY

Espanola-Whitefish Falls Area

Township	Location	Company Name	Year	Type of Information
Curtin	Central	Bousquet, L.	1971	Tr
Curtin	Central eastern	Martin, H. E. (Bridger Occurrence)	1954	DDL, GL, SA
Curtin	Central eastern	Mylrea, F. H. (Bridger Occurrence)	1959	DDL, SA
Curtin	Central	White, S. J. (Upsala Mine)	1960 –61	DDL
Curtin	Central	White, S. J.	1970–71	Tr
Foster	Lots 8 and 9 Con. III	Cerro Mining Co. of Canada Ltd. (Tamminen Prospect)	1970	Tr, SA
Foster	Lots 9, 10, 11, Con. V	Dauphin Iron Mines Ltd.	1971	DDL, SA
Foster	Lot 10, Con. V	Maki, E. J.	1963	DDL
Foster	Lots 1, 2, 3, Con. II, lots 1, 2, Con. III	Mount Keno Mines Ltd.	1954	GL, GP
Foster	Lots 2 to 8, Con. IV, lots 2, 3, 4, Con. III	Murocew, C.	1956	GL
Foster	Lots 10, 11, 12, Con. V	Prosco Ltd. (Karl Occurrence)	1957	GL, GP, SA
Foster	Lot 10, Con. V	Rivers, E. J.	1969	Tr
Foster	Lots 9, 10, Con. III	Tamminen, Taisto (Tamminen Prospect)	1970	Tr, SA
Foster	Lots 6 to 9, Con. III and Con. IV	Texas Gulf Sulphur Co. Inc. (Tamminen Prospect)	1967	DDL
Foster	Lots 9, 10, 11, 12, Con. I	White, S. J.	1954 1955	DDL
Merritt	Lot 9, Con. V	Hunta, W.	1971	Tr
Merritt	Lot 3, Con. III	Roche, P. F.	1956	DDL
Merritt	Lot 1, Con. II	Sutherland, W. D.	1961	DDL
Merritt	Lot 1, Con. II	White, S. J.	1954	DDL
Mongowin	Lots 11, 12, Con. VI	Abila Mines Ltd.[1] (Owen Property)	NA	DDL
Mongowin	Lots 8 to 12, Con. III	Dayjon Explorers[2] Ltd. (McMillan Mine)	1961	GL, GP, DDL, SA
Mongowin	Wallace Mine Locations 2 and 3	Falconbridge Nickel Mines Ltd. (Wallace Mine)	1962	DDL
Mongowin	Wallace Mine Locations 2 and 3	Hespanola Mines[3] Ltd. (Wallace Mine)	1956	GA, SA
Mongowin	Wallace Mine Locations 2 and 3	Huron Nickel Basin Mines Ltd. (Wallace Mine)	1962	DDL
Mongowin	Lots 5, 6, 7, Con. III	Jo-Ami Gold Mines Ltd.	1959 –60	DDL, SA
Mongowin	Wallace Mine Locations 2 and 3	Jolloco Explorations Ltd. (Wallace Mine)	1969 1970	GL, GP
Mongowin	Lot 7, Con. III	Kirwan, G. (Jo-Ami Occurrence)	1968	GP, DDL, SA
Mongowin	Lots 11, 12, Con. VI	Owen Property	NA	DDL
Mongowin	Wallace Mine Locations 2 and 3	Tulgestke, I. (Wallace Mine)	1964	DDL
Mongowin	West of Wallace Mine Locations 2 and 3	Viva Explorations Ltd.	1971	Report, Pros

[1] Charter cancelled October, 1959.

[2] Charter cancelled August, 1966.

[3] Address and status unknown.

Abbreviations

DDL	Diamond-drill logs
GL	Geological (may include maps and reports; company prospectuses and financial statements)
GP	Geophysical
NA	Not available
Pros	Prospectus
SA	Sampling, assaying beneficiation studies
Tr	Trenching

Espanola-Whitefish Falls Area

Township	Location	Company Name	Year	Type of Information

ONTARIO
DIVISION OF MINES
HONOURABLE LEO BERNIER, *Minister of Natural Resources*
DR. J. K. REYNOLDS, *Deputy Minister of Natural Resources*
G. A. Jewett, *Executive Director, Division of Mines* E. G. Pye, *Director, Geological Branch*

Map 2311
Merritt and Foster Townships

LEGEND

CENOZOIC[a]

QUATERNARY

PLEISTOCENE AND RECENT

Sand, gravel, clay.

UNCONFORMITY

PRECAMBRIAN[b]

LATE PRECAMBRIAN

DIABASE INTRUSIONS

14 — 14 *Diabase, olivine diabase.*

INTRUSIVE CONTACT

MIDDLE PRECAMBRIAN

MONGOWIN PLUTON†

13
- 13a *Trondhjemite.*
- 13b *Diorite, granodiorite.*
- 13c *Olivine amphibolite.*

INTRUSIVE CONTACT

AMPHIBOLITE INTRUSIONS

12
- 12a *Amphibolite.*
- 12b *Porphyritic amphibolite.*†

INTRUSIVE CONTACT

NIPISSING DIABASE

11
- 11a *Metagabbro, amphibolite.*
- 11b *Pyroxene gabbro.*

INTRUSIVE CONTACT

HURONIAN SUPERGROUP

COBALT GROUP

GORDON LAKE FORMATION†

10
- 10a *Argillite.*
- 10b *Sandstone.*

CONFORMABLE CONTACT

LORRAIN FORMATION†

9
- 9a *Fine-grained cherty sandstone.*
- 9b *White, medium-grained sandstone.*
- 9c *Ferruginous sandstone.*
- 9d *Green feldspathic, micaceous sandstone.*
- 9e *Pink feldspathic sandstone.*
- 9f *Grey sandstone.*
- 9g *Argillite.*
- 9h *Quartz and jasper pebble conglomerate.*

CONFORMABLE CONTACT

GOWGANDA FORMATION

8
- 8 *Unsubdivided.*†
- 8a *Polymictic paraconglomerate, greywacke matrix.*
- 8b *Polymictic paraconglomerate, laminated argillite matrix.*
- 8c *Polymictic orthoconglomerate, greywacke matrix.*†
- 8d *Polymictic conglomerate, protoquartzite or subgreywacke matrix.*†
- 8e *Siltstone, laminated argillite.*
- 8f *Greywacke.*†
- 8g *Biotitic protoquartzite, subgreywacke.*
- 8h *Feldspathic protoquartzite, subgreywacke.*†

CONFORMABLE TO DISCONFORMABLE CONTACT

QUIRKE LAKE GROUP

SERPENT FORMATION

7
- 7 *Unsubdivided.*
- 7a *Feldspathic quartzite, protoquartzite.*
- 7b *Biotitic protoquartzite, subgreywacke.*
- 7c *Polymictic conglomerate.*
- 7d *Calcareous siltstone, calcareous argillite, calcareous sandstone.*
- 7e *Argillite, siltstone.*

CONFORMABLE CONTACT

ESPANOLA FORMATION

6
- 6a *Limestone, silty limestone.*
- 6b *Calcareous siltstone, argillite.*
- 6c *Calcareous sandstone.*
- 6d *Chert, chert breccia.*
- 6e *Scapolite hornfels.*
- 6f *Amphibolite.*
- 6g *Diopside — idocrase — grossularite skarn.*

CONFORMABLE CONTACT

BRUCE FORMATION

5
- 5a *Polymictic conglomerate, greywacke matrix.*
- 5b *Polymictic conglomerate, calcareous greywacke matrix.*
- 5c *Polymictic conglomerate, subgreywacke or protoquartzite matrix.*
- 5d *Calcareous siltstone, argillite, limestone.*
- 5e *Argillite, laminated argillite.*
- 5f *Sandstone.*

CONFORMABLE CONTACT

HOUGH LAKE GROUP

MISSISSAGI FORMATION

4
- 4a *Feldspathic sandstone.*
- 4b *Biotitic sandstone.*
- 4c *Argillite, siltstone.*
- 4d *Polymictic conglomerate.*

CONFORMABLE CONTACT

PECORS FORMATION

3
- 3a *Biotitic protoquartzite, subgreywacke.*
- 3b *Argillite.*

CONFORMABLE CONTACT

RAMSAY LAKE FORMATION

2
- 2a *Polymictic paraconglomerate, pebbly feldspathic sandstone.*

CONFORMABLE CONTACT

ELLIOT LAKE GROUP

McKIM FORMATION

1
- 1a *Muscovitic and chloritic metapelite.*
- 1b *Biotitic metapelite.*
- 1c *Plagioclase metapelite.*
- 1d *Chloritoid metapelite.*
- 1e *Garnet metapelite.*
- 1g *Biotitic protoquartzite, subgreywacke.*

△ △ △ *Breccia.*

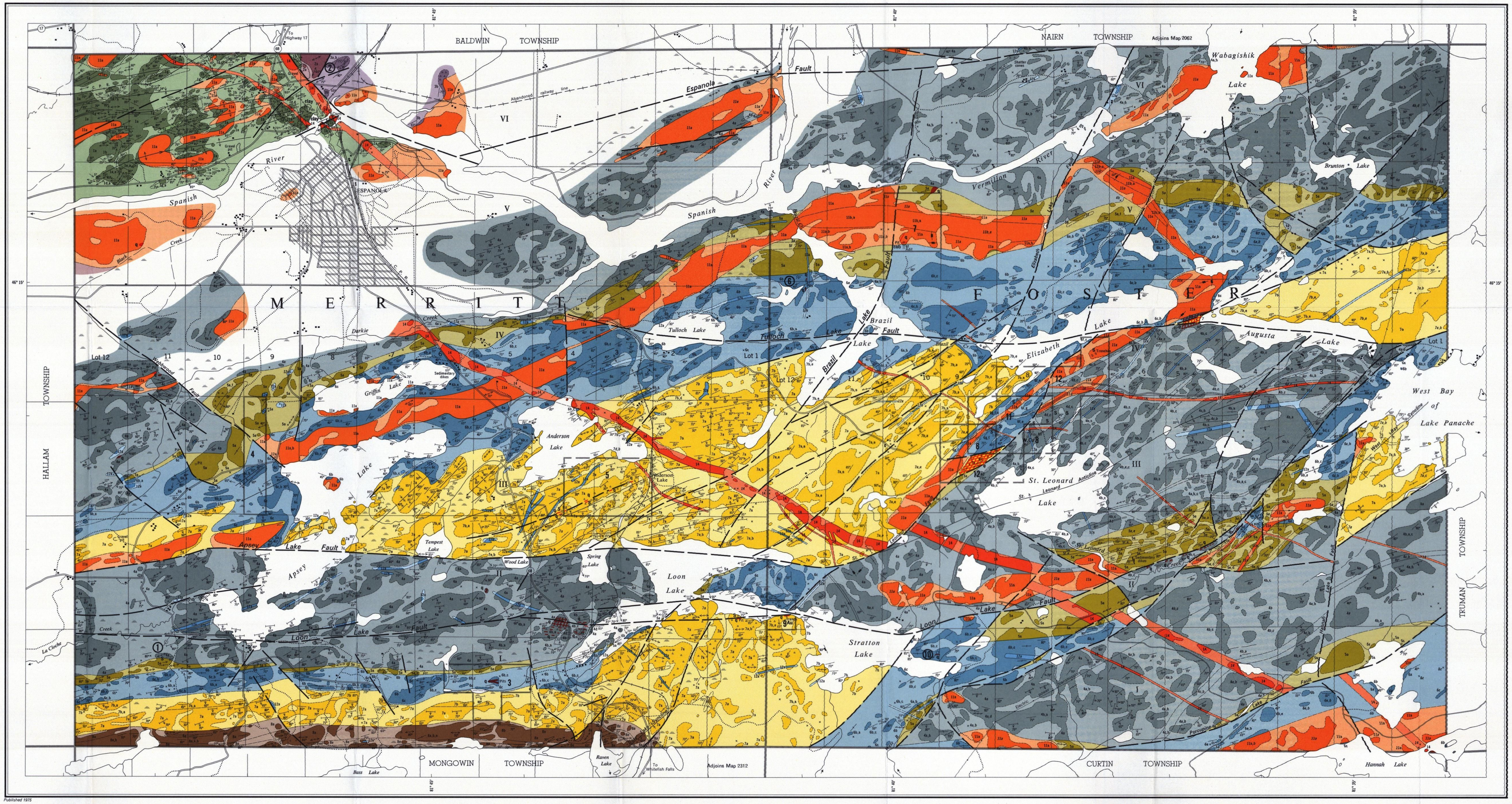
Au	*Gold.*
clay	*Clay.*
cob	*Cobaltite*
Cu	*Copper.*
Ni	*Nickel.*†
q	*Quartz.*
S	*Sulphide mineralization.*
si	*Silica.*†
W	*Tungsten.*

---

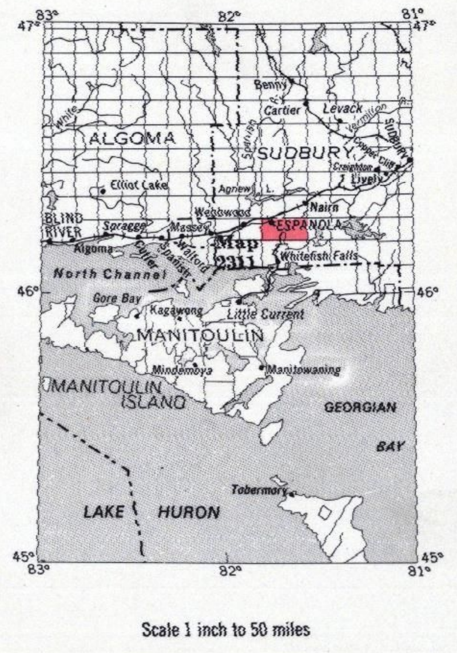
[a] *Unconsolidated deposits. Cenozoic deposits are represented by the lighter coloured and uncoloured areas of the map.*

[b] *Bedrock geology. Outcrop areas 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.*

† *Occurs only on companion sheet, Map 2312 Mongowin and Curtin Tps.*



Published 1975



Scale 1 inch to 50 miles

NTS reference 41 I/4, 41 I/5

SYMBOLS

- *Glacial striae.*
- *Small bedrock outcrop.*
- *Area of bedrock outcrop.*
- *Bedding horizontal.*
- *Bedding, top unknown; (inclined, vertical).*
- *Bedding, top (arrow) from grain gradation; (inclined, vertical, overturned.)*
- *Bedding, top (arrow) from cross bedding; (inclined, vertical, overturned).*
- *Schistosity; (horizontal, inclined, vertical).*
- *Foliation; (horizontal, inclined, vertical).*
- *Lineation with plunge.*
- *Geological boundary, observed.*
- *Geological boundary, position interpreted.*
- *Fault; (observed, assumed). Spot indicates down throw side, arrows indicate horizontal movement.*
- *Jointing; (horizontal, inclined, vertical).*
- *Drag folds with plunge.*
- *Anticline, syncline, with plunge.*
- *Fold axis.*
- *Drill hole; (vertical, inclined).*
- *Vein, vein network. Width in inches.*
- *Shaft.*
- *Building.*
- *Motor road. Provincial highway number encircled where applicable.*
- *Other road.*
- *Trail, portage, winter road.*
- *Township boundary, meridian or base line with milepost, approximate position only.*
- *Mining property, surveyed.*
- *Mineral deposit; mining property, unsurveyed.*
- *Surveyed line, approximate position only.*

SOURCES OF INFORMATION

Geology of Merritt Township by K. D. Card and C. E. Blackburn, Geological Branch, 1965.
Geology of Foster Township by K. D. Card and assistants, Geological Branch, 1966.
Geology up-dated by K. D. Card, Geological Branch 1968.
Geology was not tied to surveyed lines.

Aeromagnetic maps 1522G, 1523G, G.S.C.

Geological Survey of Canada:
Map 180A, Espanola Area, issued 1917.
Map 1971, Lake Panache, issued 1925.

Preliminary maps:
P. 322, Merritt Township, scale 1 inch to ¼ mile, issued 1965.
P. 390, Foster Township, scale 1 inch to ¼ mile, issued 1967.

Cartography by C. A. Harris and assistants, Surveys and Mapping Branch, 1974.

Base map derived from maps of the Forest Resources Inventory, Surveys and Mapping Branch.

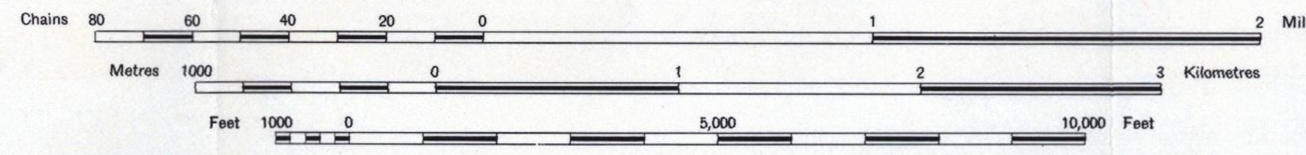
Magnetic declination in the area was approximately 7°W, 1970.

Map 2311

MERRITT AND FOSTER TOWNSHIPS

SUDBURY DISTRICT

Scale 1:31,680 or 1 Inch to ½ Mile



PROPERTIES, MINERAL DEPOSITS

MERRITT TOWNSHIP

1. *Apsey Lake occurrence.*
2. *Brown Forest Industries Ltd.*
3. *Lacelle, W.*
4. *Lanthier, Ben.*
5. *Roche, Peter J.*

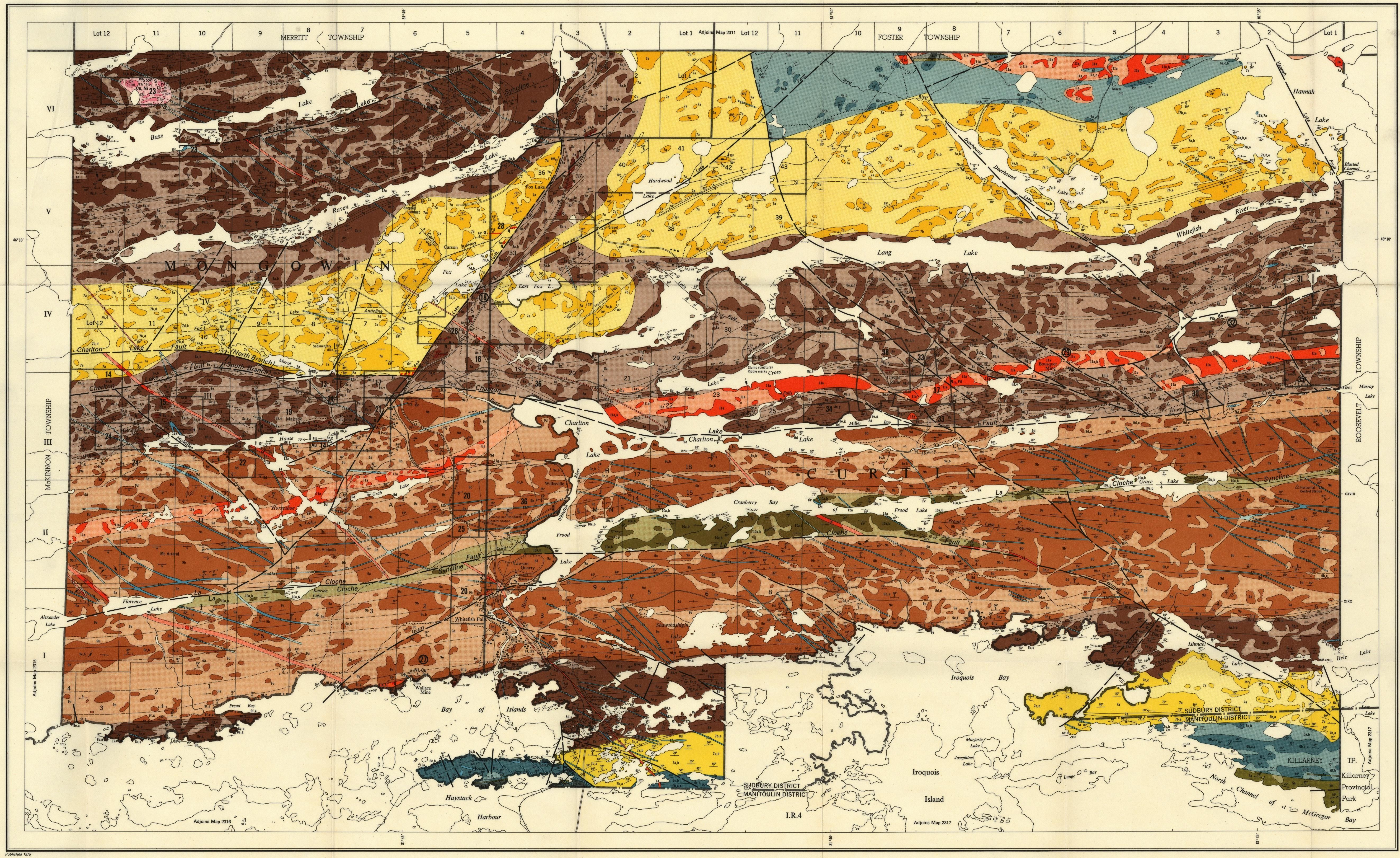
FOSTER TOWNSHIP

6. *Karl occurrence.*
7. *Maki, E.*
8. *Piispanen, V.*
9. *Scott, K.*
10. *Stratton Lake occurrence.*
11. *Tamminen, T.*
12. *Texas Gulf Sulphur Co. Inc.*

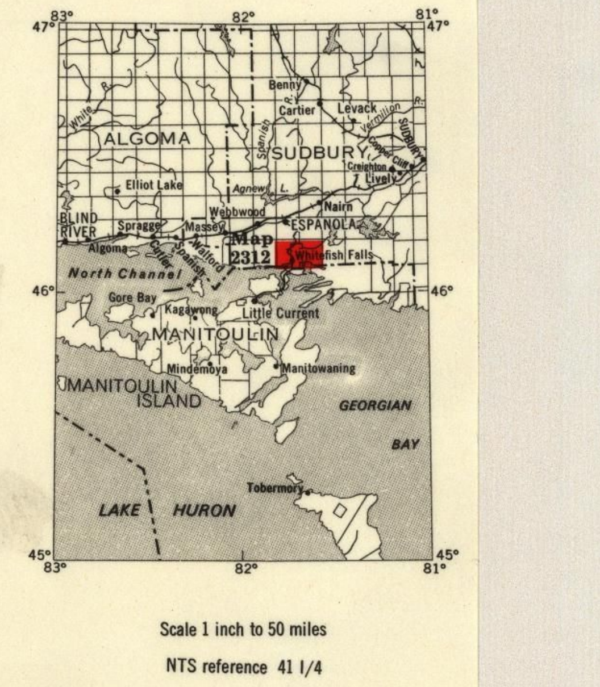
Ownership of properties as of March 31, 1968. Former properties on ground now open for staking are only shown where exploration information is available. For further information see report.

Map 2312
Mongowin and Curtin Townships

ONTARIO
DIVISION OF MINES
HONOURABLE LEO BERNIER, *Minister of Natural Resources*
DR. J. K. REYNOLDS, *Deputy Minister of Natural Resources*
G. A. Jewett, *Executive Director, Division of Mines* E. G. Pye, *Director, Geological Branch*



Published 1975



Scale 1 inch to 50 miles
NTS reference 41 I/4

LEGEND

CENOZOIC[a]

QUATERNARY
PLEISTOCENE AND RECENT
Sand, gravel, clay.

UNCONFORMITY

PRECAMBRIAN[b]

LATE PRECAMBRIAN
DIABASE INTRUSIONS

14 *14 Diabase, olivine diabase.*

INTRUSIVE CONTACT

MIDDLE PRECAMBRIAN
MONGOWIN PLUTON

13
- *13a Trondhjemite.*
- *13b Diorite, granodiorite.*
- *13c Olivine amphibolite.*

INTRUSIVE CONTACT

AMPHIBOLITE INTRUSIONS

12
- *12a Amphibolite.*
- *12b Porphyritic amphibolite.*

INTRUSIVE CONTACT

NIPISSING DIABASE

11
- *11a Metagabbro, amphibolite.*
- *11b Pyroxene gabbro.*

INTRUSIVE CONTACT

HURONIAN SUPERGROUP
COBALT GROUP
GORDON LAKE FORMATION

10
- *10a Argillite.*
- *10b Sandstone.*

CONFORMABLE CONTACT

LORRAIN FORMATION

9
- *9a Fine-grained cherty sandstone.*
- *9b White, medium-grained sandstone.*
- *9c Ferruginous sandstone.*
- *9d Green feldspathic, micaceous sandstone.*
- *9e Pink feldspathic sandstone.*
- *9f Grey sandstone.*
- *9g Argillite.*
- *9h Quartz and jasper pebble conglomerate.*

CONFORMABLE CONTACT

GOWGANDA FORMATION

8
- *8 Unsubdivided.*
- *8a Polymictic paraconglomerate, greywacke matrix.*
- *8b Polymictic paraconglomerate, laminated argillite matrix.*
- *8c Polymictic orthoconglomerate, greywacke matrix.*
- *8d Polymictic conglomerate, protoquartzite or subgreywacke matrix.*
- *8e Siltstone, laminated argillite.*
- *8f Greywacke.*
- *8g Biotitic protoquartzite, subgreywacke.*
- *8h Feldspathic protoquartzite, subgreywacke.*

CONFORMABLE TO DISCONFORMABLE CONTACT

QUIRKE LAKE GROUP
SERPENT FORMATION

7
- *7 Unsubdivided.†*
- *7a Feldspathic quartzite, protoquartzite.*
- *7b Biotitic protoquartzite, subgreywacke.*
- *7c Polymictic conglomerate.*
- *7d Calcareous siltstone, calcareous argillite, calcareous sandstone.*
- *7e Argillite, siltstone.*

CONFORMABLE CONTACT

ESPANOLA FORMATION

6
- *6a Limestone, silty limestone.*
- *6b Calcareous siltstone, argillite.*
- *6c Calcareous sandstone.*
- *6d Chert, chert breccia.†*
- *6e Scapolite hornfels.*
- *6f Amphibolite.*
- *6g Diopside — idocrase — grossularite skarn.†*

CONFORMABLE CONTACT

BRUCE FORMATION

5
- *5a Polymictic conglomerate, greywacke matrix.*
- *5b Polymictic conglomerate, calcareous greywacke matrix.†*
- *5c Polymictic conglomerate, subgreywacke or protoquartzite matrix.†*
- *5d Calcareous siltstone, argillite, limestone.†*
- *5e Argillite, laminated argillite.†*
- *5f Sandstone.†*

CONFORMABLE CONTACT

HOUGH LAKE GROUP
MISSISSAGI FORMATION

4
- *4a Feldspathic sandstone.*
- *4b Biotitic sandstone.†*
- *4c Argillite, siltstone.†*
- *4d Polymictic conglomerate.†*

CONFORMABLE CONTACT

PECORS FORMATION†

3
- *3a Biotitic protoquartzite, subgreywacke.*
- *3b Argillite.*

CONFORMABLE CONTACT

RAMSAY LAKE FORMATION

2
- *2a Polymictic paraconglomerate, pebbly feldspathic sandstone.†*

CONFORMABLE CONTACT

ELLIOT LAKE GROUP
McKIM FORMATION†

1
- *1a Muscovitic and chloritic metapelite.*
- *1b Biotitic metapelite.*
- *1c Plagioclase metapelite.*
- *1d Chloritoid metapelite.*
- *1e Garnet metapelite.*
- *1g Biotitic protoquartzite, subgreywacke.*

△ △ △ *Breccia.*

Au	*Gold.*
clay	*Clay.†*
cob	*Cobaltite†*
Cu	*Copper.*
Ni	*Nickel.*
q	*Quartz.*
S	*Sulphide mineralization.*
si	*Silica.*
W	*Tungsten.†*

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[a] *Unconsolidated deposits. Cenozoic deposits are represented by the lighter coloured areas of the map.*

[b] *Bedrock geology. Outcrop areas 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.*

† *Occurs only on companion sheet, Map 2311 Merritt and Foster Tps.*

SOURCES OF INFORMATION

Geology by K. D. Card and assistants, Geological Branch, 1966.
Geology up-dated by K. D. Card, Geological Branch, 1968.
Geology was not tied to surveyed lines.

Aeromagnetic map 1522G, G.S.C.

Geological Survey of Canada:
Map 180A, Espanola Area, issued 1917.
Map 1971, Lake Panache, issued 1925.

Preliminary maps:
P. 391 Mongowin Township, scale 1 inch to ¼ mile, issued 1967.
P. 392 Curtin Township, scale 1 inch to ¼ mile, issued 1967.

Cartography by C. A. Harris and assistants, Surveys and Mapping Branch, 1974.

Base map derived from maps of the Forest Resources Inventory, Surveys and Mapping Branch.

Magnetic declination in the area was approximately 7°W, 1970.

Map 2312

MONGOWIN AND CURTIN TOWNSHIPS

SUDBURY 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

SYMBOLS

- *Glacial striae.*
- *Small bedrock outcrop.*
- *Area of bedrock outcrop.*
- *Bedding horizontal.*
- 75° *Bedding, top unknown; (inclined, vertical).*
- 70° 70° *Bedding, top indicated by arrow; (inclined, vertical, overturned).*
- 65° 70° *Bedding, top (arrow) from grain gradation; (inclined, vertical, overturned.)*
- 75° 70° *Bedding, top (arrow) from cross bedding; (inclined, vertical, overturned).*
- 80° *Schistosity; (horizontal, inclined, vertical).*
- 80° *Foliation; (horizontal, inclined, vertical).*
- 30° *Lineation with plunge.*
- *Geological boundary, observed.*
- *Geological boundary, position interpreted.*
- *Fault; (observed, assumed). Spot indicates down throw side, arrows indicate horizontal movement.*
- 70° *Jointing; (horizontal, inclined, vertical).*
- 80° 80° *Drag folds with plunge.*
- 70° 70° *Anticline, syncline, with plunge.*
- *Fold axis.*
- DH *Drill hole; (vertical, inclined).*
- 4″ *Vein, vein network. Width in inches.*
- *Shaft.*
- *Building.*
- 68 *Motor road. Provincial highway number encircled where applicable.*
- *Other road.*
- *Trail, portage, winter road.*
- XXV *Township boundary, meridian or base line with milepost, approximate position only.*
- 16 *Mining property, surveyed.*
- ㉙ *Mineral deposit; mining property, unsurveyed.*
- *Surveyed line, approximate position only.*
- *District boundary, approximate position only.*

PROPERTIES, MINERAL DEPOSITS

MONGOWIN TOWNSHIP

13. *Clark, Ralph H.*
14. *Dayjon Explorations and Holdings Ltd.*
15. *Dayjon Explorations and Holdings Ltd. (McMillan mine).*
16. *Fagg, S.*
17. *Featherstone, C. J.*
18. *Fox Lake occurrence.*
19. *Gregory, Charles, estate (Majestic mine).*
20. *International Nickel Co. of Canada Ltd., The.*
21. *Kirwan, G. L.*
22. *New Athona Mines Ltd.*
23. *Owen, J. F.*
24. *Riddell, Wm. H., estate.*
25. *Sagima, Mary L.*
26. *Siegrist, E. A.*
27. *Wallace mine.*

CURTIN TOWNSHIP

28. *Bailey, E. (Fox Lake occurrence).*
29. *Bousquet mine.*
30. *Bousquet, I.*
31. *Boutin, P.*
32. *Bridger occurrence.*
33. *Bull, G. C. Jr.*
34. *Clark, Ralph H.*
35. *Ewing, D. (Howry Creek mine).*
36. *International Nickel Co. of Canada Ltd., The. (Lawson Quarry).*
37. *Lehman, J.*
38. *White, S. J. (Upsala mine).*

Ownership of properties as of March 31, 1968. Former properties on ground now open for staking are only shown where exploration information is available. For further information see report.