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Ontario Geological Survey

Report 206

Geology of the

Benny Area

District of Sudbury

By

K.D. Card and D.G. Innes

1981

Ontario

Ministry of
Natural
Resources

Ontario Geological Survey
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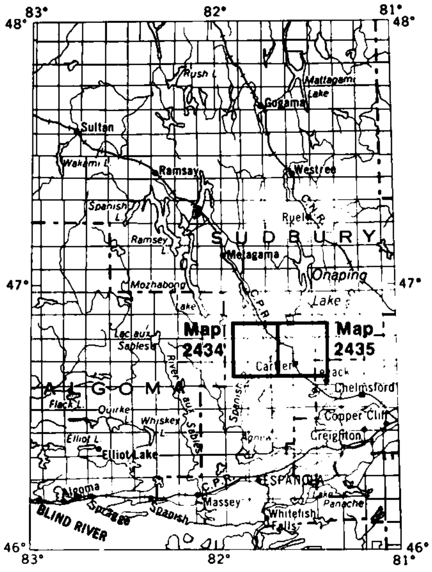
ABSTRACT

The Benny map-area, located some 64 km northwest of Sudbury, Ontario, is bounded by Latitudes 46°42′N and 46°51′N and Longitudes 81°26′W and 81°53′W. The map-area lies in the southern part of the Superior Province north of the Sudbury Nickel Irruptive, in a terrain that has been affected by Early, Middle, and Late Precambrian depositional, deformational, metamorphic, and igneous-intrusive events.

The major rock groups include the following; Early Precambrian metavolcanics and metasediments; several ages of Early Precambrian mafic and felsic intrusions; and Middle Precambrian metasediments of the Huronian Supergroup. Also, Middle Precambrian Nipissing Diabase intrusions, breccia bodies of several types and ages, and Late Precambrian olivine diabase dikes are prevalent. A mafic dike in the southeastern part of the area is tentatively considered to represent the extension of the Foy Offset, a dike-like offshoot from the Sudbury Nickel Irruptive.



SMC 14316

Figure 1–Key map showing the location of the Benny Area. Scale 1:3 168 000 (1 inch to 50 miles).

The Early Precambrian metavolcanics and metasediments form an east-west belt which is approximately 40 km long and is as much as 4.8 km wide. The metavolcanic-metasedimentary sequence is surrounded by intrusive Early Precambrian granitic and migmatitic rocks, dips steeply southward, and is considered to represent the remnant of a previously more extensive supracrustal sequence. The major rock types present include basaltic and andesitic flows having tholeiitic and calc-alkaline affinities and pyroclastic rocks of intermediate and felsic composition. The pyroclastic rock types include tuff-breccia, lapilli-tuff, and tuff. The metasediments, some of which contain sulphide minerals, include wacke, siltstone, chert, and metamorphosed equivalents of these rocks. There are a number of cyclic repetitions of mafic, intermediate, and felsic metavolcanics, and most of these cycles contain intercalations of sulphide-bearing tuff and metasediments. The sulphide mineralization, mainly pyrite and pyrrhotite, includes sphalerite, galena, and chalcopyrite, and locally forms stratiform disseminations, massive lenses, and veins.

The rocks of the Benny Belt have been regionally metamorphosed under conditions corresponding to the upper greenschist and lower amphibolite facies. Deformation is expressed by penetrative foliation and rodding lineation formed by the flattening and orientation of minerals and pre-existing elements such as pillows and rock fragments.

The Early Precambrian felsic plutonic and migmatitic rocks can be divided into two main groups: an older, pre-tectonic gneissic or foliated trondhjemite-migmatite complex; and younger, post-tectonic, massive plutons composed mainly of porphyritic quartz monzonite.

Middle Precambrian Huronian metasediments of the Mississagi, Bruce, Espanola, Serpent, Gowganda, and Lorrain Formations form a number of outliers that rest unconformably on the Early Precambrian basement rocks. The Huronian rocks have been haphazardly deformed, probably in part by gravity sliding, and have been mildly metamorphosed under low to middle greenschist facies conditions.

The Precambrian bedrock is extensively mantled by Pleistocene glacial and glaciofluvial deposits.

Exploration has been carried out in the area for zinc, lead, copper, nickel, iron, silver, gold, and uranium. Stratabound and vein-type base-metal sulphide deposits occur in the Benny metavolcanic-metasedimentary sequence. Zinc, lead, and silver have been produced from one of these deposits, the Geneva Lake Mine in Hess Township. Replacement-type deposits consisting of variable proportions and combinations of magnetite, pyrite, sphalerite, chalcopyrite, and galena occur in the Huronian sequence, particularly in calcareous rocks of the Espanola Formation at or near contacts with Nipissing Diabase intrusions.

CONVERSION FACTORS FOR MEASUREMENTS IN ONTARIO GEOLOGICAL SURVEY PUBLICATIONS

If the reader wishes to convert imperial units to SI (metric) units or SI units to imperial units the following multipliers should be used:

CONVERSION FROM SI TO IMPERIAL			**CONVERSION FROM IMPERIAL TO SI**		
SI Unit	*Multiplied by*	*Gives*	*Imperial Unit*	*Multiplied by*	*Gives*
			LENGTH		
1 mm	0.039 37	inches	1 inch	**25.4**	mm
1 cm	0.393 70	inches	1 inch	**2.54**	cm
1 m	3.280 84	feet	1 foot	**0.304 8**	m
1 m	0.049 709 7	chains	1 chain	20.116 8	m
1 km	0.621 371	miles (statute)	1 mile (statute)	**1.609 344**	km
			AREA		
1 cm^2	0.155 0	square inches	1 square inch	**6.451 6**	cm^2
1 m^2	10.763 9	square feet	1 square foot	**0.092 903 04**	m^2
1 km^2	0.386 10	square miles	1 square mile	2.589 988	km^2
1 ha	2.471 054	acres	1 acre	0.404 685 6	ha
			VOLUME		
1 cm^3	0.061 02	cubic inches	1 cubic inch	**16.387 064**	cm^3
1 m^3	35.314 7	cubic feet	1 cubic foot	0.028 316 85	m^3
1 m^3	1.308 0	cubic yards	1 cubic yard	0.764 555	m^3
			CAPACITY		
1 L	1.759 755	pints	1 pint	0.568 261	L
1 L	0.879 877	quarts	1 quart	1.136 522	L
1 L	0.219 969	gallons	1 gallon	**4.546 090**	L
			MASS		
1 g	0.035 273 96	ounces (avdp)	1 ounce (avdp)	28.349 523	g
1 g	0.032 150 75	ounces (troy)	1 ounce (troy)	**31.103 476 8**	g
1 kg	2.204 62	pounds (avdp)	1 pound (avdp)	**0.453 592 37**	kg
1 kg	0.001 102 3	tons (short)	1 ton (short)	**907.184 74**	kg
1 t	1.102 311	tons (short)	1 ton (short)	**0.907 184 74**	t
1 kg	0.000 984 21	tons (long)	1 ton (long)	**1016.046 908 8**	kg
1 t	0.984 206 5	tons (long)	1 ton (long)	**1.016 046 908 8**	t
			CONCENTRATION		
1 g/t	0.029 166 6	ounce (troy)/ ton (short)	1 ounce (troy)/ ton (short)	34.285 714 2	g/t
1 g/t	0.583 333 33	pennyweights/ ton (short)	1 pennyweight/ ton (short)	1.714 285 7	g/t

OTHER USEFUL CONVERSION FACTORS

1 ounce (troy)/ton (short)	20.0	pennyweights/ton (short)
1 pennyweight/ton (short)	0.05	ounce (troy)/ton (short)

NOTE–Conversion factors which are in bold type are exact. The conversion factors have been taken from or have been derived from factors given in the Metric Practice Guide for the Canadian Mining and Metallurgical Industries published by The Mining Association of Canada in co-operation with the Coal Association of Canada.

Geology
of the
Benny Area
District of Sudbury

By

K.D. Card[1] and D.G. Innes[2]

INTRODUCTION

The centre of the Benny map-area is approximately 64 km northwest of Sudbury, Ontario. The map-area, totalling approximately 700 km^2 is bounded by Latitudes 46°42′N and 46°51′N and Longitudes 81°26′W and 81°53′W and includes the townships of Hess, Moncrieff, and Craig, and parts of the townships of Cartier, Hart, Tofflemire, Solski, Ouellette, Gilbert, Stralak, Ulster, Munster, Leinster, Harty, and Levack (Figure 1).

The Benny map-area is located in the southern part of the Superior Province, a terrain that has been affected by Early, Middle, and Late Precambrian depositional, deformational, metamorphic, and igneous intrusive events. The major rock groups include the following: Early Precambrian metavolcanics, metasediments, and mafic and felsic intrusions of several ages; Middle Precambrian metasediments of the Huronian Supergroup, and Middle and Late Precambrian mafic intrusions. The Sudbury Nickel Irruptive is located a short distance to the southeast, and a dike-like offshoot from the main Irruptive, the Foy Offset, may extend into the eastern part of the map-area.

Access to various points in the eastern part of the map-area is provided by the following: by Highway 144 that links Sudbury and Timmins, Ontario; by gravel roads extending east and west from Highway 144; and by the transcontinental line of the Canadian Pacific Railway.

Access to points in the west is afforded by private bush roads of the E.B. Eddy Company, the Spanish River, and Bluewater and Kennedy Lakes.

The mapping, on a scale of 1:15 840 (1 inch to 1320 feet) was done over a period of about eight months in the summers of 1973 and 1974. Basemaps for the area were prepared from map sheets of the Forest Resources Inventory series

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by the Cartography Unit of the Surveys and Mapping Branch, Ontario Ministry of Natural Resources. In the field, pace and compass traverses were made at approximately 0.3 km intervals and geological data were plotted on perfatrace overlays superimposed on air photographs having a scale of 1:15 840 and were transferred to basemaps of the same scale with the aid of a sketchmaster. Preliminary geological maps published at a scale of 1:15 840 of the Gilbert-Bluewater Lakes area (P.1106), the Stralak-Bannerman Lake area (P.1107), the Geneva-Munster Lakes area (P.1108), the Charcoal Lake area (P.1109), the Spanish-Johnson Lakes area (P.1110) and the Cartier-Carhess Lake area (P.1111) were issued by the Ontario Division of Mines in 1976 (Card and Innes 1976a,b,c,d,e, and f).

During 1973, the authors were assisted in the field by: Linda B. Johnson, Alan E. Guthrie, Wayne R. Bulmer, and Anne Krympotic; and in 1974 by Alan E. Guthrie, Wayne R. Bulmer, Susan Savory, Anne Fleming, Peter J. Whittaker, and Brian Fry. Messrs. Guthrie, Bulmer, and Ms. Johnson did some of the mapping. The writers wish to thank the following persons and companies for information and assistance: E.D. Dadson, Chevron Standard Limited; E. Blanchard, Geneva Metals Incorporated; J. Descarreaux, Consulting Geologist; S. Masson, Cambrian College; R. Rouleau, Cartier; S. Winter, Cambrian College; A.E. Guthrie, Laurentian University; B. Young, Toronto; L.J. Bardswich, Sudbury; Doris and Ray Lapointe, Cartier; and A.E. Beswick, Laurentian University.

Resources and Development

Tree species present in the area include spruce, balsam, cedar, alder, and tamarack in swampy areas, and jack pine, birch, and poplar on rocky uplands and sand plains.

A few scattered mature red and white pine, remnants of the original forest cover, are present in more remote parts of the area. Lumbering began in the area about 1890, and remnants of these operations, including camboose camps, logging railways, water control dams, and sluices are still evident.

During the period 1890 to 1950, some 37 902 000 m of white and red pine sawlogs, 4 157 500 m of jackpine sawlogs, and 36 200 m^3 of spruce and jackpine pulpwood were produced from the area. Hess, Cartier, and Harty Townships alone produced 17 790 500 m of white and red pine sawlogs during the period 1901 to 1913. The logs and dimension timber had an average length of over 30 m; the longest was 52 m (Timber production records, Timber Division, Ministry of Natural Resources, Sudbury). Much of the timber produced during the early years was driven down the Spanish River to Lake Huron and rafted to mills on John Island near the mouth of the Spanish River and at Blind River. In recent years, extensive stands of jack pine and spruce have been harvested for pulp and paper manufacture.

Game and fur-bearing animals present in the map-area include moose, bear, ruffed grouse, hare, lynx, wolf, beaver, mink, otter, and marten. The principal fish species are lake trout, brook trout, pickerel, pike, and bass.

The principal community, Cartier, has a population of about 680, and is a division point on the Canadian Pacific Railway. Benny, with a population of about 30, is a logging depot. Timber is trucked to Benny from operations further north and loaded for rail shipment to the E.B. Eddy plant at Espanola.

Exploration for base metals, iron, gold, and uranium has been carried out at a number of localities within the map-area. The Geneva Lake Mine in Hess Township produced some 4 717 400 kg (10,400,000 lb) of zinc, and 1 630 000 kg (3,600,000 lb) of lead and silver valued at $28,416 in the early 1940s. In more recent years, exploration programs for base metals, iron, and uranium have been carried out by a number of companies and individuals including Chevron Standard Limited, Tex-Sol Explorations Limited, Geneva Metals Incorporated, Devon Resources Limited, Canadian Nickel Company Limited, L.J. Billoki, Amax Exploration Incorporated, St. Joseph Explorations Limited, L.G. Bardswich, Hollinger Mines Limited, Lynx-Canada Exploration Limited, Dome Mines Limited, Canadian Nickel Company Limited, and J.G. Huycke.

Locations of mineral deposits, properties, and mineral surveys in the Benny area are given in Figure 18 (Chart B, back pocket).

Physiography

The Benny map-area lies within the James Bay Physiographic Region of the Canadian Shield in the southern part of the Abitibi Upland subdivision (Bostock 1970).

Precambrian crystalline rocks form a broad, rolling surface which within the map area has an average elevation of approximately 360 m above sea level, a maximum elevation of 510 m, and an average relief of about 30 m.

Parts of the map-area are underlain by folded Middle Precambrian strata. Bedrock lithology and structure strongly control topography. Near Geneva Lake, erosion-resistant sandstones of the Lorrain Formation form prominent hills reaching a maximum elevation of about 510 m above sea level and have a local relief of about 60 m.

Areas underlain by Early Precambrian metavolcanics are topographically subdued, but in the west there are hills with elevations as much as 495 m above sea level formed of massive metabasalts. Nipissing Diabase generally forms rounded, hummocky ridges, a reflection of weathering along rectangular joint systems in these rocks. The Late Precambrian olivine diabase dikes are easily weathered and consequently are expressed topographically by long, narrow valleys. Major faults are commonly expressed by prominent topographic lineaments and scarps. The major north-northwest-trending faults strongly control the drainage patterns; major lake and stream systems such as Bluewater Lake, Kennedy Lake, and the Spanish River occupy fault valleys.

The effects of glaciation are evident in the generally subdued topography, rounded hills, and valleys partly filled with glacial debris. Extensive glacial moraine deposits occur in the area, some of which contain large boulders giving rise to a rough, hummocky topography. In other parts of the area, outwash sand and gravel form smooth sand plains. Eskers, kames, terraces, and coarse boulder pavements have local topographic expression.

The map-area lies within the Great Lakes Drainage Basin and is consequently drained southward to Lake Huron by the Spanish River and its tributaries. Numerous lakes, ponds, and swamps attest to the immature nature of the drainage regime.

The topography of the Benny map-area is shown on the following maps of the Surveys and Mapping Branch, Department of Energy, Mines, and Resources at a scale of 1:50 000: Cartier (41-I/12), Pogamasing (41-I/13), Venetian Lake West (41-I/11), and Chelmsford West (41-I/14).

Previous Geological Work

The area as a whole was not mapped in detail prior to the present survey. In 1880, the CPR route through the map-area was surveyed by W.A. Austin, and in 1899, W.A.Parks traversed the east branch of the Spanish River (Report of the Ontario Bureau Mines 1900). In 1888-1890, Robert Bell (1893) investigated the Sudbury area and extended his work northward into the Onaping Lake area (Bell 1893). M.T. Culbert made a reconnaissance traverse through the area in 1903, and W.H. Collins mapped to the north and east in the Onaping map-area (Collins 1917).

T.T. Quirke (1920) mapped the townships of Moncrieff and Hess in the Geneva Lake area. He noted the presence of both Early (Archean) and Middle (Proterozoic) Precambrian rocks, but mapped some of the Early Precambrian metavolcanics north of Geneva Lake as part of the Middle Precambrian Huronian sequence. This led him to mistakenly conclude that some of the granitic intrusions in the area are of post-Huronian age.

F.F. Osborne (1929a) mapped much of the map-area in reconnaissance fashion in 1928.

T.C. Holmes (1953) mapped a part of Hart Township as part of a Ph.D. Thesis study of the relationship between the granitic rocks and the Huronian strata of the area.

Osborne (1929a) described the Hart Township magnetite-sphalerite deposit. Ralph Tuck (1931) and J.E. Hawley (1948) have described the Geneva Lake Mine. Alan E. Guthrie (1974) studied an occurrence of zinc mineralization in metamorphosed limestones of the Espanola Formation in Hess Township. S. Masson (1976) has described the L.G. Bardswich (1)[1] property, also in the Espanola Formation, near Cartier.

K.D. Card and H.D. Meyn (1969) mapped the Leinster-Bowell area to the east, F.F. Langford (1960) mapped the Levack area to the south, and B. Dressler (1976a,b, and c) has mapped Emo, Rhodes, and Botha Townships to the northeast.

The regional geology is portrayed on Map 2361, Sudbury-Cobalt sheet, Ontario Geological Survey, and the magnetic characteristics of the area are shown on Federal-Provincial Aeromagnetic series maps 1519G (Venetian Lake), 1525G (Pogamasing), 1524G (Cartier), and 1518G (Chelmsford), (GSC 1965a,b,c, and d).

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[1] The number in parentheses is the number of the property given on Map 2435, back pocket.

GENERAL GEOLOGY

The Benny map-area is located in the southern part of the Superior Province of the Canadian Shield north of the main contact between the Early Precambrian rocks of the Superior Province and the Middle Precambrian rocks of the Southern Province (Stockwell *et al.* 1970).

The rocks in the map-area are of Precambrian age and include: an Early Precambrian metavolcanic-metasedimentary sequence; Early Precambrian felsic plutonic and migmatitic rocks; Early Precambrian mafic intrusions; Middle Precambrian metasediments of the Huronian Supergroup; Middle Precambrian mafic intrusions; the Nipissing Diabase; and Late Precambrian diabase dikes. There is a mafic dike that probably represents the extension of the Foy Offset, one of the dikes projecting out from the Sudbury Nickel Irruptive. Also, there are numerous lamprophyre and breccia dikes.

The area was affected by deformation, regional metamorphism, and felsic plutonism during the Early Precambrian Kenoran Orogeny some 2500 my or more ago. In the early part of the Middle Precambrian, renewed tectonic activity led to crustal foundering and deposition of Middle Precambrian supracrustal rocks of the Huronian Supergroup probably in localized, fault-controlled basins. The Huronian rocks were subsequently folded, faulted, mildly metamorphosed, and intruded by Nipissing Diabase bodies during the Middle Precambrian. Later events included: i) the formation of breccias, most were probably connected with the Middle Precambrian "Sudbury Event", which was either produced by explosive volcanism or meteorite impact; and ii) emplacement of northwest-trending diabase dikes of the Sudbury Swarm.

Zinc, lead, and copper sulphide mineralization of probable volcanic exhalative origin occurs in the Early Precambrian metavolcanic sequence. Replacement-type deposits of magnetite, hematite, sphalerite, galena, and chalcopyrite occur in the Huronian rocks, primarily in carbonate-rich rocks of the Espanola Formation. Minor amounts of uranium are present in the Early Precambrian rocks at several localities.

The bedrock is partly mantled by unconsolidated sand, gravel, and clay, the deposits of the Pleistocene continental glaciation.

The foregoing sequence of rock units and events is summarized in Table 1.

Precambrian

EARLY PRECAMBRIAN

Metavolcanics and Metasediments

Metamorphosed volcanic flows, pyroclastic rocks, and associated metasediments form an east-west trending belt, the Benny Belt, that extends through the middle of the map-area. The Benny Belt has an average width of approxi-

TABLE 1 TABLE OF FORMATIONS FOR THE BENNY AREA.

	Approximate Radiometric Age (millions of years)
PHANEROZOIC	
CENOZOIC	
QUATERNARY	
RECENT	
Swamp, lake, and stream deposits	
PLEISTOCENE	
Gravel, sand, silt, clay	
CONTINENTAL GLACIATION	1.0 to 0.1
UNCONFORMITY	
PRECAMBRIAN	
LATE PRECAMBRIAN	
MAFIC INTRUSIVE ROCKS	
Diabase, olivine diabase	1,250
INTRUSIVE CONTACT	
MIDDLE PRECAMBRIAN	
SUDBURY NICKEL IRRUPTIVE (FOY OFFSET) Quartz diorite, metagabbro	1,840 (?)
LAMPROPHYRE AND BRECCIA	
Lamprophyre, lamprophyric breccia, pseudotachylite breccia (Sudbury type)	
INTRUSIVE CONTACT	
LOW RANK REGIONAL METAMORPHISM AND DEFORMATION *(Penokean-Hudsonian Orogeny)*	
NIPISSING DIABASE	
Pyroxene gabbro, hornblende metagabbro, granophyric metagabbro, granophyre	2,150
INTRUSIVE CONTACT	
HURONIAN SUPERGROUP	
COBALT GROUP	
Lorrain Formation	
Feldspathic sandstone, arkose, micaceous pebbly sandstone, hematitic sandstone, quartz sandstone, quartz and jasper pebble conglomerate, siltstone	
Gowganda Formation	
Polymictic paraconglomerate, polymictic orthoconglomerate quartz-feldspar sandstone, wacke, siltstone, laminated siltstone, sandstone-siltstone slump breccia	
LOCAL DISCONFORMITY	
QUIRKE LAKE GROUP	
Serpent Formation	
Quartz-feldspar sandstone, hematitic sandstone, siltstone, wacke, conglomerate, conglomeratic sandstone, calcareous sandstone	
Espanola Formation	
Limestone, dolostone, dolomitic limestone, siltstone, calcareous siltstone, sandstone, calcareous sandstone, scapolite and diopside-wollastonite hornfels	

Table 1 continued

Bruce Formation	
Conglomerate, sandstone, siltstone	
HOUGH LAKE GROUP	
Mississagi Formation	
Quartz-feldspar sandstone, conglomerate	
UNCONFORMITY	
EARLY PRECAMBRIAN (ARCHEAN)	
LATE MAFIC INTRUSIVE ROCKS	
Metagabbro, porphyritic metagabbro, granophyric metagabbro, composite intrusions of granodiorite, syenodiorite, gabbro, and feldspathic pyroxenite	2,500 ± 100
INTRUSIVE CONTACT	
FELSIC INTRUSIVE AND METAMORPHIC ROCKS	
MASSIVE FELSIC INTRUSIVE ROCKS	
Fine- to medium-grained quartz monzonite, porphyritic leucocratic quartz monzonite, coarse grained quartz monzonite, porphyritic biotitic quartz monzonite, pegmatite, aplite	2,500 ± 100
INTRUSIVE CONTACT	
REGIONAL METAMORPHISM AND DEFORMATION (KENORAN OROGENY)	
FOLIATED, FELSIC, PLUTONIC, AND MIGMATITIC ROCKS	
Gneissic and foliated trondhjemite, granodiorite, augen gneiss, xenolithic agmatitic trondhjemite and granodiorite, leucocratic migmatitic orthogneiss, paragneiss, mafic migmatitic orthogneiss	
INTRUSIVE CONTACT	
MAFIC INTRUSIVE ROCKS	
Gneissic metagabbro sills and dikes	
INTRUSIVE CONTACT	
METAVOLCANICS AND METASEDIMENTS	
METASEDIMENTS	
Tuffaceous wacke, siltstone, quartz-feldspar sandstone, schistose, micaceous, chloritic, metasediments, tuff, graphitic siltstone, graphitic schist, chert, siliceous metasediments, tuff, oxide facies iron formation	
METAVOLCANICS	
Felsic Metavolcanics	
Rhyolite, porphyritic rhyolite, dacite, porphyritic dacite, tuff, lapilli-tuff, crystal tuff	
Intermediate Metavolcanics	
Tuff-breccia, lapilli-tuff, tuff	
Mafic Metavolcanics	
Basalt, andesite, pillowed basalt and andesite, amygdaloidal basalt and andesite, mafic tuff	

mately 2.4 km, a maximum width of 4.8 km, and is more than 38 km long. The metavolcanics extend beyond the western boundary of the map-area. In the eastern part of the map-area, where they are highly metamorphosed and extensively invaded by granitic rocks, the metavolcanics pass gradationally into migmatitic rocks consisting of variable proportions of granitic material and remnants of altered metavolcanics. Similar migmatitic rocks are developed along the northern margin of the Benny Belt in the west. Reconnaissance mapping indicates that the Benny Belt essentially ends at a northwest trending lineament, probably marking a major fault, several kilometres west of the western boundary of the area (Card and Lumbers 1977).

The metavolcanic sequence is bordered on the north and south by Early Precambrian granitic rocks, both older foliated migmatitic, gneissic, and plutonic rocks of granodiorite-trondhjemite composition and younger, massive quartz monzonite plutons. The younger, massive granitic rocks clearly intrude the metavolcanics. The contacts between the metavolcanics and the foliated granodiorite-trondhjemite plutonic rocks are generally sheared and are consequently not diagnostic of the relative ages of the two rock groups. At two localities, one in northwestern Craig Township about 0.8 km east of Bluewater Lake, and the other in southwestern Ulster Township immediately north of the Canadian Pacific Railway at Stralak, the contact between the metavolcanics and foliated granitic rocks may represent an unconformity. At both localities, a unit of coarse clastic debris 3 to 5 m thick lies between the granitic rocks and the mafic to intermediate metavolcanics. These metasediments are coarse, poorly sorted, and consist of angular to rounded grains of quartz, feldspars, and granitic rock fragments in a chloritic matrix with some carbonate. This material, unlike the overlying pyroclastic rocks, was apparently derived from the weathering of the adjacent granitic rocks prior to the deposition of the metavolcanics. If this interpretation is correct, the foliated granitic rocks at these localities represent remnants of the basement upon which the Benny metavolcanic sequence was deposited. An alternative interpretation is that the clastic units represent some type of breccia.

At several localities, notably in northeastern Moncrieff Township, the Early Precambrian metavolcanics are unconformably overlain by Middle Precambrian rocks of the Huronian Supergroup. In most localities, however, faults constitute the contacts between the two rock groups.

The Benny Belt represents a large preserved remnant of a formerly more extensive supracrustal sequence. Similar, though smaller, remnants of metavolcanics and metasediments are abundant in an area extending eastward from Benny toward the Temagami Metavolcanic-Metasedimentary Belt. The Benny Belt probably comprises a homoclinal sequence that faces south. Primary stratification and secondary stratiform foliation in the rocks are, for the most part, approximately concordant, strike east, and dip steeply north and south. Only a few relatively poor indicators of facing directions were obtained. These include determinations from one pillow top, one flow-top breccia, and several graded pyroclastic units.

The rocks of the Benny Belt have been metamorphosed under conditions corresponding to the greenschist and amphibolite facies, and have been highly deformed. Deformation is expressed by: a penetrative, flattening-type foliation with a down-dip rodding lineation; numerous faults and minor folds; and varia-

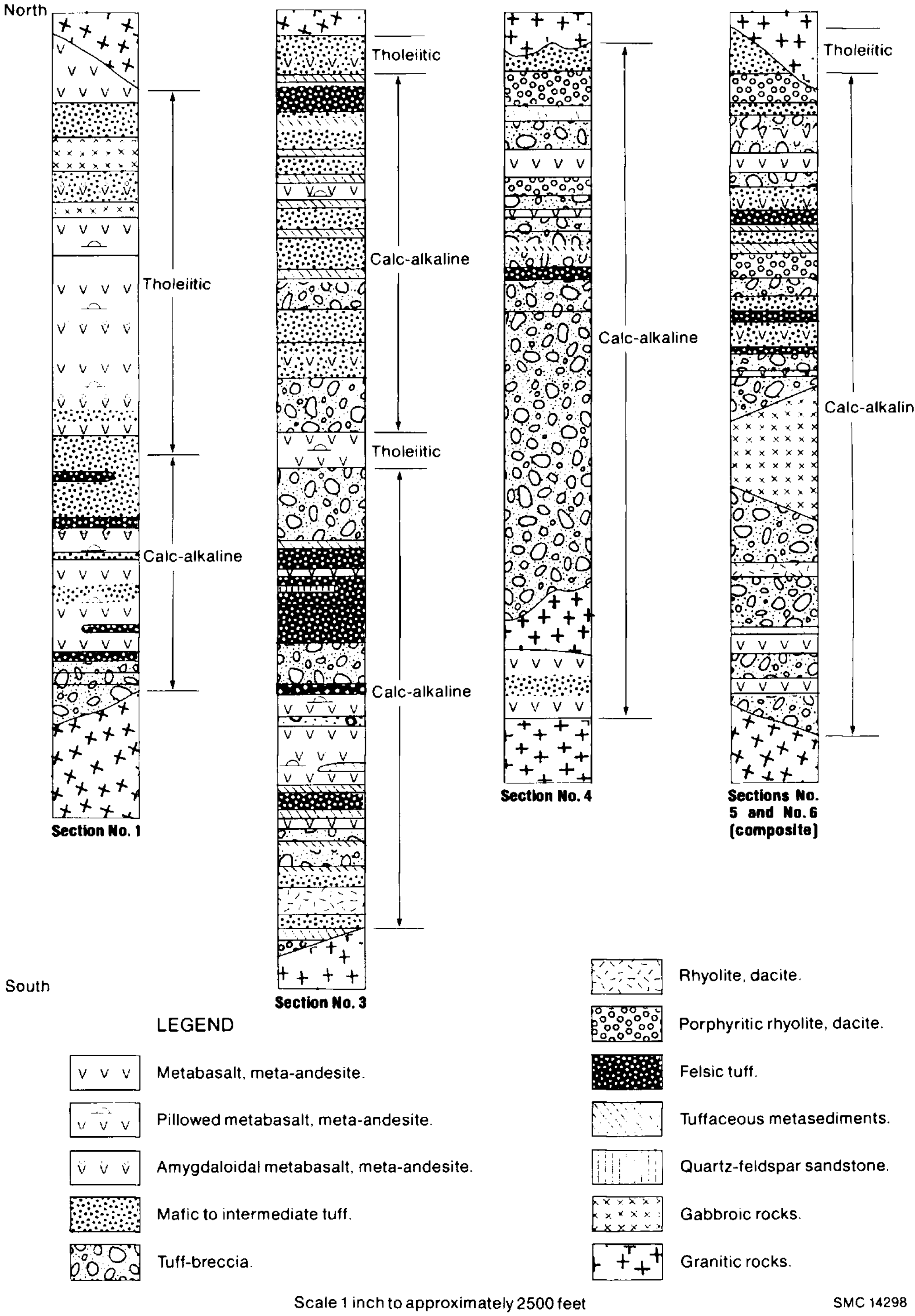


Figure 2—Generalized stratigraphic section diagrams for the Benny Metavolcanic-Metasedimentary Sequence. See Figure 19, Chart B (back pocket) for section locations. Section 2 is not plotted in this figure.

ble, though commonly extreme, flattening of pillows and rock fragments.

The Benny Belt sequence includes mafic (basalt, andesite) flows, pyroclastic rocks (tuff-breccia, lapilli-tuff, tuff) of andesite to rhyolite composition, and minor felsic (rhyolite, dacite) flows. Metasediments present include wacke, siltstone, quartz-feldspar sandstone, chert, graphitic and sulphide-rich metasediments, and oxide facies iron formation. Most of the metasediments present are interstratified with tuffs and were apparently derived directly from the metavolcanics. This, coupled with the metamorphism and intense deformation, has made it difficult to distinguish between metasedimentary and tuffaceous rocks.

The Benny metavolcanic-metasedimentary sequence displays some distinct longitudinal facies variations (Figure 2; see Figure 19, Chart B, back pocket). The western part of the belt consists mainly of tholeiitic and calc-alkaline metabasalt flows with several extensive Early Precambrian gabbroic intrusions. The central part of the belt comprises a number of cyclically repeated calc-alkaline and minor tholeiitic mafic (basalt, andesite), intermediate (andesite, dacite), and felsic (dacite, rhyolite) units with thin intercalations of metasediments and tuffs that commonly contain sulphide minerals and graphite. The sulphide-bearing units typically occur at the contacts between mafic units composed of flows and pyroclastic rocks, and felsic to intermediate units, consisting mainly of pyroclastic rocks. A typical complete cycle consists of:

(1) A lower unit of mafic metavolcanics, consisting mainly of basaltic to andesitic flows and pyroclastic rocks.

(2) A middle unit of metasediments and tuffs; commonly has graphite and stratabound sulphide concentrations, mainly pyrite and pyrrhotite, but locally also including sphalerite, galena, and chalcopyrite.

(3) An upper unit of intermediate to felsic pyroclastic rocks.

In the central part of the Benny Belt there are six to eight such cycles each of which ranges in thickness from about 150 m to over 300 m.

The eastern part of the belt consists mainly of coarse pyroclastic rocks, tuff-breccia, and lapilli-tuff of calc-alkaline andesite to rhyolite composition.

Several mafic-felsic cycles containing sulphide and graphite-bearing metasediment-tuff units occur in the northern part of the central and eastern parts of the belt and are similar to those further west.

Chemical analyses show that most of the metavolcanics belong to the calc-alkaline suite and that in terms of their alkali content, these rocks are normal to sodic. Tholeiitic metavolcanics are present mainly in the northwest. If the structural interpretation outlined earlier is correct, these rocks would represent the lowest preserved part of the sequence. Although only a relatively small remnant of a larger belt, the Benny Belt, displays many of the chemical and stratigraphic features shown by some of the larger Early Precambrian metavolcanic-metasedimentary belts of the Canadian Shield.

METAVOLCANICS

Mafic Metavolcanics

Mafic metavolcanics, including metamorphosed basalt and andesite flows and pyroclastic rocks, occur throughout the metavolcanic-metasedimentary sequence, but are most abundant in the western and northern parts of the Benny Belt. The map-units of mafic metavolcanics range in thickness from approximately 100 to over 600 m in the west and north, and from 30 to 300 m in the eastern and southern parts of the belt. Each of these map-units consists of a number of flows and pyroclastic members. For the most part, deformation has obliterated the contacts between individual flows making it impossible to estimate their thickness. In a few localities, such as around Marion Lake, and around the small ponds 1.5 km south of Marion Lake in Moncrieff Township, however, contacts are discernible, and here, individual flows are 0.5 to 7.5 m thick. Mafic flows in the west in Craig Township are thicker, and probably vary from 30 to 60 m thick.

Most of the mafic flows are massive, although pillowed, porphyritic, and amygdaloidal varieties are present. Pillows, because of the deformation, are difficult to recognize except in large, well exposed outcrops and may be more prevalent than is indicated on Maps 2434 and 2435 (back pocket). The mafic flow rocks are dark grey, greenish black, and black. These rocks are fine grained (0.1 to 1 mm; average 0.2 mm), foliated, and consist of a mozaic of metamorphic amphibole and plagioclase with lesser amounts of quartz, biotite, chlorite, epidote, iron oxides, sulphides, sphene, and carbonate (Table 2, Chart C, back pocket). Amphibole and biotite generally compose 50 to 60 percent of the rock by volume and are oriented so as to define the prominent tectonic foliation. The amphibole, either blue-green hornblende or actinolite depending on metamorphic grade, forms anhedral to subhedral, ragged poikiloblasts. The plagioclase, originally a calcic variety, is largely saussuritized and ranges in composition from about An_5 to An_{35}. Carbonate, epidote, chlorite, and quartz commonly form veinlets as well as part of the groundmass.

Amygdaloidal basalt and andesite contain light-coloured clots 1 to 10 mm in diameter composed of variable proportions of quartz, plagioclase, and epidote with minor amounts of amphibole, chlorite, and carbonate. Porphyritic mafic flows contain scattered plagioclase crystals 1 to 5 mm in length. The pillowed flows display flattened, elliptical pillows ranging from 0.5 to 2 m in length and 5 cm to 0.5 m in width (Photo 1). The pillow selvages, which commonly display a brownish recessively weathering surface, are 1 to 5 cm thick. Some pillows contain amygdules that are concentrated in concentric zones toward the outer margins. Pillows in the mafic flows south of Marion Lake, Moncrieff Township, and in Gilbert Township contain light-coloured, recessively weathered cores rich in plagioclase and epidote (Photo 2).

The mafic pyroclastic rocks are fine- to medium-grained (0.05 to 5 cm) dark grey to greenish black, foliated rocks. Deformation has made it difficult to distinguish between mafic flows and pyroclastic rocks, but in the field, rocks were mapped as pyroclastic rocks if a fragmental texture or layering could be dis-

OGS 10 141

Photo 1–Pillowed metabasalt, northeastern Craig Township. Note the recessively-weathered epidote-rich cores in many of the pillows.

OGS 10 142

Photo 2–Deformed pillows in metabasalt, Gilbert Township.

cerned. Layering appears as thin (1 mm to several cm) alternating lighter and darker coloured laminae, which are a reflection of variations in mineral composition and grain size. Lensoid blebs of quartz and quartz with epidote are also common in the mafic pyroclastic rocks.

The mafic pyroclastic rocks are mineralogically and chemically similar to their flow counterparts and consist of a foliated mozaic of amphiboles, plagioclase, and quartz, with lesser amounts of epidote, chlorite, biotite, carbonate, sphene, apatite, iron oxides, and sulphides. Most of the analyzed mafic metavolcanics from the western and northern parts of the Benny Belt are tholeiitic, whereas those from the central, southern, and eastern parts of the belt are calc-alkaline (Table 3, Chart D, back pocket; see Figures 6 and 7).

Intermediate Metavolcanics

Pyroclastic rocks of andesitic and dacitic composition, including tuff-breccia, lapilli-tuff, and tuff, occur throughout the metavolcanic-metasedimentary sequence, but are most abundant in the southern and eastern parts of the Benny Belt. Tuff-breccia comprises a major proportion of the eastern half of the Benny Belt. For example, along Highway 144 in Moncrieff Township, there is a sequence some 1200 m thick which consists mainly of coarse tuff-breccia with intercalations of lapilli-tuff and tuff.

Tuff-Breccia

The tuff-breccia is crudely stratified with individual units ranging in thickness from 0.3 to 15 m. Stratification is defined by variations in fragment size, fragment composition, degree of flattening of fragments, and packing (see Figure 2). Some units display crude grading with decreasing fragment size and fragment/matrix ratio from bottom to top. The tuff-breccia consists of flattened rock fragments in a fragmental-matrix (Photo 3). The amount of fragments ranges from about 40 percent to 90 percent and commonly averages 70 percent. Fragments range in maximum dimension from 2 cm to about 0.6 m; most are 5 to 15 cm. There are variations in fragment compositions from one stratification unit to another; some units consist of about 70 percent felsic and intermediate volcanic fragments; other units consist of over 90 percent mafic fragments. The fragments are flattened. There are variations in the degree of flattening from one fragment type to another and from one stratification unit to another. Mafic fragments are commonly more flattened than adjacent felsic fragments. Axial ratios of flattened fragments, that is the ratio of the longest dimension in the plane of the foliation to the shortest dimension normal to this plane, range from about 2:1 to 20:1; commonly this ratio is about 3:1.

Some of this deformation is obviously of tectonic origin since the fragments are flattened and oriented within the tectonic foliation. Relatively great variations, however, occur in the degree of flattening from one stratification unit to another. Occasionally these are over distances of a few metres; probably some

Photo 3–Tuff-breccia, northeastern Craig Township.

of the flattening is due to primary welding (Photos 4 and 5). In some units, the boundaries between individual fragments or between fragments and matrix are indistinct, giving the rock a blotchy, diffuse, "salt and pepper" texture. This is possibly also due to welding. Some of the mafic fragments retain vestiges of an original scoriaceous texture, whereas others have the streamlined shapes and fine-grained rims indicative of bombs. Some felsic fragments have ragged outlines and sharp tails suggesting an eutaxitic structure.

The mafic fragments are fine-grained dark grey to black metabasalt and meta-andesite rich in amphiboles, plagioclase, biotite, and chlorite. The intermediate and felsic fragments are fine- to medium-grained light grey, buff, and pink, and include rhyolite, dacite, porphyritic rhyolite and dacite, and crystal tuff rich in quartz and feldspars. A very few fragments of coarser granitic rocks are present locally.

The sparse fragmental matrix is coarse, unsorted, and consists of ash, and rock and mineral fragments up to several mm in maximum dimension. It is composed of amphiboles, biotite, chlorite, quartz, feldspars, and epidote with minor white micas, carbonate, sphene, iron oxides, and sulphides. Veinlets of quartz, chlorite, epidote, and carbonate are common.

Garnet porphyroblasts are developed in the tuff-breccia in several localities. Elongate minerals such as biotite and amphibole are preferentially oriented within the foliation plane. The plagioclase ranges in composition from albite to andesine.


OGS 10 144

Photo 4–Tuff-breccia, north-central Craig Township. Note the relatively undeformed nature of the rock.

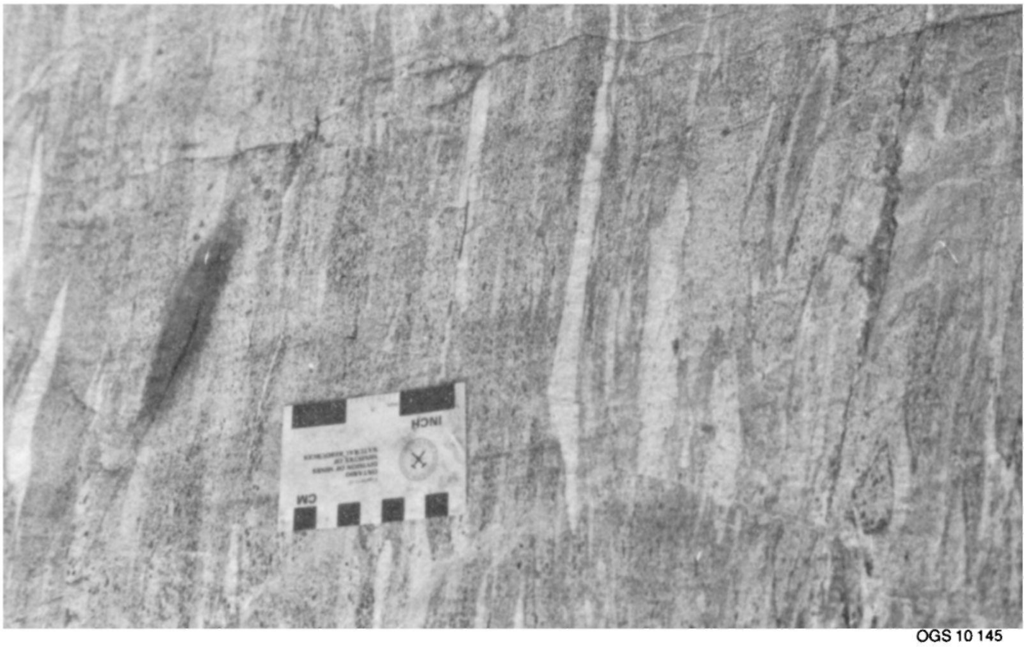

OGS 10 145

Photo 5–Deformed tuff-breccia, north-central Craig Township. Note the high degree of flattening and alignment of the fragments. Photograph 5 was taken approximately 1 m from Photo 4.

Chemical analyses of tuff-breccia samples show that the rock is andesitic in bulk composition; most samples analysed are calc-alkaline, high-alumina andesites (see Table 3).

Lapilli-Tuff

Lapilli-tuff units occur throughout the sequence, and are interstratified with tuff-breccia and mafic to felsic volcanic rocks. The main concentration of lapilli-tuff occurs in the eastern half of the Benny Belt both east and west of the main centre of accumulation of tuff-breccia in northeastern Moncrieff Township. Lapilli-tuff probably represents the lateral facies equivalents of the coarser tuff-breccia deposited further away from the main centre of explosive volcanic activity.

The lapilli-tuff is a layered, commonly laminated, grey to buff fragmental rock composed of flattened volcanic lapilli and crystals of quartz and feldspar in a tuffaceous matrix. Layering ranges in thickness from about 1 to 20 cm; laminations are commonly 1 to 10 mm thick. The lapilli are generally less than 3 cm in maximum dimension, although scattered fragments up to 10 cm in length are common. Lapilli compose approximately 70 percent of the rock and include felsic, intermediate, and mafic rock types. The matrix is poorly sorted and coarse with abundant rock and mineral fragments 1 to 3 mm in length with finer grained interstitial material. Quartz crystals, commonly deformed into elliptical "eyes" are abundant in some units.

Lapilli-tuff is mineralogically and texturally similar to the coarser tuff-breccia with which it is associated, but the lapilli-tuff is generally richer in felsic fragments and quartz.

The chemically analyzed lapilli-tuffs are mainly calc-alkaline, high-alumina andesites and dacites (see Table 3).

Tuff

Fine-grained intermediate tuff occurs as minor units interstratified with mafic metavolcanics, metasediments, lapilli-tuff, and tuff-breccia. One of the thicker units of intermediate tuff is exposed at the junction of Highway 144 and the Benny road in northern Moncrieff Township and can be traced for several kilometres east and west of this location. Other tuff units are thin and discontinuous.

The tuff is a thin-bedded, laminated dark grey to white rock. Layering ranges in thickness from less than 1 to 10 cm and averages about 2 cm. The laminations are generally less than 1 mm thick. The grain size ranges from less than 0.01 to about 1 mm, and is generally less than 0.05 mm. The rock consists of quartz, plagioclase, biotite, chlorite, white micas, epidote, iron oxides, and sulphides. Large chlorite porphyroblasts are locally present, these occur for example at the junction of Highway 144 and the Benny road. Some intermediate tuff units contain stratiform concentrations of sulphide minerals; these are mainly pyrite and pyrrhotite. A chemical analysis of intermediate tuff shows that it is a high-alumina calc-alkaline dacite (see Table 3).

Felsic Metavolcanics

Rhyolite and dacite, mainly pyroclastic rocks with lesser amounts of felsic flows, occur throughout the Benny Belt. These rocks are most abundant in the east part of the map-area. In the area west of the Spanish River, felsic metavolcanics are mainly in the south where they are intercalated with intermediate and mafic metavolcanics. East of the Spanish River, these rocks occur throughout the succession and are interstratified with intermediate and mafic metavolcanics and metasediments, and form the upper parts of the mafic to felsic metavolcanic cycles. These rocks form discrete stratigraphic units up to 150 m thick, but are generally less than 50 m.

Felsic Pyroclastic Rocks

Felsic pyroclastic rocks, including lapilli-tuff and crystal tuff, are light grey, white, and pinkish fragmental rocks composed of variable proportions of volcanic rock fragments and crystals set in a tuffaceous matrix. These rocks are thin bedded, 1 to 30 cm thick, generally 1 to 5 cm thick, and are laminated.

The lapilli, mainly of felsic composition, are flattened, generally less than 2 cm in length, and consist of fine-grained polygranular aggregates of quartz and feldspars. Some are fine-grained porphyry fragments. Crystals of quartz and plagioclase 1 to 5 mm in diameter are prevalent. Some coarser felsic fragmental units consist of close-packed, angular felsic fragments 2 to 5 cm in length set in a groundmass of similar composition. These could represent felsic flow breccias or welded felsic pyroclastic rocks.

The matrix is fine grained (0.01 to 0.1 mm) and rich in quartz, feldspars, and micas. Some fine-grained fragmental scoriaceous material is also present.

The felsic pyroclastic rocks consist mainly of quartz and alkali feldspars with lesser amounts of white mica, biotite, chlorite, amphibole, epidote, carbonate, sphene, iron-titanium oxides, and sulphides. Some units contain stratiform concentrations of sulphides which are mainly pyrite and pyrrhotite. Garnet porphyroblasts are locally present. Chemically, most of the felsic pyroclastic rocks analyzed are calc-alkaline rhyolite and dacite; one sample is a sodic trachyte (see Table 3).

Rhyolite and Dacite

Fine grained, relatively massive units of volcanic rocks of rhyolitic to dacitic composition probably represent felsic flows. A few units have recognizable phenocrysts of quartz and feldspars; others have flow layering and large segregations of quartz which may represent spherulites.

The felsic volcanic rocks are fine grained (0.02 to 0.1 mm), light grey, cream, and pinkish, and are composed mainly of quartz and feldspars with minor amounts of white micas, biotite, chlorite, epidote, carbonate, iron oxides, and sulphides. The porphyritic varieties contain quartz and feldspar phenocrysts as much as 2 mm in maximum dimension.

Chemical analyses of typical felsic flow rocks given in Table 2 (Chart C, back pocket) show that they are calc-alkaline rhyolites and dacites.

METASEDIMENTS

Metasediments, including metamorphosed wacke, siltstone, graphitic siltstone, chert, and their schistose equivalents occur throughout the Benny Belt. These rocks commonly contain stratabound, stratiform concentrations of sulphides which consist mainly of pyrite and pyrrhotite, which locally also contain sphalerite, galena, and chalcopyrite. In addition, there are minor amounts of quartz-feldspar sandstone and one unit of oxide facies iron formation.

The metasediments are interbedded with tuff, and for the most part, the dominantly metasedimentary units, shown on Maps 2434, 2435, back pocket, consist of mixtures of schistose, pyritic, and graphitic metasediments and tuff. Most of the metasedimentary material was probably derived from the volcanic rocks and from volcanic exhalative processes. This, coupled with deformation and metamorphism, makes it difficult to distinguish between metasediments and tuffs.

The metasedimentary units are generally less than 60 m thick, and most are only 15 to 30 m thick. Many can be traced over distances in excess of 3 km along strike. West of the Spanish River, the metasediments are concentrated in the southern half of the Benny Belt. East of the Spanish River, they occur throughout the sequence and form parts of the volcanic cycles described previously.

In detail, the stratigraphy of the metasedimentary members is complex as is shown by the following description of a section upward through one of these units in Craig Township east of the Spanish River:

0(North) - Mafic and intermediate metavolcanics;
0-1.2 m - White, pyritic metamorphosed chert;
1.2-6.0 m- Grey, siliceous siltstone with minor pyrite;
6.0-15.0 m - Black, graphitic, pyritic siltstone;
15.0-27.0 m - Grey, siliceous, fine-grained wacke or tuff with minor, disseminated pyrite;
27.0-30.0 m - White, pyritic meta-chert with massive sulphide (pyrite, pyrrhotite) lenses up to 45 cm thick;
30.0-36.0 m - Dark grey cherty siltstone with 5 percent sulphides (pyrite, pyrrhotite);
36.0-37.5 m - White meta-chert with minor pyrite;
37.5-42 m - Greenish grey cherty siltstone or tuff with 5 percent pyrite;
42.0 m South - Felsic pyroclastic rocks and flows.

Siltstone, wacke, and the schistose, micaceous, and chloritic metamorphic equivalents of these rocks are fine- to medium-grained, dark grey rocks. The rocks are thinly bedded, generally less than 5 cm thick, and are commonly laminated.

Siltstone consists of fine-grained (generally less than 0.05 mm) quartz, feldspar, biotite, chlorite, muscovite, epidote, sphene, iron oxides, and sulphides.

Wacke is poorly sorted and fine grained, most clastic grains are less than 0.3 mm in size, but the rock also contains scattered mineral and rock fragments up to 2 or 3 mm in maximum dimension. Wacke is mineralogically similar to siltstone, but commonly also contains rock fragments, chiefly chert, and fine-grained metavolcanics.

Siltstone, wacke, and their schistose equivalents contain sulphide minerals in the form of stratabound disseminations, massive lenses, and veinlets. These sulphides are chiefly pyrite and pyrrhotite, but locally, sphalerite, galena, and chalcopyrite, are present. Some units contain up to 10 percent disseminated graphite.

Siliceous metasediments, as well as metamorphosed chert, and muscovitic and chloritic quartz-rich schists are white to light grey rocks consisting mainly of quartz with variable amounts of muscovite, chlorite, biotite, epidote, carbonate, and opaque minerals. These rocks are fine grained and laminated with alternating quartzose and micaceous or chloritic laminae ranging in thickness from 1 mm to 2 cm. Sulphide minerals, in the form of stratiform disseminations and lenses and cross-cutting veinlets, are prevalent.

The quartz-feldspar sandstone present in northwestern Craig Township is a brown-weathering, white, thinly bedded, 2 to 5 cm thick rock. It consists of approximately equal proportions of quartz and feldspars (plagioclase and potassic feldspar), with minor amounts of biotite, muscovite, chlorite, epidote, carbonate, and opaque minerals, chiefly pyrite. The rock is moderately well sorted with an average grain size of 0.1 mm and a few larger grains up to 0.3 mm.

The thin unit of iron formation in north-central Craig Township consists of alternating magnetite-rich, quartz rich, and chloritic laminae approximately 1 to 3 mm thick. It is very fine grained, and the laminae are less than 0.01 mm thick. In addition to quartz, chlorite, and magnetite, this rock contains minor amounts of epidote, sphene, and micas.

Trace element analyses of typical metasediments of the Benny Belt are given in Tables 4 and 5.

Mafic Intrusive Rocks

Metagabbro dikes, sills, and small plutons occur throughout the metavolcanic-metasedimentary sequence, and like their host rocks, are metamorphosed, deformed, and intruded by granitic rocks. These bodies are probably genetically related to the metavolcanics and represent synvolcanic intrusions and possibly, feeder dikes. Many of these intrusions are too small to be shown on the maps due to the scale of mapping used during the survey. The larger intrusions are confined to the northwestern and north-central parts of the Benny Belt where they are associated with, and apparently interfinger with, thick me-

TABLE 4 CHEMICAL ANALYSES OF EARLY PRECAMBRIAN METASEDIMENTS, BENNY AREA. CHEMICAL ANALYSES BY GEOSCIENCE LABORATORIES, ONTARIO GEOLOGICAL SURVEY.

Sample Number	97	98	99	100
	Major Components in Weight Percent			
SiO_2	62.7	55.0	50.0	52.7
Al_2O_3	20.2	10.8	16.2	11.2
Fe_2O_3	0.17	17.3	10.7	18.6
FeO	1.54	—	—	—
MgO	1.02	0.85	1.40	1.45
CaO	6.08	1.68	<0.01	1.30
Na_2O	3.70	4.24	5.85	3.02
K_2O	2.12	0.68	1.35	1.33
TiO_2	1.07	0.61	0.46	0.13
P_2O_5	0.07	0.06	0.04	0.02
S	0.03	9.94	4.78	11.10
MnO	0.05	0.06	0.04	0.34
CO_2	0.15	1.85	0.30	0.10
H_2O^+	0.79	1.25	1.34	3.71
H_2O^-	0.41	0.29	0.52	0.42
C	—	—	8.23	—
Total	100.1			
S.G.	2.66			
	Trace Elements in Parts Per Million (PPM)			
Ag	<1	<1	<1	29
Ba	580	120	120	2
Be	<1	<1	<1	2
Co	25	55	65	15
Cr	150	15	90	9
Cu	30	40	310	1100
Ga	35	15	25	10
Li	60	10	35	15
Mo	<1	3	20	2
Ni	45	65	200	15
Pb	110	30	50	880
Sc	40	8	25	<5
Sn	40	15	20	3
Sr	300	100	10	300
V	150	40	80	10
Y	25	20	10	15
Zn	45	140	25	300
Zr	150	150	30	200

Sample Descriptions

97 BC-74-131	Quartz-feldspar sandstone, northwestern Craig Tp.
98 BI-74-19	Layered cherty metasediment with sulphide.
99 BC-74-151	Graphitic siltstone, northwestern Craig Tp.
100 BC-74-233	Intermediate tuffaceous metasediment with sulphides, Lake Geneva Mine Area, Hess Tp.

Modal Analyses in Volume Percent

	BC-74-131	BI-73-205	BG-74-257	BC-74-114	BG-74-113
Quartz	45.4	74.4	22.8	19.4	38.0
Plagioclase	41.1	10.9	68.0	30.4	46.6
Potassic Feldspar		2.3			

Table 4 continued

	BC-74-131	BI-73-205	BG-74-257	BC-74-114	BG-74-113
Biotite	6.1		4.4		11.0
Chlorite	1.0	11.8			
Muscovite	4.0			29.4	
Epidote	x		1.6		3.8
Carbonate	x				
Rock Fragments				20.8	
Iron Oxides	0.2	0.6		x	0.6
Sulphides	x	x	3.2		x
Sphene	x				
Graphite		x			

Sample Descriptions

BC-74-131	Quartz-feldspar sandstone, northwestern Craig Township.
BI-73-205	Tuffaceous metasediment, Moncrieff Township.
BG-74-257	Pyritic metasediment, Hess Township.
BC-74-114	Coarse clastic metasediment ("basal rubble"), Craig Township.
BG-74-113	Tuffaceous metasediment, Craig Township.

Abbreviations

S.G.	Specific Gravity
x	Present in minor amounts.

tabasalt flows. These intrusions, like the associated flows, are tholeiitic.

The mafic intrusive rocks are dark grey to black, fine- to coarse-grained (0.2 - 5 mm), foliated, homogeneous rocks consisting essentially of amphibole and plagioclase with minor quartz, chlorite, epidote, sphene, and iron oxides. The amphibole, blue-green hornblende, commonly forms oriented porphyroblasts up to 5 mm in length. The plagioclase, originally a calcic variety (labradorite), is saussuritized.

Chemical and modal analyses of typical specimens are given in Table 6.

TABLE 5 TRACE ELEMENT ANALYSES OF EARLY PRECAMBRIAN METASEDIMENTARY AND TUFFACEOUS ROCKS, BENNY AREA.

Sample Number	69	70	71	72	73	74	75	76	77	78	79	80	81	82
	Trace Elements in Parts per Million (PPM) (except where otherwise indicated)													
Ag	1	1	1	60	1	1	1	1	1	2	30	35	70	1
Co	51	38	21	271	19	22	20	32	57	48	37	99	300	21
Cr	44	95	84	18	42	92	82	78	7	8	5	30	5	42
Cu	330	250	163	1950	210	181	260	370	70	160	1.66%	300	1.13%	220
Ga	20	10	20	20	30	25	25	25	4	30	35	30	7	30
Li	16	12	8	12	18	22	10	6	2	64	11	4	7	44
Mn	360	560	920	590	570	780	1260	920	12	54	780	670	510	900
Mo	7	4	1	20	1	5	1	1	9	1	1	4	20	1
Ni	91	79	50	18	31	48	41	31	94	10	12	124	62	33
Pb	30	782	28	1364	136	95	94	135	55	171	455	1.09%	5090	162
Sc	20	20	30	5	25	30	30	25	5	10	9	9	5	20
Sn	25	25	20	30	20	30	20	10	40	40	70	45	35	15
Sr	150	200	150	100	200	200	250	250	10	10	1500	100	100	150
V	90	100	150	20	100	150	150	150	15	30	80	50	20	150
Y	25	25	20	10	35	30	25	30	10	10	30	15	10	25
Zn	116	1240	104	4.76%	390	116	120	79	36	710	1.36%	5.55%	5.60%	500
Zr	150	150	100	80	200	200	150	250	80	300	500	100	60	200
Ba	120	140	190	60	180	120	340	330	80	120	70	140	60	220

Sample Number	83	84	85	86	87	88	89	90	91	92	93	94	95	96
	Trace Elements in Parts per Million (PPM)													
Ag	1	1	1	1	1	1	120	1	1	1	1	1	1	1
Co	11	44	19	102	283	78	88	22	104	50	22	26	168	78
Cr	82	70	87	14	43	96	40	36	3	16	58	8	26	285
Cu	137	250	200	65	150	950	3105	210	59	490	145	180	1550	300
Ga	25	25	30	6	30	25	35	20	5	3	20	25	15	10
Li	10	7	42	4	42	6	28	10	2	6	30	17	42	9

Table 5 continued

Sample Number	83	84	85	86	87	88	89	90	91	92	93	94	95	96
Mn	500	580	640	68	1050	1360	710	320	38	770	2600	1070	270	1070
Mo	1	4	1	15	8	4	5	2	9	6	1	1	2	2
Ni	31	70	63	29	106	122	44	37	67	240	40	29	160	129
Pb	86	137	155	5	42	105	6180	159	21	71	169	127	79	122
Sc	25	20	25	5	10	15	10	15	5	5	30	30	8	20
Sn	15	25	20	30	15	40	130	20	35	15	20	20	25	20
Sr	150	100	250	10	100	150	30	150	60	10	300	200	60	300
V	150	100	150	30	80	70	40	60	25	20	150	200	50	100
Y	15	20	25	10	20	15	25	25	10	10	15	40	10	10
Zn	132	90	102	57	106	1800	12.2%	400	49	98	158	124	1530	95
Zr	150	100	200	40	150	60	80	200	60	40	80	150	100	150
Ba	100	100	170	100	130	90	100	140	80	70	190	220	120	110

Sample Descriptions

69.	BI-74-12	Sulphide-bearing quartz vein in metavolcanics; S.W. portion of Ulster Tp., 305 m S. of western tip of Straight L.
70.	BC-74-21	Siliceous, pyritic metasediment; S.W. portion of Ulster Tp., 450 m N.W. of railway and southern Tp. line junction.
71.	BG-74-21	Pyritic chert; N.W. portion of Moncrieff Tp., 710 m E. of E. end of Straight L., Lot 10, Conc. 6, NW¼, N½.
72.	BI-74-13	Massive sulphides; N.E. portion of Craig Tp., 365 m N.E. of N.E. end of Capper L., Lot 1, Conc. 6, NE¼, N½.
73.	BC-74-17	Pyritic tuff metasediment; south central Ulster Tp., 1370 m W.S.W. of S.W. end of Ulster L.
74.	BC-74-27	Sulphide bearing metasediment or tuff; north-central Moncrieff Tp., 550 m S. of Ulster L., Lot 7, Conc. 6, NW¼, N½.
75.	BG-74-30	Pyritic tuff; N.W. portion of Moncrieff Tp., 365 m S.W. of eastern tip of Straight L., Lot 11, Conc. 6, NW¼, N½.
76.	BC-74-40	Pyritic chert; N.E. portion of Craig Tp., 1800 m S.E. of Spanish R.-Marion Cr., junction, Lot 1, Conc. 5, NE¼, N½.
77.	BG-74-44	Massive pyrite; N.W. portion of Moncrieff Tp., 1525 m west of Benny, Lot 8, Conc. 5, NW¼, N½.
78.	BC-74-47	Pyritic, sericite schist; N.E. portion of Craig Tp., 120 m N. of central Capper L., Lot 1, Conc. 6, NE¼, N½.
79.	BC-74-49	Sericitic rhyolite; N.E. portion of Craig Tp., 120 m N. of central Capper L., Lot 1, Conc. 6, NE¼, N½.
80.	BB-74-50	Massive sulphides; N.E. portion of Craig Tp., 610 m S.W. of western tip of Capper L., Lot 2, Conc. 6, NE¼, N½.
81.	BC-74-51	Massive sulphides; N.E. portion of Craig Tp., 120 m N. of central Capper L., Lot 1, Conc. 6, NE¼, N½.
82.	BI-74-68	Pyritic tuff, or metasediment; S.E. portion of Gilbert Tp., 1370 m W.N.W. of S.E. corner of Tp.
83.	BC-74-84	Pyritic chert; N.E. portion of Craig Tp., 1100 m E.N.E. of Spanish-Mogo R. junction, Lot 2, Conc. 5, NE¼, N½.

Table 5 - continued on next page.

Table 5 continued

84. BC-74-89	Intermediate tuff; N.E. portion of Craig Tp., 915 m N.E. of Spanish-Mogo R. junction, Lot 2, Conc. 5, NE¼, N½.
85. BC-74-93	Pyritic chert; N.E. portion of Craig Tp., 1435 m S.E. of Spanish R.-Marion Cr., Lot 2, Conc. 6, NE¼, N½.
86. BC-74-97	Massive pyrite; N.E. portion of Craig Tp., 1435 m S.E. of Spanish R.-Marion Cr. junction, Lot 2, Conc. 6, NE¼, N½.
87. BI-74-103	Pyritic tuff; N.E. portion of Moncrieff Tp., 2195 m N.E. of Benny, N. of road, Lot 5, Conc. 6, NE¼, N½.
88. BG-74-103	Pyritic metasediment; south central Stralak Tp., 185 m E.N.E. of Kennedy L., on southern Township boundary.
89. BC-74-105	Pyritic chert (sulphide); N.E. portion of Craig Tp., 760 m W.S.W. of western tip of Capper L., Lot 2, Conc. 6, NE¼, N½.
90. BC-74-108	Pyritic chert; N.E. portion of Craig Tp., 760 m W.S.W. of western tip of Capper L., Lot 2, Conc. 6, NE¼, N½.
91. BI-74-118	Massive sulphides; north central Moncrieff Tp., 915 m N.E. of Benny, Lot 6, Conc. 6, NE¼, N½.
92. BC-74-124	Massive sulphides; 2045 m E.N.E. of Kennedy-Bluewater L. narrows, Lot 7, Conc. 6, NW¼, N½, Craig Tp.
93. BC-74-125	Pyritic chert; 2045 m E.N.E. of Kennedy-Bluewater L. narrows, Lot 7, Conc. 6, NW¼, N½, Craig Tp.
94. BC-74-153	Pyritic chert; northwest corner of Craig Tp.
95. BC-74-180	Pyritic chert; 1710 m N.W. of S.E. Tp. corner, S.E. portion of Gilbert Tp.
96. BC-74-200	Pyritic chert; 1680 m N.E. of Benny, north central Moncrieff Tp., Lot 6, Conc. 6, NE¼, N½.

Note: Chemical analyses by Geoscience Laboratories, Ontario Geological Survey.

Geochemistry of the Metavolcanics and Metasediments

Chemical analyses of samples of metavolcanics and associated metamorphosed intrusions that occur in the map-area are given in Tables 2, 3, 4, 5, and 6. Sixty-eight samples were analyzed by the Geoscience Laboratories, Ontario Geological Survey, for 14 major oxides and as many as eleven minor elements. The major components, SiO_2,Al_2O_3, total Fe, MgO, CaO, Na_2O, K_2O, TiO_2, P_2O_5, and MnO were analyzed by an X-ray fluorescence spectrometer using glass pellets prepared by fusion with lithium tetraborate flux. The following components were determined by rapid wet chemical methods, H_2O, CO_2 and S (also some P_2O_5). The trace elements were determined by spectrographic and atomic methods. Values for Ba, Co, Cr, Cu, Ni, Pb, Sr, V, Y, and Zr are considered accurate to within 15 percent, and Zn to within 20 percent. All chemical analyses contained in this report are given in weight percent unless otherwise stated.

Cation (molecular) norms are presented in the tables and were calculated using a computer programme developed by the Geoscience Laboratories, Ontario Geological Survey.

Duplicate samples were submitted to the Geoscience Laboratories, Ontario Geological Survey, for control purposes. Duplicate analyses failed to show any significant discrepancies in the analytical data presented herein.

ALTERATION

Volcanic rocks in the map-area have been affected by prograde and retrograde metamorphism and metasomatic processes. In addition, alteration due to recent weathering and hydrothermal activity is evident.

Most of the volcanic rocks have undergone lower amphibolite facies metamorphism. Local areas near Highway 144 and at the southwest end of the Benny Belt have undergone mid- to upper-greenschist facies metamorphism. Geochemical changes due to this metamorphism have undoubtedly occurred. Hydration and carbonatization processes suggest a fluid phase existed which probably involved major oxide components. J.R. Cann (1971) suggested that such metamorphism has probably only caused minor bulk introduction or removal of elements from rocks, although migration of elements under one or more sets of conditions may have taken place.

Local redistribution of some elements is probably reflected by scatter in some of the classification and variation diagrams. The elements Ca, Fe, Na, K, Mg, and Si have been mobile in the lavas and pyroclastic rocks as is shown by the presence of epidote, blue and brown chlorite, quartz, opaque minerals, and minor carbonate as fracture fillings, in amygdules, and by the breakdown of the feldspars and ferrosilicates. Local areas, especially in the vicinity of the Geneva Lake Mine, show an intense patchy and veined network of epidotization. There is also evidence of minor hornfels-type alteration marginal to most intrusive rocks within the belt.

Strongly foliated rocks were mainly not analyzed in order to minimize the masking of original chemistry by metamorphic readjustments. Also, rocks ex-

TABLE 6 CHEMICAL ANALYSES, NORMS AND MODAL ANALYSES OF MAFIC INTRUSIVE ROCKS, BENNY AREA.

Sample Number	53	54	55	56	57	58	59	65
				Major Components in Weight Percent				
SiO_2	38.90	49.60	50.20	53.30	48.90	49.10	54.20	58.10
Al_2O_3	5.62	15.60	12.40	14.00	17.00	14.50	14.90	13.80
Fe_2O_3	1.82	3.57	2.13	1.84	1.25	2.01	0.54	3.20
FeO	10.60	7.95	10.50	8.60	7.87	11.60	9.32	4.95
MgO	12.80	7.14	5.66	5.00	8.03	6.94	4.67	4.41
CaO	15.10	10.20	9.80	11.90	12.20	9.11	10.10	5.48
Na_2O	2.16	2.94	2.35	1.94	2.92	2.67	2.19	2.91
K_2O	0.41	0.65	1.40	0.63	0.24	0.48	0.82	4.02
TiO_2	2.90	0.97	1.52	1.02	0.50	1.28	0.92	0.96
P_2O_5	0.19	0.08	0.05	0.08	0.04	0.09	0.08	0.59
S	0.20	0.00	0.06	0.08	0.01	0.05	0.05	0.02
MnO	0.45	0.21	0.23	0.17	0.17	0.24	0.17	0.14
CO_2	4.82	0.06	0.10	0.11	0.10	0.10	0.10	0.06
H_2O^+	3.42	0.92	2.18	1.35	0.95	2.10	1.22	1.29
H_2O^-	0.43	0.44	0.42	0.12	0.29	0.33	0.17	0.43
Total	99.80	100.30	99.00	100.20	100.50	100.60	99.40	100.40
S.G.	3.00	2.98	3.02	2.97	2.98	3.05	2.96	2.82
				Trace Elements in Parts per Million				
Ba	120	150	330	140	100	140	180	980
Be	6	<1	<1	<1	<1	<1	<1	4
Co	45	40	40	45	40	50	45	20
Cr	580	660	140	75	240	65	100	110
Cu	230	35	95	140	75	160	140	40
Ga	10	10	20	20	15	15	20	10
Li	15	8	30	8	15	30	8	35
Ni	210	80	70	5	100	120	90	40
Pb	25	<10	30	<10	20	25	<10	20
Sc	15	35	6	50	40	25	40	20

Table 6 continued

Sample Number	53	54	55	56	57	58	59	65
Sn	7	< 1	15	< 1	5	5	< 1	< 1
Sr	20	100	100	300	50	30	300	300
V	200	150	300	300	200	250	100	100
Y	15	20	25	30	< 10	15	20	25
Zn	240	85	130	95	70	120	100	90
Zr	200	45	30	80	25	50	90	150

Norms (Molecular percent)

	53	54	55	56	57	58	59	65
Quartz			1.224	7.498			7.274	8.646
Orthoclase		3.901	8.767	3.858	1.419	2.929	5.033	24.330
Albite		26.785	22.339	18.034	23.982	24.735	20.405	26.735
Anorthite	4.840	27.862	20.280	28.617	32.558	27.003	29.484	13.009
Diopside	36.122	12.700	13.564	14.467	14.863	8.543	8.800	6.442
Hedenbergite	11.372	5.674	11.126	11.118	7.279	6.684	8.787	2.249
Enstatite		8.118	9.762	7.059		11.234	8.980	9.237
Ferrosilite		3.627	8.008	5.425		8.789	8.967	3.225
Fosterite	15.409	4.151			11.041	3.198		
Fayalite	4.851	1.854			5.407	2.502		
Magnetite	2.079	3.787	2.358	1.992	1.306	2.168	0.586	3.423
Ilmenite	4.414	1.371	2.242	1.471	0.696	1.840	1.330	1.369
Apatite	0.435	0.170	0.111	0.173	0.084	0.194	0.174	1.264
Pyrrhotite	0.759		0.221	0.288	0.035	0.179	0.180	0.071
Nepheline	12.712				1.330			
Leucite	2.119							
Differentiation Index	14.83	30.69	32.33	29.39	26.73	27.66	32.71	59.71
Colour Index	74.25	41.28	47.06	41.53	40.59	44.96	37.45	25.95

Table 6 - continued on next page.

Table 6 continued

Modal Analyses in Volume Percent

Sample Number	53	54	55	56	57	58	59	65	BC-74 -189	BC-74 -171	BC-74 -170	BI-73 -340	BB-74 -253	BC-73 -100	BC-74 -13	BG-74 -157
Amphibole	A	56.0	A	49.7	A	60.4	475	15.8		21.1	16.3	37.1	x			54.6
Orthopyroxene									25.5							
Clinopyroxene									33.1			11.7	52.4	12.8	13.2	
Plagioclase		34.3	AB	34.2	A	35.4	43.6	34.9	7.9	54.2	51.5	47.9	46.0	62.1	61.4	41.8
Potassic Feldspar								9.8			13.3					
Quartz		2.3	C	4.2		1.8	3.4	18.2		4.7	7.7	2.0	1.6			2.0
Chlorite	B	1.8	C			0.9		0.4	26.5	0.1	0.5		x	x	x	
Biotite	C		BC	4.2			2.5	8.1		16.6	9.4			1.0	x	
Muscovite																
Epidote		4.7		5.1			0.3	5.0		1.4						
Carbonate	C									0.1						
Sphene		x		1.2			2.7	2.5		1.5	1.0					0.8
Iron Oxides	C	0.9		0.7		1.5		0.3	7.0	0.3	0.3	2.2	x	8.9	9.5	0.8
Sulphides												x				
Olivine														15.5	15.8	
Apatite														x	x	

Sample Descriptions

53	BI-74-101	Lamprophyre, Lot 5, Conc. 6, Hess Township.
54	BC-74-172	Coarse metagabbro, Early Precambrian composite pluton, Gilbert Township.
55	BC-74-115	Early Precambrian metagabbro dike, northwestern Craig Township.
56	BI-73-321	Metagabbro, Nipissing Diabase, Hess Township.
57	BI-74-51	Early Precambrian foliated metagabbro, southwestern Stralak Township.
58	BI-74-65	Early Precambrian foliated metagabbro, southwestern Stralak Township.
59	BC-73-55	Metagabbro, Nipissing Diabase southeast shore of Geneva Lake, Hess Township.
65	BC-74-174	Coarse, massive syenodiorite, Early Precambrian composite pluton, southeast Gilbert Township.
	BC-74-189	Feldspathic pyroxenite, Early Precambrian composite pluton, northern Ouellette Township.
	BC-74-171	Gabbro, Early Precambrian composite pluton, Gilbert Township.
	BC-74-170	Hornblende syenodiorite, Early Precambrian composite pluton, Gilbert Township.

Table 6 continued

BI-73-340	Partly altered gabbro, Nipissing Diabase, Moncrieff Township.
BB-74-253	Pyroxene gabbro, Nipissing Diabase, Harty Township.
BC-73-100	Olivine diabase, Late Precambrian, Munster Township.
BC-74-13	Olivine diabase, Late Precambrian, southwestern Ulster Township.

Abbreviations
A,B,C - Scale of abundance
A - 20 to 60 percent
B - 10 to 20 percent
C - 1 to 10 percent
x - Present in minor amounts.
S.G. - Specific Gravity

Note: Chemical analyses by Geoscience Laboratories, Ontario Geological Survey.

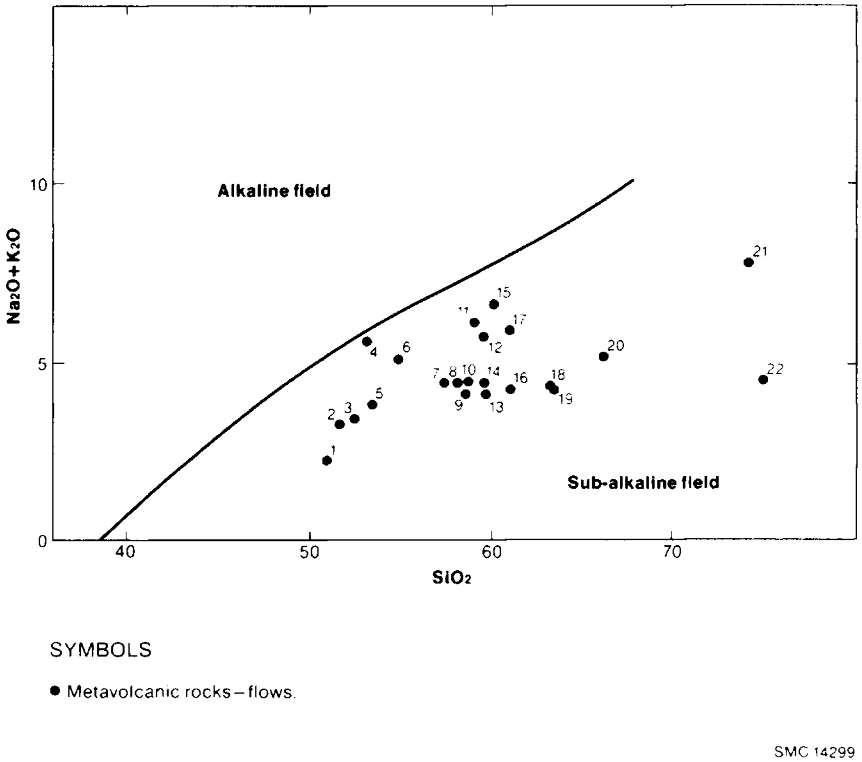


Figure 3–Na_2O and K_2O versus SiO_2 diagram.
To correlate sample numbers on figure with sample numbers plotted on Figure 19, see Table 2.

hibiting metasomatic effects developed about mafic and felsic intrusive bodies were not included in the analyzed samples. Coarse fragmental rocks were channel sampled for analyses.

Classification diagrams relying on amounts of alkalies, Ca, and Si are probably influenced by the various types of alteration processes mentioned. Some of these effects may be recorded by the data scatter. Classification diagrams relying on normative colour index and plagioclase composition may be problematic. B.N. Church (1975) showed that any error in the determination of Na_20 resulted in an increase by a factor of eight in the error of calculation of normative albite. Similarly, errors in Ca0 were increased five times in normative anorthite calculations.

The volcanic rocks have been altered. Hence, the determination of the primary chemical nature of these rocks is uncertain. In the figures (Figures 3 to 9), the analyses of the pyroclastic rocks show much more scatter, indicating a greater degree of alteration than the lavas. Lavas from the eastern part of the map-area show more scatter than those from the western part of the Benny Belt. This is consistent with field and thin-section observations.

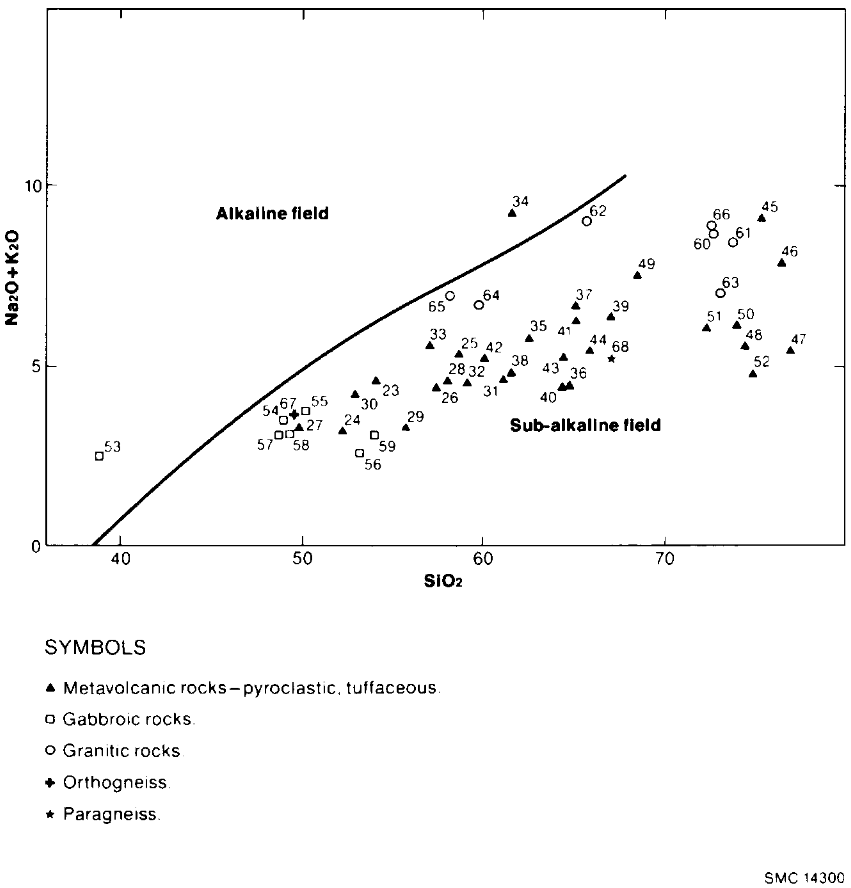
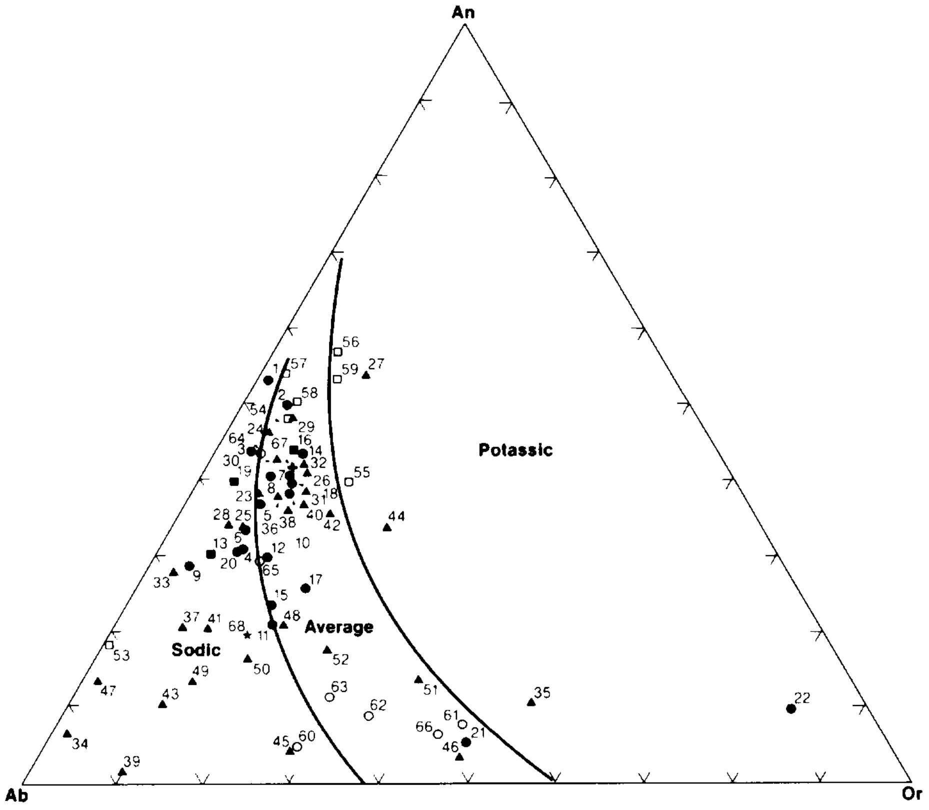


Figure 4–Another Na_2O and K_2O versus SiO_2 diagram.
To correlate sample numbers on figure with sample numbers plotted on Figure 19, see Tables 2, 3, 5, and 7.

METHODS OF CLASSIFICATION

The metavolcanics and associated intrusions in the map-area have been classified according to various chemical classification schemes.

L.D. Tilley (1950) suggested that most basalts belong to one of two major groups: alkalic or subalkalic. Numerous other workers including G.A. MacDonald and T. Katsura (1964), F. Chayes (1966), H. Kuno (1968), A. Miyashiro (1974), and T.N. Irvine and W.R.A. Baragar (1971) have attempted to classify volcanic rocks into these two groups. With the exception of Chayes (1966), all these authors used the ratio of alkalies to silica to make this general distinction between volcanic rock families.

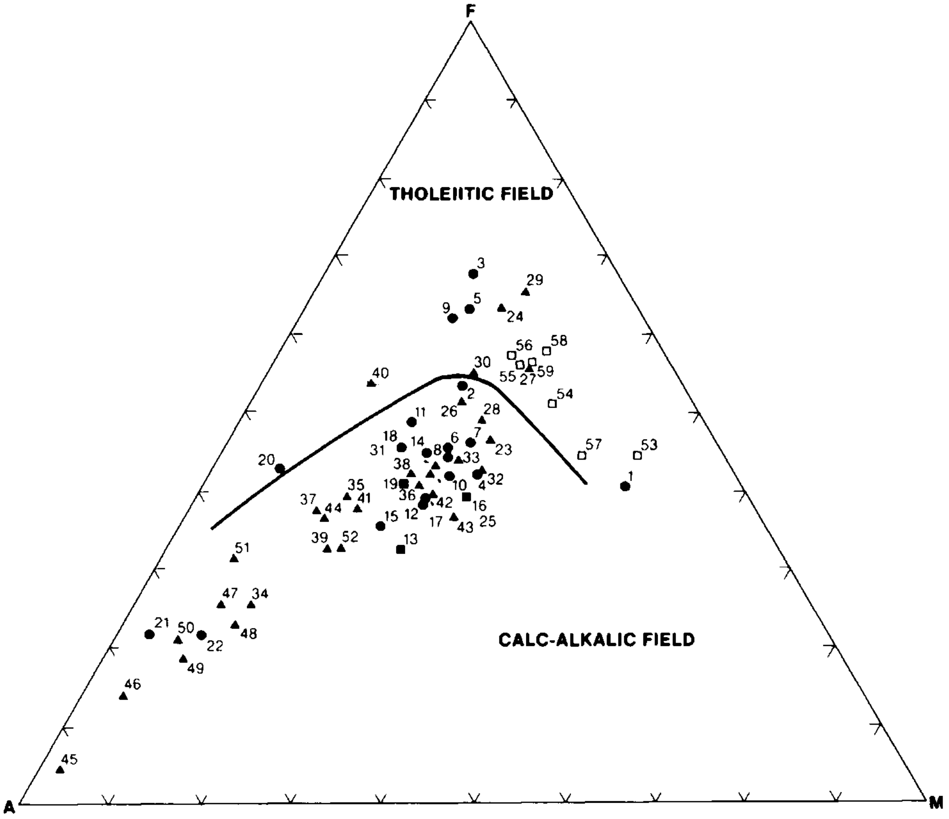


SYMBOLS

- ● Metavolcanic rocks—flows
- ▲ Metavolcanic rocks—pyroclastic, tuffaceous.
- ■ Metavolcanic rocks—porphyritic
- □ Gabbroic rocks.
- ○ Granitic rocks.
- ✦ Orthogneiss.
- ★ Paragneiss.

SMC 14301

Figure 5—Anorthite-albite-orthoclase diagram.
To correlate sample numbers on figure with sample numbers plotted on Figure 19, see Tables 2, 3, 5, and 7.

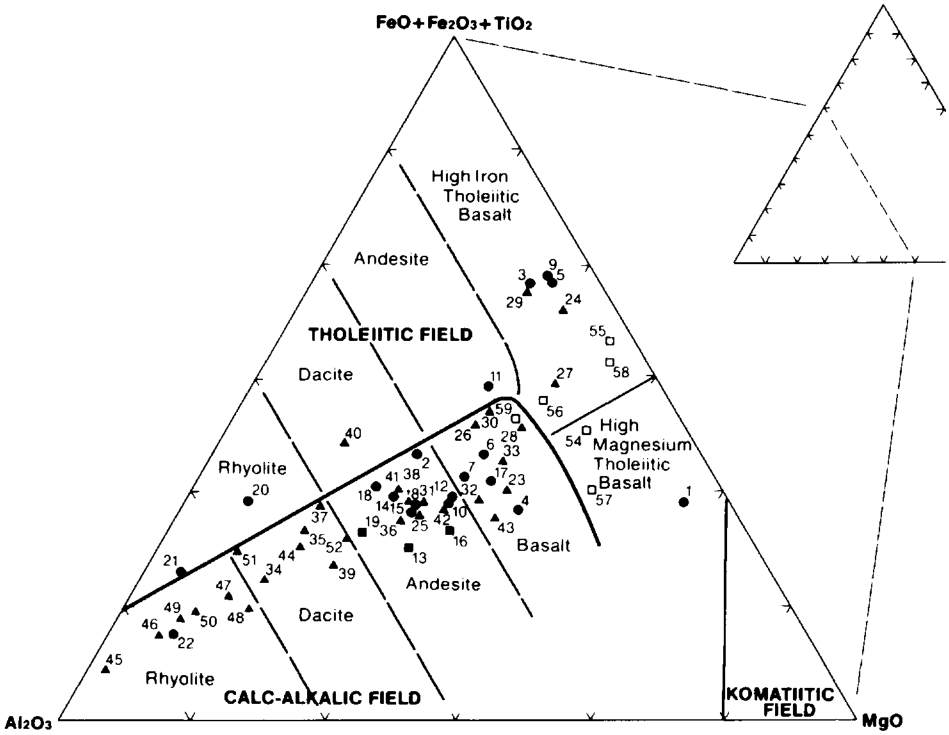


SYMBOLS

- ● Metavolcanic rocks–flows.
- ▲ Metavolcanic rocks–pyroclastic, tuffaceous.
- ■ Metavolcanic rocks–porphyritic.
- □ Gabbroic rocks

SMC 14302

Figure 6–AFM diagram for rocks in the Benny Area.
To correlate sample numbers on figure with sample numbers plotted on Figure 19, see Tables 2, 3, 5, and 6.



SYMBOLS

● Metavolcanic rocks–flows.

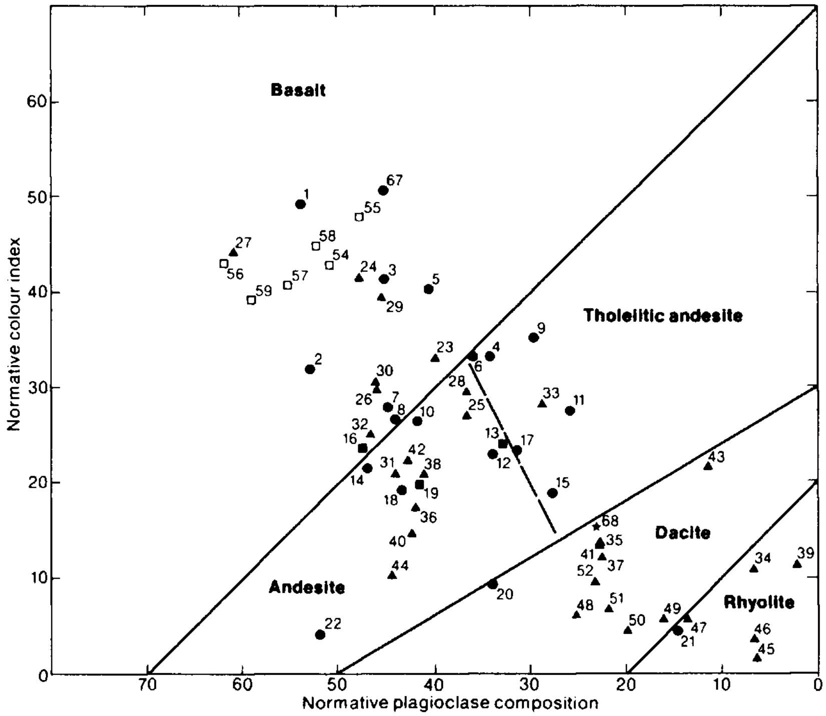
▲ Metavolcanic rocks–pyroclastic, tuffaceous.

■ Metavolcanic rocks–porphyritic.

□ Gabbroic rocks.

SMC 14303

Figure 7–Jensen diagram for metavolcanics in the Benny Area.
To correlate sample numbers on figure with sample numbers on Figure 19, see Tables 2, 3, 5, and 6.



SYMBOLS

- ● Metavolcanic rocks–flows.
- ▲ Metavolcanic rocks–pyroclastic, tuffaceous.
- ■ Metavolcanic rocks–porphyritic.
- □ Gabbroic rocks.
- ★ Paragneiss.

SMC 14304

Figure 8–Normative plagioclase versus normative colour index diagram.
To correlate sample numbers on figure with sample numbers on Figure 19, see Tables 2, 3, 5, and 7.

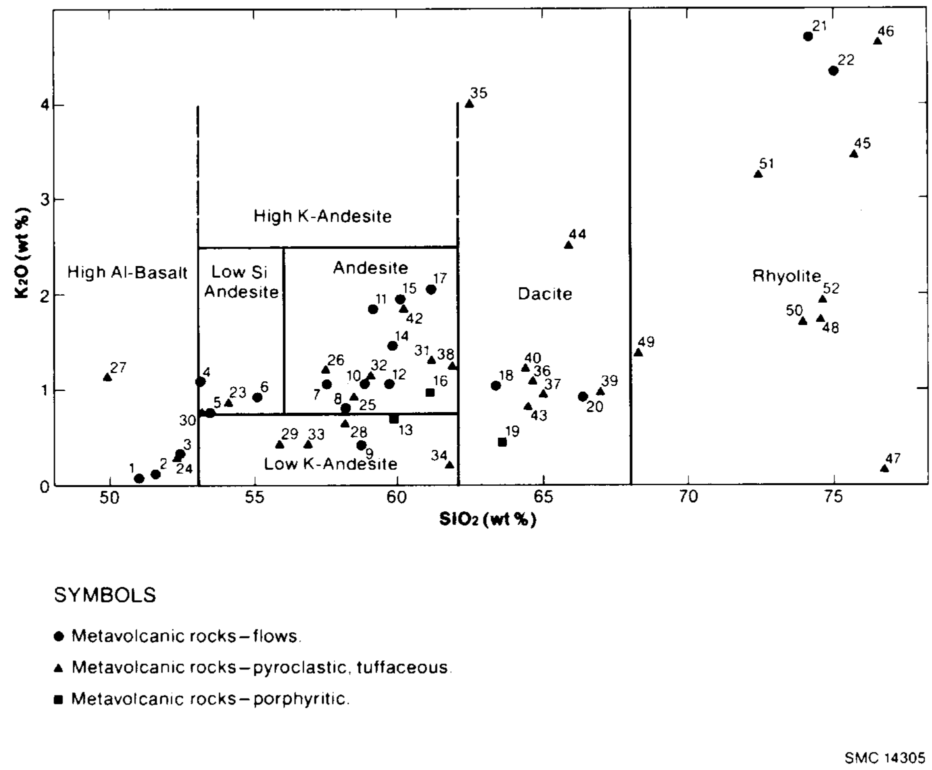


Figure 9–K_2O versus SiO_2 diagram for metavolcanics in the Benny Area.
To correlate sample numbers on figure with sample numbers on Figure 19, see Tables 2, 3, and 5.

The Anorthite-Albite-Orthoclase projection presented by Irvine and Baragar (1971) is used to separate soda-rich and potash-rich variants of subalkalic rocks (see Figure 5).

The AFM diagram, developed by L.R. Wager and W.A. Deer (1939), is used to distinguish between tholeiitic and calc-alkaline series rocks. In such a diagram, the early and middle stages of crystallization of a typical tholeiitic series are represented by curves approximately parallel to the Mg0-Fe side, and in the late stage, a sharp turn occurs towards the $Na_20 + K_20$ corner to accommodate the more silicic rocks. Miyashiro (1974) suggested that a complete gradation exists between the typical tholeiitic and typical calc-alkaline series and proposed an alternative method of graphical distinction between the two groups. In a typical tholeiitic series, the $Si0_2$ content remains nearly constant or decreases slightly during the early stage of fractional crystallization; that is with an increasing Fe0 to Mg0 ratio. Magmas of the calc-alkaline series show more rapid increases of the $Si0_2$ content with fractional crystallization.

L.S. Jensen (1976) developed a diagram to relate the determinations of chemistry to field mapping methods based on the cation percentages of Al_20_3, Fe0, Fe_20_3, $Ti0_2$, and Mg0. The diagram shows the approximate differentiation trends of calc-alkaline and tholeiitic volcanic rocks in a similar manner to the AFM diagram.

Irvine and Baragar (1971) used a normative colour index/normative plagioclase composition diagram to separate basalt, andesite, dacite, and rhyolite in a volcanic series. J.A. Hallberg (1972) suggested that the use of colour index as the sole criterion for distinguishing andesite from basalt is questionable. Hallberg (1972) suggested that even when a normative definition is applied, the inclusion of carbonatized samples and analyses of fragmental volcanic rocks may affect rock classification. Diagenetic and metamorphic alteration will affect a rock's position in the classification system. Hallberg classifies basalts as having normative An/An + Ab ratios less than 50.

A.E. Beswick and G. Soucie (1976) used analytical data obtained from chemical analyses of an Archean greenstone belt and plotted them on standard compositional variation diagrams. The resulting data scatter was attributed to metasomatic processes. A graphical method, which involved the plotting of the analytical data in terms of oxide molecular proportion ratios to test the metasomatic hypothesis was developed. Various oxides are plotted in the form log X/Y versus log Z/Y (Figures 10, 11, 12, and 13) where X, Y, and Z are the oxide molecular proportions calculated from the whole rock weight percent analyses. Rocks from fresh post-Mesozoic suites show well-defined trends on the moleplots. Beswick and Soucie (1976) suggested that rocks which had suffered metasomatic alteration would be displaced from these trends. Also, the amount of the displacement should reflect the extent of the metasomatism, whereas the direction of the displacement should reflect the nature of the metasomatism.

Various workers including S.C. Hart *et al.* (1970) and P.W. Gast (1968) have used trace elements to compare ancient and modern volcanic rocks and to distinguish between tholeiitic and alkaline volcanic suites. Hart *et al.* (1970) suggested that Archean basalts average 2100 ppm K, 175 ppm Sr, and 70 ppm Ba, and that these rocks are closely related to the modern low-potassium tholeiites of island arcs.

DISCUSSION OF RESULTS

Figures 3, 4, 5, 6, 7, 8, 9; and Figures 18 and 19 (Chart B, back pocket) display the analytical data obtained from the chemical analyses of volcanic and associated intrusive rocks which occur in the map-area. In the Alkalies/Silica plot (see Figures 3 and 4), lavas, pyroclastic rocks (except Sample Number 34), associated mafic intrusions (except Sample Number 53), and granitic rocks, fall within the subalkaline field and have a low total alkali content typical of tholeiitic or calc-alkaline suites. Sample Number 34 represents a felsic lapilli-tuff having the chemistry of a sodic trachyte (9.17 percent Na_20 and 19.5 percent Al_20_3). Sample Number 53 represents a mafic dike, and is classified as a lamprophyre.

Anorthite-albite-orthoclase projections (see Figure 5) show average to sodic

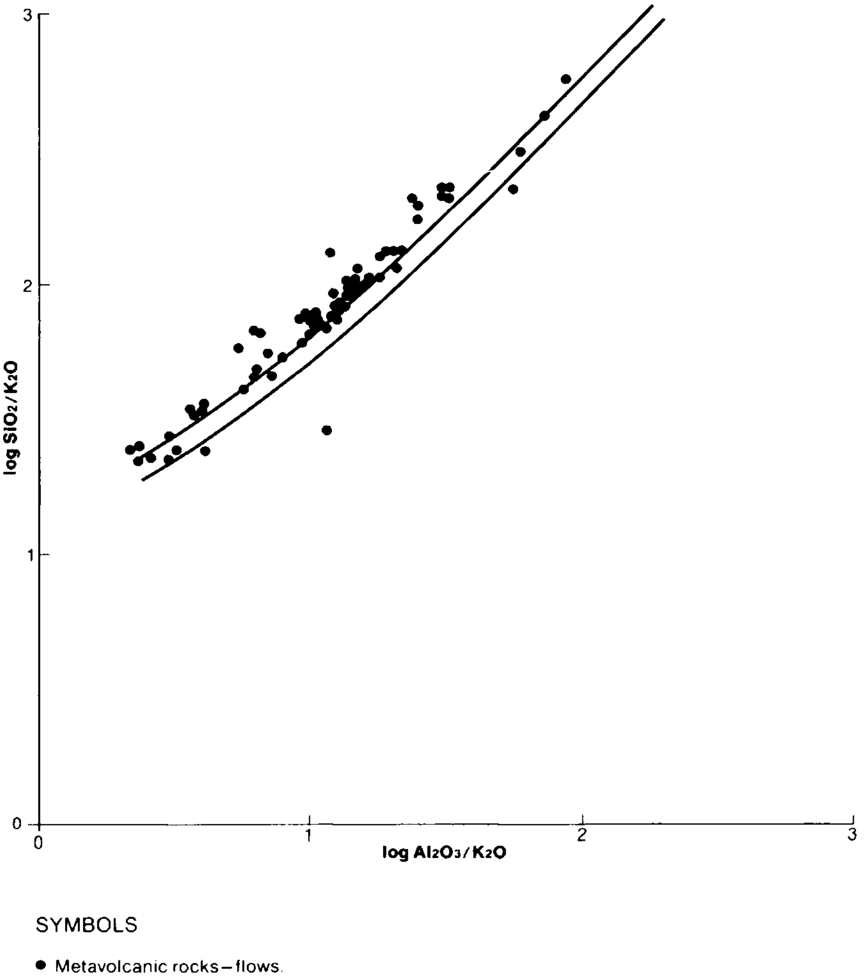
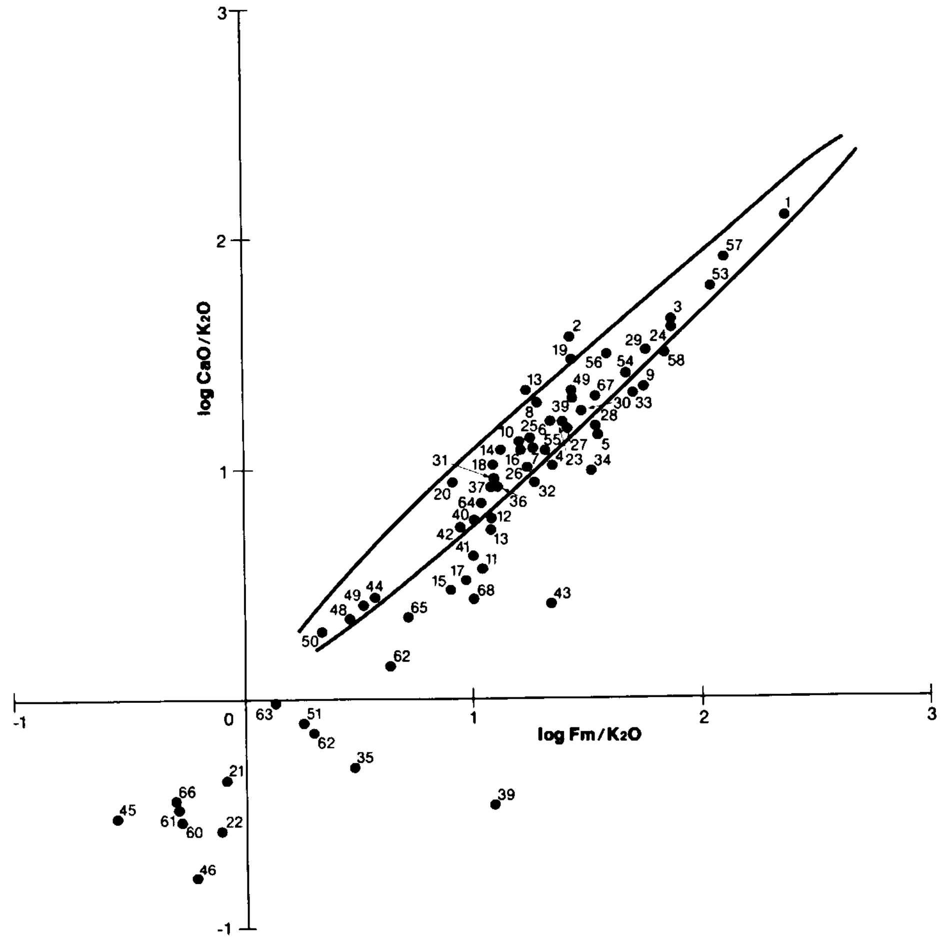


Figure 10–Log SiO_2/K_2O versus log Al_2O_3/K_2O diagram for metavolcanics in the Benny Area (after Beswick and Soucie 1976).
To correlate sample numbers on figure with sample numbers on Figure 19, see Tables 2, 3, 5, and 7.



SYMBOLS

● Metavolcanic rocks–flows.

SMC 14307

Figure 11–Log CaO/K_2O versus log Fm/K_2O diagram for metavolcanics of the Benny Area. Solid lines enclose field of unaltered volcanic rock compositions as defined by Beswick and Soucie (1976).
To correlate sample numbers on figure with sample numbers on Figure 19, see Tables 2, 3, 5, and 7.

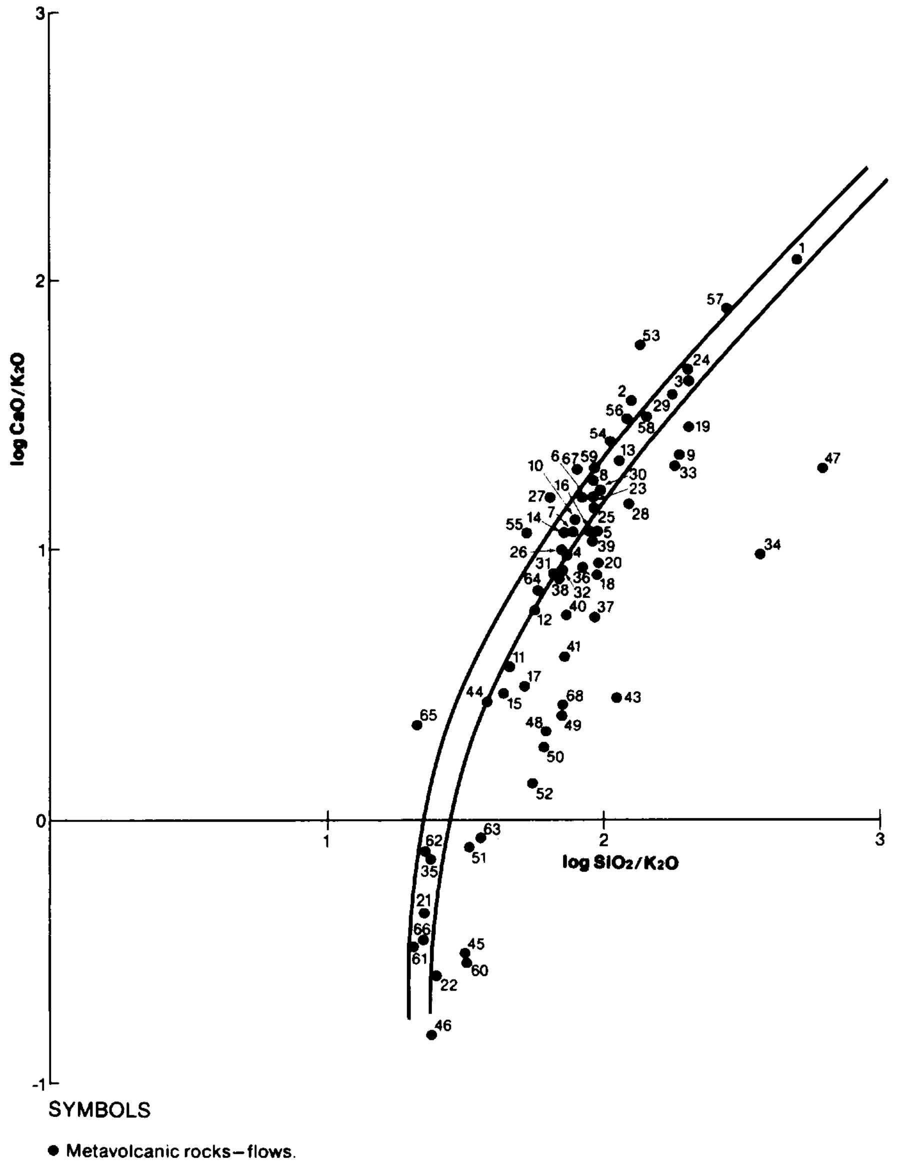


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Figure 12–Log CaO/K_2O versus log SiO_2/K_2O diagram for metavolcanics of the Benny Area (after Beswick and Soucie 1976).

To correlate sample numbers on figure with sample numbers on Figure 19, see Tables 2, 3, 5, and 7.

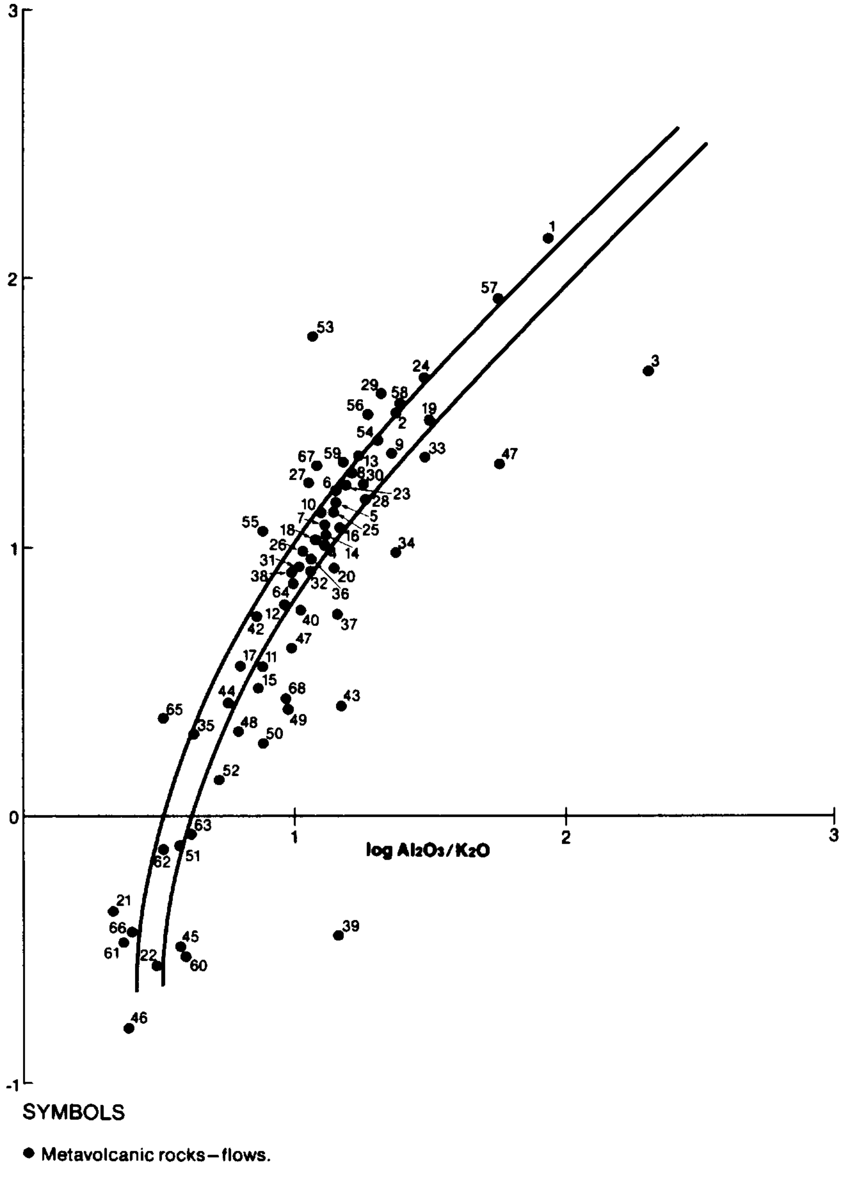

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Figure 13–Log CaO/K$_2$O versus log Al$_2$O$_3$/K$_2$O diagram for metavolcanics of the Benny Area (after Beswick and Soucie 1976).
To correlate sample numbers on figure with sample numbers on Figure 19, see Tables 2, 3, 5, and 7.

trends for the volcanic rocks in the map-area. One rhyolite (Sample Number 22) and three pyroclastic samples (Sample Numbers 27, 35, and 44) plot in the potassic field. Figure 4 reveals that gabbroic rocks show low to average potash content and the porphyritic volcanic rocks show low potash and high soda contents. Plots of gabbroic rocks parallel the mafic volcanic trends, but are displaced towards lower sodium and higher potassium fields. Plots of the intrusive metagabbro bodies in the western part of the map-area cannot be readily separated from the mafic volcanic plots, suggesting that in terms of their potassium, sodium, and calcium contents, these rocks may have a common origin.

The AFM plot (see Figure 6), shows that the bulk of the analyses of the metavolcanics in the map-area lie in the calc-alkaline field. The plot shows a decrease in total iron and magnesium content with increasing alkali content for all the rocks, and this is consistent with a hypothesis of progressive differentiation of the magma. Plots lying within the tholeiitic field represent mafic lavas from the western part of the Benny Belt and have the highest total iron content of all the lavas in the map-area. Mafic intrusive rocks plot within the tholeiitic field. Trends displayed by Figure 6 are consistent with those found in Jensen's plot (see Figure 7). Figure 7 illustrates that most of the metavolcanics plot within the calc-alkaline field with some transition into the tholeiitic field. Gabbroic rocks plot predominantly within the high iron tholeiitic and high magnesium tholeiitic basalt field. Analyses of lavas from the western part of the Benny Belt plot within the tholeiitic field in Figure 7; this is consistent with the AFM diagram.

Plots of normative colour index/normative plagioclase composition for the volcanic and gabbroic rocks of the map-area (see Figure 8) suggest a calc-alkaline series trend from basalt through to rhyolite. Some lavas plot in the tholeiitic andesite field and all gabbroic rocks fall within the basalt field.

The metavolcanics in the map-area have a relatively high proportion of intermediate (andesitic) members. Figure 9 distinguishes rock types within the andesite family. The presence of dacite on Figure 9 is not consistent with normative plagioclase versus normative colour index plots (Figure 8), where only basalt, andesite, tholeiitic andesite, and rhyolite are defined. Also, Jensen's plot (Figure 7) does not indicate dacitic compositions. The $K_20/Si0_2$ diagram (Figure 9) shows the presence of low silica andesite, low potassium-andesite, and high alumina basalt from the base of the volcanic sequence, and andesite, dacite, and rhyolite from the middle and upper parts of the volcanic sequence. The porphyritic rocks are distinct on the diagram showing a slightly lower potassium-content than the other flow rocks and plot transitionally between andesitic and dacitic compositions. The plots of the metavolcanic flows show three silica gaps on Figure 9, these are: 55.1 to 57 percent $Si0_2$, 61.2 to 63.4 percent $Si0_2$ and 66.3 to 74.2 percent $Si0_2$. These silica gaps may be a result of sampling bias, but may also reflect some geochemical phenomena of volcanism.

The molecular ratios of various oxides of the metavolcanics are plotted in Figure 9. Several of the plots fall outside the fields defined by fresh, post-Mesozoic volcanic suites, indicating that some of the metavolcanics in the map-area have been metasomatically altered. The pyroclastic rocks generally show greater scatter than do the lavas from the eastern part of the belt. There is also an indication that the general trends for the metavolcanics are somewhat offset from the trends for the post-Mesozoic suites. This suggests that the unaltered chemistry of the Early Precambrian volcanic rocks may have been somewhat different from the more modern volcanic rocks.

MINOR ELEMENT VARIATIONS

The trace elements in the lavas, Cr, Ni, Cu, Zn, Co, and Sc generally decrease with increasing SiO_2 content while Pb, Ba, and Y generally increase. Pb, Zn, and Co are generally highest in the intermediate silica range. Sr, V, and Zr values are highest in the intermediate composition rocks and decrease towards both the mafic and felsic end members.

In the pyroclastic rocks Cr, Ni, Ca, Co, Y, and Sc generally decrease with increasing SiO_2 whereas Pb, Zn, Ba, and Zr increase. Zn is highest in the intermediate and felsic range, whereas Co remains high with amounts of as much as 65 percent SiO_2. Sr and V are highest in the intermediate range and, as in the lavas, decrease toward the mafic and felsic end-members.

Trace element values for basaltic rocks of the Benny Belt correspond to the tholeiitic or abyssal basalts of Best (1968) and are generally similar to the modern low-potassium tholeiites of S.C. Hart *et al.* (1970). The degree of variation in individual trace-element values, Sr and Ba for example, which is probably partly due to alteration, does not allow for the comparison of modern and Precambrian lavas.

Metavolcanics of the Benny Belt are low in sulphur compared with some other Early Precambrian sequences. Mafic metavolcanics in the area generally contain less than 0.05 percent sulphur, whereas similar rocks from the Noranda area contain, on average, 0.09 percent sulphur, and from Yellowknife, 0.07 percent sulphur (Cameron 1974). Higher sulphur concentrations, greater than 0.10 percent, occur in intermediate (56 to 65 percent SiO_2) metavolcanics of the Benny Belt, and occur notably in coarse pyroclastic rocks associated with sulphide-rich metasediment-tuff units. This accords with the known association of sulphide deposits with intermediate to felsic pyroclastic rocks in many other Early Precambrian metavolcanic-metasedimentary sequences.

Figure 14 is a plot of zinc content of analyzed metavolcanics versus their silica content (after Wolfe 1974). The trend line on the diagram showing decreasing zinc content with increasing silica represents "normal" variations in zinc attributable to differentiation processes. The field drawn about the trend line defines the range of zinc variation expected in Early Precambrian metavolcanic rock suites. Data falling outside this field is presumed to reflect abnormal zinc concentrations connected with mineralizing processes. The flow rocks analyzed from the Benny Belt, with one exception, fall within the "normal" field of zinc distribution. The exception is a sample of the mafic metavolcanic unit that forms the footwall of the Geneva Lake Mine Deposit (see Figure 4). Analyzed felsic pyroclastic rocks also plot mainly within the "normal" zinc field. Pyroclastic samples with anomalous zinc values are mainly from the Geneva Lake Mine area, and from the coarse tuff-breccia sequence along Highway 144.

Inspection of trace element analyses of metasedimentary and tuffaceous rocks (see Table 5) shows that samples of those rocks from horizons with known base-metal deposits commonly contain more than 250 ppm Cu, 150 ppm Pb, and 500 ppm Zn. Similar rocks from sulphide-bearing zones with no apparent

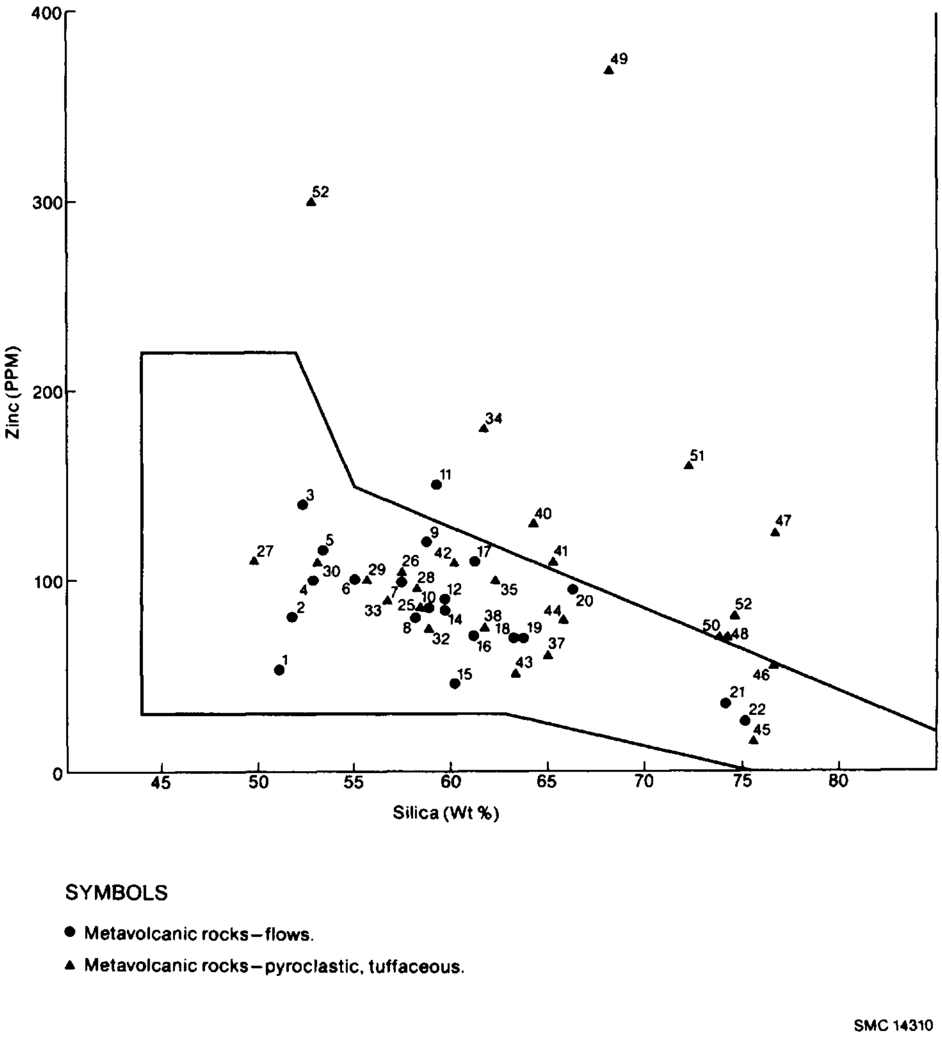

Figure 14–Zinc versus SiO_2 diagram.
To correlate sample numbers on Figure with sample numbers on Figure 19, see Tables 2, 3, and 5.

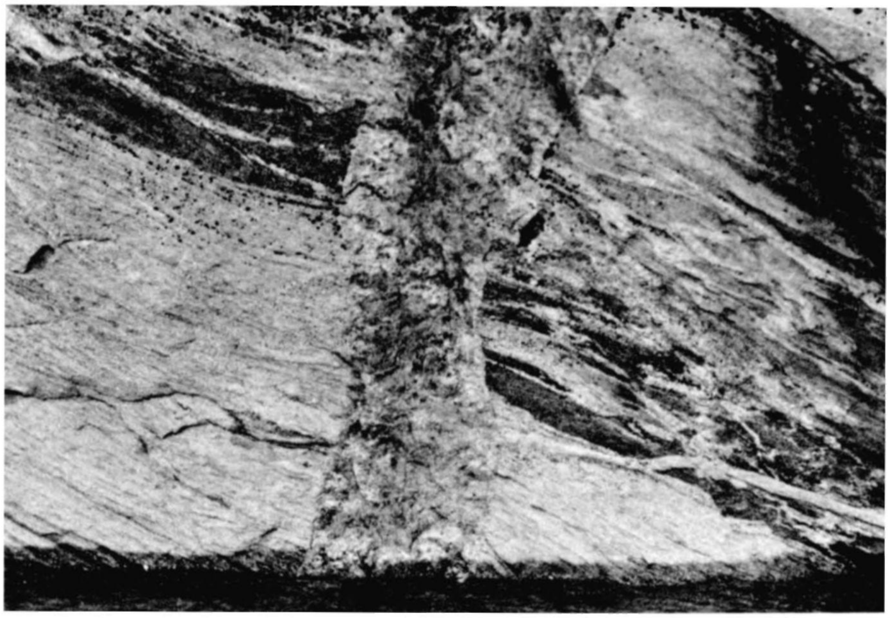

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Photo 6–Migmatitic gneiss, cut by a pegmatite dike, Kennedy Lake, Stralak Township.

base-metal sulphide deposits generally contain less than 250 ppm Cu, 150 ppm Pb, and 500 ppm Zn.

Felsic Intrusive and Metamorphic Rocks

FOLIATED, FELSIC, PLUTONIC, AND MIGMATITIC ROCKS

Foliated, gneissic, and migmatitic rocks, including foliated trondhjemite and granodiorite, augen gneiss, xenolithic, and agmatitic trondhjemite and granodiorite, leucocratic migmatitic orthogneiss and paragneiss, and mafic migmatitic orthogneiss, form much of the terrain bordering the Benny metavolcanic-metasedimentary belt. These rocks are, for the most part, apparently intrusive into, or derived from, the metavolcanics and metasediments. However, as described previously, there is a possibility that some of the gneisses represent the basement upon which the metavolcanic-metasedimentary sequence was deposited. The gneissic and migmatitic rocks are intruded by younger, massive quartz monzonite, pegmatite, and aplite, and by swarms of mafic and breccia dikes (Photo 6).

Foliated trondhjemite and granodiorite of plutonic origin containing scattered xenoliths of older mafic and gneissic rocks form much of the terrain north and southwest of the Benny Belt. These rocks are faintly layered light grey to pinkish rocks with a well-developed penetrative foliation defined by oriented, cataclastically deformed minerals. They are medium-grained (average 1 mm in grain size), equigranular to subporphyritic rocks composed essentially of quartz, plagioclase (oligoclase), amphibole, and biotite with minor potassic feldspar, chlorite, zircon, sphene, and iron oxides.

Augen gneiss, containing deformed plagioclase phenocrysts, occurs with the trondhjemite and granodiorite. The augen gneiss is mineralogically similar to the trondhjemite and granodiorite and probably represents deformed, porphyritic phases of the older felsic plutonic rocks.

Minor amounts of xenolithic material, sharp-bordered and diffuse schlieren of mafic and migmatitic rocks are scattered throughout the trondhjemite and granodiorite. Where xenolithic material was observed in amounts greater than 15 percent, the rocks were mapped as xenolithic and agmatitic trondhjemite and granodiorite. Such rocks occur mainly north of the Benny Belt, especially in the eastern part of the map-area. They consist of mafic fragments, probably representing mafic metavolcanic and intrusive material, and layered, gneissic, and migmatitic rocks set in a trondhjemitic or granodioritic groundmass. The xenoliths range in maximum dimension from about 2 cm to 100 m. Some xenoliths display older gneissic foliations that are not parallel to the younger cataclastic foliation imposed on the xenoliths and the groundmass.

Migmatitic gneiss, including grey paragneiss, felsic layered gneiss, and mafic orthogneiss, occurs throughout the granitic terrain, but is concentrated at the northwestern and northeastern ends of the Benny Belt. They represent, for the most part, remnants of the formerly more extensive metavolcanic-sequence that has been highly metamorphosed and intruded by granitic material. Such rocks consist of variable proportions of metavolcanic, metasedimentary, and granitic material, and generally display prominent gneissic layering. The layers are a few centimetres to about a metre thick and consist of alternating dark-coloured mafic members and light-coloured granitic members. In some units, individual layers maintain a relatively constant thickness; in others, the layers are wispy, lensoid, and discontinuous. Cross-cutting granitic, aplitic, and pegmatitic dikes are prevalent. The mafic migmatite consists of over 50 percent mafic material and comprises alternating mafic and felsic layers or schlieren 2 cm to 0.5 m thick. The mafic layers consist essentially of hornblende and plagioclase with variable amounts of quartz, biotite, epidote, chlorite, sphene, iron oxides, and sulphides. The felsic layers, composed of quartz and plagioclase with variable amounts of biotite, amphibole, and potassic feldspars, are of granodioritic composition.

The felsic migmatites are similar to their mafic counterparts except that the felsic component is dominant.

Grey paragneiss (Map Code 6d, Map 2434, back pocket) forms several remnants south of the Benny Belt in western Craig Township and eastern Ouellette Township. The paragneiss is interstratified with mafic gneiss, and is surrounded by foliated trondhjemite-granodiorite. The paragneiss is a grey, fine- to medium-grained (0.1 to 1 mm), layered, foliated rock composed of quartz, plagioclase, potassic feldspar, biotite, amphibole, chlorite, epidote, and iron oxides.

Chemical, normative, and modal analyses of gneissic and migmatitic rocks are given in Table 7.

MASSIVE FELSIC INTRUSIVE ROCKS

Massive, generally unfoliated rocks of quartz monzonite composition underlie much of the terrain south of the Benny Belt and form several small plutons to the north of the belt. In the south they form part of an extensive batholith, the "Cartier Batholith", that extends eastward toward Lake Wanapitei and southward toward the Agnew Lake area where similar felsic plutonic rocks form the "Birch Lake Batholith" (Card and Palonen 1976). The Cartier Batholith is a member of a group of composite felsic plutons, the "Algoman granites", that were emplaced some 2500 m.y. or more ago in the southern part of the Superior Province (Van Schmus 1965). They represent magmatic intrusions emplaced at intermediate (mesozonal) crustal levels following the major deformation and regional metamorphism of the Kenoran Orogeny (Stockwell *et al.* 1970).

The felsic plutonic rocks are pink to light grey, generally leucocratic, medium to coarse grained, and commonly porphyritic. These rocks have an average composition of quartz monzonite, and consist of quartz, plagioclase, and potassic feldspar with minor biotite and amphibole and accessory muscovite, chlorite, epidote, sphene, zircon, and iron oxides (Table 7). The plagioclase is commonly oligoclase (An_{25+5}). The porphyritic rocks contain perthitic microcline phenocrysts up to 2 cm in length.

Locally, as along Highway 144, 0.8 km south of the Canadian Pacific Railway crossing, the rocks are coarsely porphyritic and have a distinct rapakivi texture. The pink perthitic microcline phenocrysts are as much as 10 cm in length and are mantled by green, altered plagioclase. These coarse porphyritic rocks are generally richer in femic minerals than the finer grained varieties and are locally cataclastically deformed.

Fine- to medium-grained (0.1 to 0.5 mm) equigranular granitic rocks occur throughout the Cartier Batholith and form dikes cutting the older gneiss and metavolcanics. The equigranular granitic rocks display both gradational and sharp intrusive contacts with the porphyritic quartz monzonite. A small body of medium-grained leucocratic quartz monzonite that intrudes metavolcanics of the Benny Belt along Highway 144 approximately 1.5 km north of the Canadian Pacific Railway crossing in Moncrieff Township, contains pegmatitic dikes with minor amounts of fluorite and molybdenite. The equigranular granitic rocks range in composition from quartz monzonite to granite; most are quartz monzonite mineralogically similar to their porphyritic counterparts. Equigranular granite and pegmatite occasionally have a pronounced graphic texture.

Fine-grained pink aplite and coarse pegmatite are common throughout the Cartier Batholith and also cut the older gneiss and metavolcanics. Some pegmatite dikes have large, 1 to 5 cm, grey phenocrysts of oligoclase set in a pink

TABLE 7 CHEMICAL ANALYSIS, NORMS, AND MODAL ANALYSES OF GRANITE ROCKS, BENNY AREA.

Sample Number	60	61	62	63	64	66	67	68
				Major Components in Weight Percent				
SiO_2	72.80	73.80	65.50	73.20	59.80	72.90	49.60	67.10
Al_2O_3	15.80	13.40	15.40	14.60	15.80	14.00	12.80	14.30
Fe_2O_3	0.25	0.58	1.95	0.37	2.85	0.38	3.83	1.97
FeO	0.41	0.73	2.03	1.46	4.08	0.97	11.40	3.28
MgO	0.38	0.42	1.46	0.73	3.35	0.32	4.93	3.19
CaO	0.62	1.01	1.82	1.51	6.05	1.04	10.90	2.22
Na_2O	5.26	3.37	4.69	4.04	4.34	3.75	2.72	3.80
K_2O	3.42	5.08	4.24	3.04	1.38	4.96	0.88	1.39
TiO_2	0.02	0.23	0.84	0.16	0.71	0.25	1.58	0.59
P_2O_5	0.03	0.06	0.33	0.11	0.11	0.10	0.19	0.15
S	0.02	0.01	0.08	0.06	0.01	0.02	0.10	0.19
MnO	0.07	0.02	0.06	0.03	0.15	0.01	0.37	0.11
CO_2	0.10	0.33	0.17	0.11	0.05	0.21	0.05	0.06
H_2O^+	0.22	0.56	0.71	0.79	0.76	0.76	0.83	1.83
H_2O^-	0.25	0.06	0.07	0.13	0.40	0.04	0.38	0.44
Total	99.60	99.70	99.40	100.30	99.80	99.70	100.60	100.60
S.G.	2.60	2.65	2.73	2.68	2.71	2.65	3.17	2.80
				Trace Elements in Parts per Million				
Ba	140	770	1030	650	180	440	250	430
Be	35	<1	3	<1	3	2	<1	2
Co	<5	<5	9	5	20	<5	45	20
Cr	15	15	25	15	25	20	110	210
Cu	10	10	20	8	60	8	80	35
Ga	90	20	20	10	10	30	10	10
Li	7	6	8	4	10	6	6	15
Ni	10	8	10	<5	40	9	50	75
Pb	20	35	140	25	<10	25	<10	15
Sc	<5	<10	<10	<10	20	<10	25	10
Sn	15	10	10	<1	<1	2	1	<1

Table 7 continued

Sample Number	60	61	62	63	64	66	67	68
Sr	< 10	300	400	300	200	200	30	300
V	20	40	100	40	90	20	100	60
Y	15	< 10	40	30	25	30	25	10
Zn	20	75	90	50	75	30	130	120
Zr	20	40	200	80	45	30	40	70
				Norms (Molecular percent)				
Quartz	25.061	30.197	15.579	31.091	11.102		0.263	27.770
Corundum	2.608	0.737	0.635	2.408				3.204
Orthoclase	20.243	30.711	25.408	18.197	8.282		5.384	8.415
Albite	47.260	30.926	42.663	36.709	39.537		25.261	34.923
Anorthite	2.882	4.721	6.961	6.854	19.846		20.814	10.271
Diopside					5.716		13.837	
Hedenbergite					2.192		13.241	
Enstatite	1.050	1.185	4.084	2.040	6.526		7.160	9.015
Ferrosilite	0.474	0.412	0.438	1.639	2.502		6.851	2.456
Magnetite	0.262	0.620	2.066	0.392	3.023		4.142	2.108
Ilmenite	0.028	0.328	1.186	0.226	1.004		2.277	0.841
Apatite	0.063	0.128	0.700	0.233	0.234		0.411	0.321
Pyrrhotite	0.069	0.035	0.281	0.211	0.035		0.359	0.675
Differentiation Index	92.56	91.83	83.65	86.00	58.92			
Colour Index	1.81	2.54	7.77	4.30	20.96			
				Modal Analyses in Volume Percent (Estimated and Measured)				
Amphibole		X			B	1.3	30.7	
Plagioclase	A	37.1	36.8	A	A	34.1	47.3	A
Potassic Feldspar	AB	31.5	10.0	AB	C	24.5		
Quartz	A	29.4	43.8	A	BC	34.0	6.4	A
Chlorite	C			C	C	1.8	10.0	B
Biotite		2.0	7.4			4.1		
Muscovite		X		C	BC			BC

Table 7 - continued on next page.

Table 7 continued

Sample Number	60	61	62	63	64	66	67	68
Epidote		X						
Sphene		X	0.8					
Iron-Titanium Oxide		X	1.8				5.6	
Sulphides						0.2		

Sample Descriptions

60	BI-74-123	Pegmatite; 2045 m WSW at Benny, Lot 9, Conc. 5, NW¼, N½, Moncrieff Tp.
61	BC-73-1	Porphyritic quartz monzonite, Cartier Township.
62	BI-73-25	Augen gneiss, pink feldspar phenocrysts (2-3 cm) aligned in f.g. dark green matrix 460 m SE of NW tip of Bannerman L., Lot 4, Conc. 4, NE¼, N½, Moncrieff Tp.
63	BC-73-6	Med. g. to f.g., pink feldspar phenocrysts (1 cm) in matrix of dark grey granodiorite; SE portion Ulster Tp., 1524 m W of SW tip of Retort L.
64	BB-74-141	Med. to c.g., gneissic grey granodiorite; E central Gilbert Tp., 460 m NE of SE tip of Snider L.
66	BI-73-29	F.g., med.g., grey-pink, poorly foliated quartz monzonite; 550 m NNW of NW tip of Bannerman L., Lot 5, Conc. 5, NE¼, N½, Moncrieff Tp.
67	BC-74-143	F. to c.g., weakly foliated, med. greenish grey paragneiss; 795 m SW of Kennedy-Bluewater L. narrows, Lot 9, Conc. 5, NW¼, N½, Craig Tp.
68	BC-74-141	Med. g., non-foliated, med. greenish grey paragneiss; 795 m SW of Kennedy-Bluewater L. narrows, Lot 9, Conc. 5, NW¼, N½, Craig Tp.

Modal Analyses in Volume Percent

	BC-73-144	BI-73-271	BC-73-115	BB-74-108	BB-74-105	BC-74-145	BC-73-116	BI-73-18	BB-74-86
Quartz	32.6	20.8	25.6	3.2	2.8	24.2	25.8	32.1	29.5
Plagioclase	49.6	50.6	45.3	56.7	31.0	53.4	48.0	41.1	12.0
Potassic Feldspar	3.0	0.3	8.2				19.7	25.5	57.0
Hornblende		27.3		30.6	65.8		2.2		
Biotite	11.8		14.9	3.3		21.4	2.7		
Chlorite	X		X	0.1				0.2	
Muscovite			X						0.2
Epidote	2.2	X	X	3.5	0.4	0.6	0.9		
Sphene	0.8	0.9	X	1.5			0.5		

Table 7 continued

	BC-73-144	BI-73-271	BC-73-115	BB-74-108	BB-74-105	BC-74-145	BC-73-116	BI-73-18	BB-74-86
Apatite			X				X		
Zircon	X	X	X				X	X	
Iron Oxides		0.1	X	1.3		0.4	0.2	1.1	1.3
Sulphides									

Sample Descriptions

BC-73-144	Gneissic granodiorite (trondhjemite), Munster Township.
BI-73-271	Gneissic granodiorite (trondhjemite), Ulster Township.
BC-73-115	Gneissic granodiorite, Munster Township.
BB-74-108	Hornblende syenodiorite, Stralak Township.
BB-74-105	Mafic orthogneiss, Stralak Township.
BB-74-145	Grey paragneiss, Craig Township.
BC-73-116	Quartz monzonite, Munster Township.
BI-73-18	Fine-grained, equigranular quartz monzonite dike, Moncrieff Township.
BB-74-86	Graphic, pegmatitic granite, Craig Township.

Abbreviations

Med.g.	Medium grained
Med.g. to c.g.	Medium grained to coarse grained
f.g.	Fine grained
f. to c.g.	Fine to coarse grained
X	Present in minor amounts.

Note: Chemical analyses by Geoscience Laboratories, Ontario Geological Survey.

groundmass of oligoclase, quartz, and potassic feldspar. These pegmatites have a quartz monzonite composition.

The massive granitic rocks contain xenoliths of older rocks, chiefly mafic fragments. Some inclusions are sharp-bordered, whereas others have been partly assimilated and have a diffuse wispy appearance. A non-penetrative cataclastic foliation is present locally, and there are numerous dikes of metagabbro, Sudbury-type breccia, and biotite-rich, lamprophyric breccia. Magnetite is commonly present in the breccia seams.

Late Mafic Intrusive Dikes

Mafic dikes are prevalent throughout the area where they intrude the quartz monzonite, the older gneisses, and the metavolcanic-metasedimentary rocks of the Benny Belt. In addition, there are two small composite mafic to intermediate plutons in the western part of the map-area.

The metagabbro dikes are essentially undeformed, transect earlier-formed tectonic structures in the older rocks, and consequently are post-tectonic with respect to the major Early Precambrian deformation. The dikes have been metamorphosed, probably by the Middle Precambrian low grade regional metamorphism that also affected the Huronian rocks. The mafic dikes do not cut the Huronian sequence and hence were emplaced during the latter part of the Early Precambrian or the early part of the Middle Precambrian. No radiometric age data are available for the dikes within the map-area, but similar dikes to the north in the Matachewan area, the "Matachewan Diabase Dikes" have been dated at 2455 m.y. by K/Ar whole rock methods (Wanless *et al.* 1965) and at 2690 ± 93 m.y. by Rb/Sr whole rock methods (Gates and Hurley 1973). It is probable that the mafic dikes are approximately 2500 ± 100 m.y. old.

The metagabbro dikes are generally less than 15 m thick. These rocks form several prominent sets, one set trends north-northwest approximately parallel to the major north-northwest-trending fault system. Another dike set trends northeast approximately parallel to faults such as the Maltese Lake Fault and those in the Benny area in Moncrieff Township (see Figure 15, Chart A, back pocket). The approximate parallelism of dike sets and faults implies that there was regional tectonic control of dike emplacement.

The dike rock is a dark grey to black, medium-grained equigranular to coarsely porphyritic metagabbro. Subhedral to round, greenish white, altered plagioclase phenocrysts up to 5 cm in diameter are present in some intrusions. The dikes commonly display fine-grained chilled margins. These rocks are composed of saussuritized plagioclase (labradorite), epidote, quartz, biotite, chlorite, sphene, iron oxides, and sulphides. Amphibole is seen to be pseudomorphous after pyroxene in some of the samples studied.

The age of the composite plutons in the west is unknown. The plutons are undeformed, only partly altered mineralogically, and apparently intrude quartz monzonite of the Cartier Batholith. The plutons are not in contact with Huronian rocks, so no upper limit can be placed on their age. As far as can be ascertained, however, these rocks are of approximately the same age as the Matachewan-type mafic dikes.

The plutons are elliptical bodies approximately 0.4 to 0.8 km in diameter and consist of hornblende granodiorite, hornblende syenodiorite, gabbro, and feldspathic pyroxenite. The hornblende granodiorite and syenodiorite are reddish, coarse-grained (1 to 5 mm) subporphyritic rocks composed of plagioclase, hornblende, potassic feldspar, quartz, biotite, chlorite, epidote, sphene, and iron oxides. The plagioclase, originally a zoned intermediate variety, is variably saussuritized and forms phenocrysts up to 5 mm in diameter. The gabbro is a dark grey to black rock composed mainly of plagioclase (labradorite), hornblende, and biotite with minor quartz, epidote, carbonate, sphene, chlorite, and iron oxides. The pyroxenite is a black coarse-grained (0.5 mm to 2 cm) rock composed mainly of subhedral to euhedral clinopyroxene and orthopyroxene grains with biotite, amphiboles, talc, chlorite, iron-oxides, and minor interstitial calcic plagioclase. Plagioclase and clinopyroxene are commonly fresh, whereas the orthopyroxene is generally partly altered to fine-grained pseudomorphic aggregates of amphibole and talc. Pyroxene commonly forms poikilitic crystals up to several cm in length with abundant inclusions of the other minerals.

Chemical and modal analyses of metagabbro dikes and of rocks from the composite plutons are given in Table 6.

MIDDLE PRECAMBRIAN

Huronian Supergroup

Middle Precambrian metasediments of the Huronian Supergroup form a number of outliers unconformably overlying the Early Precambrian basement rocks of the map-area. The Huronian supracrustal rocks comprise the following: the Mississagi Formation of the Hough Lake Group, the Bruce, Espanola, and Serpent Formations of the Quirke Lake Group; and the Gowganda and Lorrain Formations of the Cobalt Group. These rocks, mainly coarse clastic sedimentary rocks were derived from the adjacent Early Precambrian terrain and were deposited in basins superimposed on the Early Precambrian crust. The Huronian strata were later erratically deformed and mildly metamorphosed. This probably occurred during the same Middle Precambrian deformational-metamorphic events that affected Huronian rocks in areas to the south some 1700 to 2200 m.y. ago.

The contact between the Huronian cover rocks and the Early Precambrian basement is an erosional unconformity that has been erratically deformed. In a few localities, the unconformity is flat-lying and undisturbed, but for the most part it has been faulted and rotated. Faults commonly form the Huronian-basement contacts. These faults penetrated the basement, formed a series of blocks that were rotated and moved vertically, and carried the Huronian cover with them. These movements resulted in passive deformation, and probably, the gravity sliding of large blocks of the Huronian cover rocks.

The Huronian outliers are confined to the eastern part of the map-area, east of a line extending from northeastern Tofflemire Township to central Ulster Township. The outliers in the map-area are part of a series of Huronian remnants that form an arcuate belt north of the Sudbury Structure. This belt extends northward and eastward from Porter and Vernon Townships, through the Benny area to join with the extensive Huronian cover of the Cobalt Embayment (see Card and Lumbers 1977). The Huronian outliers probably represent the remnants of a formerly more extensive cover that has been largely removed by erosion. It is also probable that the distribution of these remnants reflects the configuration of the original basin. Essentially, these remnants represent the deepest parts of an arcuate basin or system of basins that were formed during the early part of the Middle Precambrian about the northern margin of a positive area that is presently occupied by the Sudbury Structure. The trend of the arcuate belt of Huronian remnants is approximately parallel to a northeast-trending regional fault system. Thus, the depositional basins were probably controlled by movements on these structures.

Strata of the lower part of the Huronian Supergroup, namely the Hough Lake and Quirke Lake Groups are confined to the southeastern part of the map-area. North and west of a line extending from north-central Hart Township to Bannerman Lake and thence eastward to the northeast corner of Hess Township; rocks of the upper part of the Huronian Supergroup, namely the Gowganda and Lorrain Formations lie directly on Early Precambrian basement. South and east of this line, rocks of the lower part of the Huronian, including the Mississagi, Bruce, and Espanola Formations lie unconformably on the basement rocks.

The unconformable contact between the Lorrain Formation and Early Precambrian granitic rocks is exposed in northeastern Tofflemire Township. Here, a thin unit of black siltstone lies on an undulating erosion surface developed on coarse-grained porphyritic monzonite of the Cartier Batholith.

The unconformable contact between the Gowganda Formation and the Early Precambrian rocks is exposed at a number of localities. In northeastern Moncrieff Township, flat-lying Gowganda conglomerate rests on an irregular erosion surface developed on steeply-dipping, foliated units of Early Precambrian metavolcanics. Here, the basal Gowganda conglomerate contains a high proportion of angular volcanic fragments derived from the underlying bedrock. In southeastern Ulster Township, gently dipping Gowganda sedimentary rocks overlie Early Precambrian gneissic granodiorite that is intruded by several Early Precambrian metagabbro and aplite dikes. Below the Huronian strata, the granodiorite is disrupted and joints and fractures are filled with mud [wacke]. Above this surface, there is a unit of conglomerate consisting of angular blocks of granodiorite with minor metagabbro and aplite fragments in a massive greenish black muddy matrix. The basement rock fragments have been moved only very short distances. A few metres higher in the section, the rock is a paraconglomerate with a variety of angular to subrounded granitic, volcanic, and metagabbro pebbles in a laminated muddy matrix. On the north shore of Geneva Lake in Hess Township, rocks of the Gowganda Formation rest on an undulating erosion surface developed on pink, equigranular quartz monzonite. There is local relief on this surface of up to 1.5 m, and the overlying basal conglomeratic unit pinches out against this basement high.

Carbonate-rich rocks of the Espanola Formation lie directly on granitic basement rocks of the Cartier Batholith at a number of localities in Hart, Mon-

TABLE 8 CHEMICAL ANALYSES AND MODAL ANALYSES OF HURONIAN ROCKS, BENNY AREA.

Sample Number	101	102	103	104	105	106	107	108
				Major Components in Weight Percent				
SiO_2	9.65	7.82	2.46	6.00	6.53	40.50	7.37	69.30
Al_2O_3	1.85	1.69	1.10	1.40	1.50	4.67	0.90	12.40
Fe_2O_3	0.00	0.07	3.30	0.33	0.33	6.73	0.32	2.91
FeO	0.57	0.57		1.32	1.40	8.25	2.59	1.19
MgO	0.93	0.74	18.20	1.40	1.60	4.00	1.67	2.93
CaO	48.30	49.20	31.20	48.60	48.80	19.30	27.80	2.07
Na_2O	0.13	0.11	—	0.08	0.08	0.00	0.05	0.62
K_2O	0.38	0.48	—	0.17	0.17	0.03	0.27	4.53
TiO_2	0.10	0.09	—	0.10	0.10	0.19	0.10	0.40
P_2O_5	0.02	0.02	—	0.02	0.02	0.09	0.02	0.15
S	0.03	0.03	0.02	0.03	0.02	0.11	0.02	0.11
MnO	0.13	0.03	1.19	0.06	0.08	0.13	0.12	0.07
CO_2	38.40	38.70	43.30	39.20	39.10	14.80	41.60	1.36
H_2O^+	0.04	0.13	—	0.09	0.17	2.29	0.00	0.99
H_2O^-	0.17	0.07	—	0.35	0.37	0.31	0.31	0.26
Total	100.70	99.80	100.80	99.10	100.20	101.40	98.20	99.30
S.G.	2.73	2.73	—	2.73	2.87	2.73	2.77	2.69

Trace Elements in ppm

	101	102	103	104	105	106	107	108
Ag				<1	< 1	< 1	< 1	< 1
Ba	100	170		50	60	50	60	460
Be	< 1	< 1		< 1	< 1	3	2	5
Co	< 5	< 5		< 5	< 5	10	< 5	10
Cr	20	15		15	15	50	10	115
Cu	8	8		15	15	1800	110	10
Ga	< 10	< 10		2	2	20	2	30
Li	4	3		5	5	5	3	15
Mo	< 1	< 1		< 1	< 1	8	< 1	< 1
Ni	< 5	8		5	5	35	< 5	30
Pb	< 10	< 10		< 10	< 10	< 10	40	< 10
Sc	100	100		< 5	< 5	7	< 5	15
Sn	< 1	< 1		< 3	< 3	4	< 3	6
Sr	300	400		700	700	100	50	100
V	20	< 10		15	20	35	10	50
Y	< 10	< 10		< 10	< 10	10	20	25
Zn	15	8		10	10	20	35	70
Zr	< 10	< 10		30	20	150	15	300

Sample Descriptions

101.	BC-73-57	V.f.g., light grey banded limestone-siltstone, Espanola Fm., Geneva Lake, Hess Tp.
102.	BC-73-60	Buff coloured, v.f.g., poorly foliated limestone; 1250 m W of W Tp. line, Lot 10, Conc. 3, SW¼, S½, Hess Tp.
103.	BI-73-184	Dolostone, Espanola Formation, Hess Tp. S½, Lot 7, Conc. 4.
104.	Bardswich 1	Sandy limestone, Espanola Formation, Hess Lake, Hess Tp.
105.	Bardswich 1D	Sandy limestone, Espanola Formation, Hess Lake, Hess Tp.

Table 8 - continued on next page.

106. Bardswich 2	Calcareous siltstone with sulphides, Espanola Formation, Hess Lake, Hess Tp.
107. Silt Lake 1	Sandy dolostone, Espanola Formation, Silt Lake, Hess Tp.
108. Silt Lake 2	Sandy dolostone, Espanola Formation, Silt Lake, Hess Tp.

Modal Analyses in Volume Percent

Sample Number	BI-73 -231	BI-73 -209	BJ-73 -5	BI-73 -227	BC-71 -15	BC-73 -51	BJ-73 -14	BJ-73 -48	BJ-73 -2
Quartz	23.0	41.4	51.5	22.0	25.2	7.1	45.2	39.6	65.6
Feldspar	25.4	51.0	12.0	16.3	22.2	4.5	46.8	38.4	20.2
Rock Fragments	27.2	5.2	8.2	1.5	41.0	73.6	X	19.0	
Matrix	17.4			59.5				5.0	
Sericite	X			X	X	4.7	X		
Biotite	X		17.5		9.4	10.1	X		3.8
Chlorite	X		X		2.2				
Carbonate	7.0	2.0	10.8	X			8.0		10.2
Epidote									
Iron-titanium Oxides	X		X	0.7	X	X	X	X	X
Sulphides		X	X		X	X	X		0.2

Sample Number	BC-73 -11	BC-73 -50	BI-73 -169	BI-73 -167	BI-73 -127	BJ-73 -19	BI-73 -173	BC-73 -97
Quartz	45.0	40.8	66.2	42.2	63.0	63.8	69.8	60.0
Feldspar	48.1	39.2	18.0	57.0	0.6	X		
Rock Fragments					X	1.6	1.4	20.4
Matrix	6.3		15.8		35.2	34.2	28.2	
Sericite					X	X		19.6
Biotite		20.0						
Chlorite	X			0.8				
Carbonate	X							
Epidote	X							
Iron Oxides	0.6	X	X	X		0.4	X	
Sulphides		X	X			X		
Apatite				X				
Zircon					X			
Tourmaline						X		
Andalusite							X	X

Sample Descriptions	
BI-73-231	Pebbly sandstone, Serpent Formation, western Hess Township.
BI-73-209	Pebbly sandstone, Serpent Formation, Hess Township.
BJ-73-5	Pebbly sandstone, Serpent Formation, western Hess Township.
BI-73-227	Wacke, Serpent Formation, western Hess Township.
BC-73-15	Polymictic conglomerate, Gowganda Formation, Hess Township.
BC-73-51	Polymictic conglomerate, Gowganda Formation, Hess Township.
BC-73-14	Conglomeratic sandstone, Gowganda Formation, Hess Township.
BI-73-48	Pebbly sandstone, Gowganda Formation, Ulster Township.
BJ-73-2	Sandstone, Gowganda Formation, western Hess Township.
BC-73-11	Sandstone, Gowganda Formation, Ulster Township.

Table 8 continued

BC-73-50	Silty sandstone, Gowganda Formation, Hess Township.
BI-73-169	Feldspathic sandstone, Lorrain Formation, Moncrieff Township.
BI-73-167	Arkose, Lorrain Formation, eastern Moncrieff Township.
BI-73-127	Micaceous sandstone, Lorrain Formation, northeastern Hess Township.
BJ-73-19	Green micaceous sandstone, Lorrain Formation, Hess Township.
BI-73-173	Pebbly sandstone, Lorrain Formation, Hess Township.
BC-73-97	Pebbly sandstone, Lorrain Formation, Moncrieff Township.

Abbreviations

v.f.g. — Very fine grained
S.G. — Specific Gravity
X — Present in minor amounts.
< — Less than

Note: Chemical analyses by Geoscience Laboratories, Ontario Geological Survey.

crieff, and Hess Townships. These occurrences are all essentially bedded limestone and dolostone resting on a relatively smooth erosion surface. Commonly, the erosion surface and the overlying sedimentary rocks have been tilted into nearly-vertical attitudes.

Conglomeratic rocks of the Bruce Formation and sandstone and conglomerate of the Mississagi Formation locally form the base of the Huronian sequence in Hess Township. These units are generally only a few metres thick, and like the Espanola Formation, rest unconformably on a relatively smooth, deformed, erosion surface developed on the Early Precambrian basement rocks.

Chemical and modal analyses of Huronian rocks are given in Table 8.

HOUGH LAKE GROUP

Mississagi Formation

A lens of sandstone and conglomerate tentatively correlated with the Mississagi Formation occurs along the boundary between Moncrieff and Hess Townships south of Geneva Lake. This unit has a maximum thickness of 20 m and consists of medium-bedded, medium-grained, white weathering sandstone with minor silty partings and beds of conglomerate and conglomeratic sandstone that consists of lenses and scattered pebbles of quartz, chert, granite, and metavolcanics in a micaceous sandstone matrix.

The foregoing rocks rest unconformably on an irregular erosion surface developed on Early Precambrian granitic basement rocks and are overlain by conglomerate of the Bruce Formation. Quirke (1920) and Osborne (1929a) correlated rocks lying above the Early Precambrian basement and below the Espanola Formation at several other localities with the Mississagi Formation. These units are mainly conglomerates similar to those of the Bruce Formation and are so correlated in this report.

QUIRKE LAKE GROUP

Bruce Formation

Conglomeratic rocks correlated with the Bruce Formation occur at a number of localities in Hess and Moncrieff Townships. These conglomeratic units are generally only a few metres thick, are lensoid, and fill depressions in the ancient erosion surface developed on the Early Precambrian basement rocks. West of the Canadian Pacific Railway tracks in western Hess Township, these rocks overlie sandstone of the Mississagi Formation. East of the railway, the conglomeratic rocks rest directly on granitic basement. The basal sediment is a coarse, rubbly conglomerate containing large angular fragments of the underlying bedrock. This is overlain by a unit of coarse conglomerate with subangular to subrounded fragments of granitic, metavolcanic, and metasedimentary rocks averaging 5 cm in diameter set in a coarse wacke matrix.

Conglomeratic rocks correlated with the Bruce Formation unconformably overlie the granitic basement, and are overlain by rocks of the Espanola Formation north of a small pond in central Hess Township, on the north shore of a second pond in northeastern Hess Township, and in northwestern Harty Township. The conglomerate is polymictic, has a disrupted framework, and consists of granitic, metavolcanic, and metasedimentary clasts up to 8 cm in diameter set in a dark-weathering, commonly pyritic, feldspathic wacke matrix. Interbeds of sandstone and siltstone are present. On the southern shore of Geneva Lake there is a remnant of Bruce conglomerate resting on granitic basement. On nearby islands composed of granitic rocks, there are surfaces with weathered, broken granite fragments cemented by seams of mudstone. These surfaces probably represent exhumed paleo-weathering surfaces developed at the base of the Huronian sequence by erosion during the Eparchean Interval.

Espanola Formation

Limestone, dolostone, sandstone, and siltstone of the Espanola Formation occur in north-central Hart Township, in Moncrieff Township south of Bannerman Lake, in southwestern Hess Township south of Clear Lake[1], and as a discontinuous outcrop belt extending from Silt Lake in western Hess Township to

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[1] This lake is known in the region as Hess Lake, but the Nomenclature Section has changed it to Clear Lake.

northwestern Harty Township. The formation ranges in thickness from less than 15 m to over 90 m and averages about 45 m. For the most part, the Espanola Formation lies unconformably on the Early Precambrian basement rocks; locally it conformably overlies conglomerate of the Bruce Formation.

The Espanola Formation can be subdivided into a lower limestone-dolostone member 15 to 60 m thick, and an upper siltstone- sandstone member 15 to 30 m thick. The lower member comprises thin-bedded, less than 2.5 cm thick units of white-weathering limestone and buff-weathering dolostone with thin, 0.5 to 2 cm thick, brown to black weathering siltstone interbeds, and thicker bedded, 2.5 to 30 cm thick, dolomitic limestone and dolostone units with minor amounts of siltstone. Some dolostone and limestone units contain appreciable amounts of detrital quartz and feldspar, either scattered throughout the bed, or forming sandy laminae and interbeds up to 30 cm thick. On weathering, variations in the proportions of carbonates, silt, and sand present from bed to bed have resulted in an irregular, ribbed weathering surface. Sedimentary breccia units consisting of angular fragments of limestone, dolostone, and siltstone up to 5 cm in length occur in a massive limestone matrix, and are present along the southeastern shore of Geneva Lake and in central Hess Township. The breccia chips are commonly arranged in an imbricate fashion.

The upper member comprises thin-bedded (less than 2 cm) laminated siltstone and thicker bedded (2 to 15 cm) interbedded siltstone and sandstone. Variable, but generally minor amounts of carbonate minerals are present throughout the sequence, and locally there are thin units of calcareous siltstone and silty limestone. Light-coloured quartz-feldspar sandstone and dark coloured wacke are present in the member. Parallel laminations, cross-laminations, lensoid beds, and graded beds are common.

A generalized section through the Espanola Formation, measured in central Hess Township, is as follows:

Lower Carbonate Member

0.0-0.9 m - Thin-bedded, laminated, white sandy limestone with siltstone interbeds.

0.9-5.4 m - Thin-bedded buff weathering silty dolostone.

5.4-8.4 m - White-weathering, laminated, thin-bedded limestone with thin siltstone interbeds.

8.4-17.4 m - Medium-bedded to thick-bedded (15 to 30 cm) dolostone and dolomitic limestone with minor siltstone interbeds.

17.4-23.4 m - Thin-bedded, white weathering limestone with siltstone interbeds. The proportion of siltstone increases upward from about 15 percent to 50 percent.

Upper Siltstone - Sandstone Member

0-1.0 m - Thin bedded, laminated black pyritic siltstone with dolomitic siltstone interbeds.

1.0-13.0 m - Siltstone with interbeds of quartz-feldspar sandstone and wacke. Cross-laminations and lensoid beds are prevalent.

13.0-14.2 m - Thin-bedded calcareous siltstone and silty limestone.

14.2-17.3 m - Thin-bedded siltstone and sandstone with the proportion of sandstone increasing upward in a transitional contact zone with the overlying Serpent Formation.

The carbonate-rich rocks of the Espanola Formation consist of variable proportions of calcite and dolomite with lesser amounts of detrital quartz and feldspar and phyllosilicate minerals including biotite, phlogopite, chlorite, muscovite, epidote, and pyrite. Locally, south of Clear Lake in Hess Township, quartz and feldspars are major components, forming sandy limestone, dolostone, and calcareous sandstone. The thin-bedded, relatively pure limestone-dolostone beds display graded bedding; the size of the carbonate grains decreases upward from about 0.6 mm at the base to 0.04 mm at the top of each graded unit and the proportion of micaceous minerals increases. Recrystallization and replacement textures are common, especially in the thicker bedded dolostone units where patches of coarsely recrystallized dolomite, calcite, and quartz occur. Near Nipissing Diabase intrusions, the carbonate-rich and silty rocks have been contact metamorphosed, and scapolite, tremolite-actinolite, chlorite, wollastonite, and diopside porphyroblasts have developed. Magnetite and sulphide minerals, including pyrite, sphalerite, galena, and chalcopyrite occur in these recrystallized, contact metamorphosed rocks.

The dark-weathered siltstone interbeds in the calcareous units consist of fine-grained (0.01 mm or less) chlorite, epidote, biotite, muscovite, carbonate, quartz, feldspar, and opaque minerals. The siltstones of the upper part of the formation are mineralogically similar and are commonly laminated with alternating fine-grained, mica rich laminae, and coarser, silt to fine sand laminae. Some beds are graded, others are cross-laminated.

Sandstones of the Espanola Formation are of two types; poorly sorted, fine- to medium-grained (0.1 to 1 mm) wacke consisting of angular to subrounded grains of quartz and feldspar in an abundant micaceous matrix; and better-sorted, thin- to medium-bedded, quartz-feldspar sandstone commonly containing carbonate cement. Chemical and modal analyses of typical rocks of the Espanola Formation are given in Table 8.

Serpent Formation

Rocks of the Serpent Formation, including quartz-feldspar sandstone, conglomeratic sandstone, conglomerate, wacke, and siltstone occur in western Hess and adjacent Moncrieff Township, in central and northeastern Hess Township, and in northern Hart Township. Some of the rocks near Bannerman Lake in Moncrieff Township that were correlated by previous workers (Quirke 1920; Osborne 1929a) with the Serpent Formation are herein correlated with the Gowganda Formation. Because of the conglomeratic nature of the Serpent Formation in the map-area, distinction of the Serpent and Gowganda Formations is not straight forward, and the correlations made are tentative.

The contact between the Serpent Formation and the underlying Espanola Formation is conformable and gradational over a stratigraphic interval some 5 to 10 m thick which consists of interbedded siltstone and sandstone. The base of the Serpent Formation was placed within this zone at the base of the first relatively thick-bedded (0.3 to 0.6 m) quartz-feldspar sandstone unit.

In northern Hart Township, the Serpent Formation is approximately 60 to 90 m thick and consists of quartz-feldspar sandstone with silty partings and interbeds. In western Hess and adjacent Moncrieff Township, the Serpent Formation is about 450 m thick and comprises crossbedded feldspathic sandstone, conglomeratic sandstone, and conglomerate. In the narrows at the west end of Geneva Lake, the Serpent Formation comprises coarse-grained, conglomeratic sandstone with lenses of quartz pebble-rich conglomerate and greenish siltstone. On the island to the north, conglomeratic sandstone with scattered pebbles averaging 2 cm in diameter is overlain by thin-bedded wacke and siltstone with linguoid and asymmetric ripples.

In the main outcrop area in central Hess Township, the Serpent Formation ranges in thickness from a maximum of about 240 m in the east to 450 to 600 m in the central part of the Benny Belt, and thins eastward toward the eastern boundary of Hess Township. It is apparently absent in northeastern Harty Township.

The lower part of the Serpent Formation consists of quartz-feldspar sandstone, conglomeratic sandstone, conglomerate, siltstone, and wacke. The bedding is generally 0.3 to 0.6 m thick in the basal parts and thickens to 0.9 m or more in the coarse, crossbedded conglomeratic units. Lensoid beds, scour-and-fill structures, and mud-chip breccias are common in this section. The upper part of the formation consists mainly of thick-bedded (0.6 to 1.5 m), crossbedded and parallel laminated feldspathic sandstone with interbeds and partings of wacke and siltstone.

Sandstone of the Serpent Formation is medium to coarse grained, poorly to moderately sorted, and consists mainly of quartz and feldspar with lesser amounts of muscovite, biotite, and chlorite. Carbonate cement is common as well as pyrite. Feldspar is present in amounts of 10 to 50 percent and plagioclase is generally the dominant feldspar species. One sandstone unit in central Hess Township contains hematite as disseminations and grain coatings; other members are rich in carbonate minerals and pyrite.

Pebbles present in the conglomeratic rocks are rounded, average 2.5 to 5 cm in diameter, and are mainly quartz and granite with lesser chert and volcanic fragments. The pebbles are either scattered throughout the coarse conglomeratic sandstone beds, or concentrated to form conglomerate lenses and interbeds with approximately 70 percent pebbles in a coarse, gritty matrix rich in quartz and feldspar.

Siltstone and wacke of the Serpent Formation are thin bedded laminated rocks consisting of variable proportions of silt and fine sand size quartz, feldspar, and rock fragments with abundant interstitial biotite, chlorite, muscovite, carbonate, iron oxides, and sulphides.

Modal analyses of typical rocks of the Serpent Formation are given in Table 8.

COBALT GROUP

Gowganda Formation

Rocks of the Gowganda Formation form parts of a number of outliers in the eastern half of the map-area. In the northeast, the Gowganda Formation rests directly on an erosional unconformity developed on the Early Precambrian basement rocks. In the southeast, the Gowganda strata overlie older Huronian formations which are, mainly conglomeratic sandstones of the Serpent Formation. The contact between the Gowganda and Serpent Formations is not clearly defined, although Quirke (1920) described the contact relationship between these two formations as "inconspicuously unconformable". For the most part, the present authors could discern no unconformity at the base of the Gowganda Formation in the map-area and the contact appears gradational. During the mapping, the base of the Gowganda Formation was arbitrarily placed at the base of the first major unit of polymictic conglomerate with a wacke matrix. In northwestern Harty Township, the base of the Gowganda Formation rests directly on rocks of the Espanola Formation; there are large blocks of Espanola limestone incorporated in the basal Gowganda Formation.

Rocks of the Gowganda Formation occur in northern Harty Township, in northern Moncrieff Township, and southern Ulster Township, Munster Township, and in a belt extending from east-central Moncrieff Township to southwestern Leinster Township. The formation ranges in thickness from 150 to 600 m and is generally 360 to 450 m thick. The lower half of the formation is conglomeratic, whereas the upper half consists mainly of siltstone and sandstone. The proportion of sandstone increases upward.

The Gowganda Formation in northwestern Hart Township is exposed on the east and west limbs of a synclinal structure. It overlies rocks of the Serpent Formation on the east limb and rests unconformably on granitic basement on the west limb. The eastern sequence is approximately 350 m thick and consists of about 200 m of orthoconglomerate and paraconglomerate with intercalations of siltstone, wacke, and quartz-feldspar sandstone overlain by 150 m of sandstone and siltstone with conglomerate lenses. The western sequence is approximately 180 m thick, thickens southward, and comprises a lower conglomeratic unit and an upper sandstone-siltstone sequence.

The Gowganda outliers in northern Moncrieff Township and in Ulster and Munster Townships are fault-bounded remnants resting directly on an erosion surface developed on the Early Precambrian basement. A conglomerate consisting of angular fragments of underlying basement rocks is commonly found at the base of the formation and this grades upward into stratified orthoconglomerate, paraconglomerate, siltstone, and sandstone. Boulders up to 20 m in diameter are present in the lower conglomeratic sedimentary rocks. Siltstone and sandstone display laminated bedding, graded beds, cross-laminations, ball-and-pillow structures, slump-breccia, and pebble dikes.

At the western end of Geneva Lake, where the Gowganda Formtion is up to 600 m thick, the lower 240 m consists of orthoconglomerate and paraconglomerate with interbedded siltstone and sandstone. This is succeeded by 120 m of wacke and siltstone with scattered clasts and slump structures, and by some 240 m of interbedded sandstone and siltstone with conglomerate lenses. The formation thins rapidly northeastward. On the north shore of Geneva Lake it is approximately 150 m thick.

In the main outcrop belt extending eastward from Geneva Lake to southwestern Leinster Township, the Gowganda Formation is approximately 350 to 450 m thick. The lower 180 to 240 m comprises alternating conglomeratic and siltstone-sandstone units. The conglomeratic units consist of boulder-rich orthoconglomerate, and paraconglomerate (pebbly sandstone, mudstone). The siltstone-sandstone units include fine-grained wacke, arkose, laminated siltstone, and irregularly laminated siltstone-sandstone. The upper 150 to 200 m consists of interbedded siltstone, wacke, and quartz-feldspar sandstone with a few conglomerate lenses. There is a prominent unit of sandstone-siltstone slump breccia approximately 30 m thick in the upper half of the formation. This rock consists of contorted masses of silty sandstone up to 10 m long in a sandy siltstone matrix. There are also repetitions of thin regularly bedded and laminated siltstone and irregularly laminated, wavy bedded siltstone-wacke units.

A variety of sedimentary structures is present in the Gowganda Formation. The conglomeratic units display internal stratification, sorting, channeling, and locally, grading. "Drop stones", relatively coarse clasts in a laminated fine-grained wacke matrix, are present in the paraconglomerate units. The siltstone-sandstone sequences display fine, regularly laminated bedding, coarser irregular laminae with lensoid sand units that represent "starved" ripples, ripple cross-lamination, graded beds, and abundant evidence of slumping and mass flow, including load casts, flames, ball-and-pillow structures, and slump breccias.

Conglomeratic rocks of the Gowganda Formation are of two main types: polymictic orthoconglomerate with a relatively coarse wacke matrix; and polymictic paraconglomerate (pebbly mudstone) consisting of scattered clasts in a massive or laminated fine-grained wacke-siltstone matrix. The orthoconglomerate beds are commonly lensoid, 0.6 to 1.5 m thick, display some evidence of sorting, and are interbedded with feldspathic sandstone, siltstone, and wacke. The pebbles are generally subrounded, average 3 to 5 cm in diameter, and are as much as 40 cm in diameter. They are mainly granitic, with lesser amounts of mafic and felsic igneous, quartz, and quartzite clasts. The basal conglomerate units are generally rich in angular clasts of the underlying basement rocks. The orthoconglomerate matrix is a poorly sorted, coarse-grained (1 to 5 mm) rock composed of angular to subrounded grains of quartz, feldspars, and rock fragments with interstitial phyllosilicates and carbonate minerals. Fine-grained metavolcanic fragments constitute the bulk of the sand-size rock fragments which are present in most of the samples studied.

The interbedded coarse-grained, pebbly sandstones are essentially similar to orthoconglomerate and consist of scattered rock fragments and poorly sorted, subangular grains of quartz and feldspars with interstitial micas and carbonate minerals.

Polymictic paraconglomerate consists of 5 to 30 percent clasts in a massive, fine-grained wacke or laminated siltstone matrix. The angular to subrounded clasts are commonly less than 5 cm in diameter, but range up to 30 cm. Granitic clasts are dominant, although mafic and felsic volcanic, metagabbro, quartz, and gneiss clasts also occur in the rock.

The Gowganda siltstones are thin-bedded (2 mm to 1 cm), commonly laminated (0.1 to 2 mm) rocks consisting of alternating light-coloured silty laminae and dark-coloured micaceous laminae. They are fine grained, although sand-size grains are commonly present disseminated throughout the beds or aligned in rows or lenses parallel to bedding. The wackes are fine- to medium-grained, poorly sorted rocks consisting of 30 to 70 percent sand-size grains up to 1 mm in diameter in a phyllosilicate-rich matrix. The Gowganda siltstone and wacke consist of quartz, feldspars, rock fragments, muscovite, biotite, chlorite, iron oxides, and sulphides.

The quartz-feldspar sandstones of the Gowganda Formation are generally rich in feldspars, plagioclase and potassic feldspar, and consequently are arkose or arkosic wacke. Modal analyses of typical rocks of the Gowganda Formation are given in Table 8.

Lorrain Formation

Rocks of the Lorrain Formation form the upper parts of Huronian outliers in northeastern Tofflemire Township, northern Hart Township, to the west and north of Geneva Lake in Moncrieff Township, and in Hess Township south of Geneva Lake. Erosion has removed the upper part of the Lorrain Formation in the Benny map-area leaving a maximum preserved thickness of approximately 450 to 600 m.

The Lorrain Formation in the map-area is divisible into four conformable lithostratigraphic units:

(1) *Lower Arkose Member* - approximately 60 m of medium- to coarse-grained arkose. The basal sandstones are commonly silty and in Tofflemire Township, a black siltstone unit approximately 3 m thick at the base of the Lorrain Formation rests directly on Early Precambrian granitic basement rocks. The average grain-size of the sandstone of this unit increases upward, as does the average bedding thickness from approximately 0.1 to 0.5 m to 0.2 to 1.5 m. Crossbedding is present.

(2) *Green Micaceous Sandstone Member* - 120 to 180 m of green, micaceous sandstone with scattered pebbles and conglomerate lenses. The sandstones of the lower 15 to 30 m of this unit are fine to medium grained, medium bedded (0.1 to 0.6 m), and contain green silty sandstone partings and interbeds 2 to 15 cm thick. The sandstones of the remainder of the unit are coarse grained, thick-bedded (0.6 to 1.8 m), and contain scattered pebbles and conglomerate lenses. The conglomerate lenses are commonly 2 to 30 cm thick and consist of 70 to 90 percent rounded quartz, chert, and jasper pebbles less than 2.5 cm in diameter. There are a number of sedimentary cycles within the Green Micaceous Sandstone Member consisting of a thick lower unit of pebbly sandstone, a thin middle conglomerate unit, and a thin upper silty sandstone unit. Each of these cycles may represent an influx of unsorted detritus, followed by winnowing of the upper parts and removal of the finer mate-

rial leaving the coarser detritus as a lag pebble deposit. The overlying silty sandstone units may represent the finer materials deposited during "inter-flood" stages.

Toward the top of the Green Micaceous Member, there are interbeds and units of buff, hematitic sandstone similar to that of the succeeding member.

(3) *Buff Sandstone Member* - 120 to 150 m of buff, orange, and reddish micaceous sandstone with scattered pebbles and conglomerate lenses. The beds in this member are commonly 1 to 2 m thick, and festoon crossbedding is present.

(4) *White Sandstone Member* - up to 150 m of thick-bedded (0.3 to 1.2 m), medium-grained, white micaceous sandstone. Scattered pebbles and conglomerate lenses are prevalent.

The sandstones of the Lower Arkose Member are poorly to moderately sorted, medium- to coarse-grained rocks consisting of quartz, feldspars, and chert and granitic rock fragments with minor (1 to 15 percent) interstitial muscovite, chlorite, and chert.

The sandstones of the Green, Micaceous, Buff, and White Members are all texturally and mineralogically similar. These are medium- to coarse-grained, moderately sorted rocks consisting of quartz and chert fragments in an abundant (25 to 35 percent) matrix rich in phyllosilicates.

Highly altered feldspars and granitic rock fragments are present in some of the green sandstones. The dominant phyllosilicate in these rocks is a greenish ferri-muscovite. The buff sandstones owe their colour to minor amounts of hematite that occur as grain coatings and disseminations. Metamorphic porphyroblasts of andalusite are present in the white sandstones. In one sample, clumps of euhedral tourmaline crystals of metamorphic or hydrothermal origin were noted.

NIPISSING DIABASE

Tholeiitic gabbro bodies of the Nipissing Diabase suite intrude Huronian and older rocks in the Benny map-area. These rocks form a group of mafic dikes, sills, cone-sheets, and irregular bodies that were emplaced about 2150 ± 30 m.y. ago throughout the eastern part of the Southern Province and adjacent parts of the Superior Province (Van Schmus 1965; Card and Pattison 1973).

Irregular dike-like bodies of Nipissing Diabase approximately 150 to 450 m in outcrop width occur in the eastern half of the map-area in the same general area as the Huronian rocks. The intrusions mainly trend northeast, parallel to the structural-stratigraphic trends in the Huronian rocks and parallel to a system of northeast faults. Locally, however, Nipissing Diabase intrusions cut sharply across these trends. Emplacement of Nipissing Diabase intrusions was controlled, to a large extent, by pre-existing structures in the Huronian and Early Precambrian rocks. The Nipissing Diabase bodies are massive and unfoliated. Post-Nipissing deformation, other than movements on some faults, was negligible. They have been altered, probably by the same low-grade regional metamorphic event that affected the Huronian rocks.

The Nipissing Diabase intrusions comprise pyroxene gabbro, hornblende metagabbro, granophyric metagabbro, and granophyre. The pyroxene gabbro is a dark grey, brown-weathering, medium-grained (average 1 mm) rock composed of approximately equal proportions of plagioclase and pyroxene with minor quartz, micrographic intergrowth of quartz and feldspar, and ilmenite-magnetite. Minor amounts of secondary amphibole, mica, chlorite, talc, and epidote are commonly present. Both clinopyroxene (augite) and orthopyroxene (bronzite; inverted pigeonite) are present. The plagioclase is labradorite (An65 + 5). The texture is medium grained and doleritic, consisting of subhedral to euhedral plagioclase crystals, euhedral orthopyroxene crystals, and anhedral clinopyroxene, quartz, and micrographic intergrowth.

Metamorphic alteration of the gabbro occurs throughout the area, but is most prevalent in the south. Alteration begins along fractures in the gabbro and spreads outward from them. The pyroxenes are replaced by amphiboles, both actinolite and blue-green hornblende, the plagioclase is altered to albite and epidote. Ilmenite laths in the primary ilmenite-magnetite intergrowths are altered to leucoxene. Thus, metagabbro is a dark green to black rock consisting of variable proportions of amphiboles, plagioclase, quartz, epidote, biotite, chlorite, sphene, leucoxene, micrographic intergrowth, magnetite, and sulphides. Both actinolite and blue-green hornblende are present, and commonly the two minerals occur together with actinolitic cores being rimmed by hornblende. Granophyric metagabbro is similar to metagabbro except that quartz and micrographic intergrowth are present in amounts of 15 to 50 percent. Granophyric gabbro forms irregular masses with gradational contacts enclosed in the "normal" metagabbro. Minor amounts of granophyre, a pink, fine- to medium-grained rock consisting essentially of plagioclase, quartz, micrographic intergrowth, and lesser amounts of amphibole, chlorite, epidote, sphene, carbonate, apatite, zircon, and sulphides, form small irregular masses and dikes in some intrusions.

Nipissing Diabase intrusions commonly display well-developed rectangular joint sets. One body in Leinster Township is layered locally with alternating thin (1 to 2 cm) plagioclase-rich layers and thicker (5 to 10 cm), "normal" gabbro layers. Contacts with the country rocks are not well exposed; the contact phase is commonly fine-grained, chilled, schistose metagabbro. Magnetite and sulphide minerals are present in the country rocks near Nipissing Diabase intrusions at several locations. These are notably in areas where Nipissing Diabase intrudes carbonate-rich rocks of the Espanola Formation.

Chemical analyses, norms, and modal analyses of Nipissing Diabase samples are given in Table 6.

LAMPROPHYRE AND BRECCIA

Lamprophyre, lamprophyric breccia, and pseudotachylite or Sudbury-type breccia dikes cut the Nipissing Diabase and older rocks of the map-area. Lamprophyre and lamprophyric breccia dikes, all of which are too small to be shown as separate units on Maps 2434, 2435 (back pocket), occur erratically throughout the map-area. The distribution of Sudbury-type breccias is shown on Figure 16 (see Chart A, back pocket), and it can be seen that they are most abundant in the southeastern part of the map-area nearest the Sudbury Nickel Irruptive. These breccias constitute part of a zone of intensely brecciated country-rocks some 15 to 30 km wide surrounding the Nickel Irruptive. They were formed as a result of an explosive event of great magnitude centred at Sudbury. This event, variously ascribed to explosive volcanism (Speers 1957), or the impact of a meteorite (Dietz 1964), apparently occurred shortly before emplacement of the Sudbury Nickel Irruptive some 1840 m.y. ago (Krogh and Davis 1974). It should be noted that although Sudbury-type breccias are most prevalent near the Sudbury Structure, they are present, and even are abundant locally in areas many kilometres to the north of the map-area.

The absolute age or ages of the lamprophyre and lamprophyric breccia dikes are unknown, but in an outcrop of quartz monzonite 1 km south of Cartier, which forms part of the Cartier Batholith, a dike of lamprophyric breccia cuts a Sudbury-type breccia. This indicates a younger age for the lamprophyres. Rb-Sr age determinations by Van Schmus (1971) indicate that lamprophyre dikes in the Blind River area are 1415 + 40 m.y. old.

The lamprophyre and lamprophyric breccia dikes are narrow, generally less than 0.3 m wide, and can seldom be traced more than a few metres along strike. The lamprophyre dikes are dark grey to black, fine-grained rocks composed of biotite, amphibole, pyroxene, chlorite, calcite, and iron titanium oxides. Biotite typically forms phenocrysts up to 1 cm in length. A chemical analysis of a lamprophyre given in Table 6 shows that it is rich in CaO, MgO, and FeO, and poor in Al_2O_3 and SiO_2. The lamprophyric breccia dikes consist of rounded fragments of mafic rocks in a sparse, biotite-rich matrix.

The Sudbury-type breccias consist of rounded to angular disoriented fragments of country-rock in a very fine grained, dark-coloured rock flour matrix. The breccia has formed as a result of *in situ* attrition. The dark colour of the matrix is partly attributable to the fine grain-size and possibly to the presence of disseminated carbon. Sulphides, both pyrite and pyrrhotite, are locally present in the breccia as disseminations in the matrix and as rounded to ragged deformed fragments up to 1.5 cm in maximum dimension. The Sudbury-type breccias form dikes and irregular bodies that pervade the country-rocks with no apparent regard for pre-existing structures or lithological contrasts. Many of the breccia bodies are spatially associated with faults, topographic lineaments, and mafic intrusions.

SUDBURY NICKEL IRRUPTIVE

Foy Offset

A mafic dike that intrudes Early Precambrian granitic rocks in Hess Township in the eastern part of the map-area is tentatively correlated with the Foy Offset (Card and Meyn 1969), a dike-like offshoot from the Sudbury Nickel Irruptive. This was made on the basis of petrographic similarities and the common presence of nickel-copper sulphides. If the dike in the map-area is an extension of the Foy Offset, this offshoot is in excess of 32 km in length and represents the longest known offset dike of the Sudbury Nickel Irruptive.

The mafic dike correlated with the Foy Offset can be traced from a point near the Onaping River in Harty Township west-southwestward into Hess Township, a distance of about 2.5 km. The dike is 8 to 30 m wide, is probably near vertical, and intrudes brecciated, altered granitic rocks of the Cartier Batholith. The dike bifurcates at several localities, and narrow offshoots extend out into the country rocks. The dike rock is a dark-coloured, fine-grained altered quartz diorite or metagabbro consisting of saussuritized plagioclase, biotite, amphiboles, and quartz. Small 3 cm long granitic inclusions are locally abundant in the border zones, and locally, the dike appears to be a composite intrusion with fine-grained quartz diorite border zones and a medium-grained, sulphide-bearing interior zone.

Minor amounts of disseminated sulphide minerals are present, and at several localities disseminated to massive pyrrhotite with pentlandite and chalcopyrite form up to 30 percent of the dike. These occurrences have been tested by pits and diamond-drill holes.

LATE PRECAMBRIAN

Mafic Intrusive Rocks

Late, northwest-trending diabase dikes are the youngest rocks in the area, are unmetamorphosed and transect previously formed tectonic structures in both the Middle Precambrian and Early Precambrian rocks. These dikes are approximately parallel to northwest faults such as the Straight Lake Fault and the Munster Lake Fault and were apparently partly emplaced along such structures; they are displaced by late movements on northeast-trending faults. The dikes are part of a regional swarm, the Sudbury Swarm. Radiometric age investigations of a number of dikes throughout the region, namely the potassium-argon and rubidium-strontium methods have yielded dates in the range 1000 to 1460 m.y. (Van Schmus 1965; Wanless *et al.* 1968; Gates and Hurley 1973). It is probable that northwest-trending diabase dikes of more than one age are present. Many of them, probably including the dikes in the map-area, are approximately 1250 m.y. old.

Several late diabase dikes extend from northwestern Harty Township, through Hess Township into Ulster and Munster Townships in the eastern part of the map area. Another occurs along the Canadian Pacific Railway tracks in northwestern Moncrieff and southwestern Ulster Townships. The dikes are narrow, generally 15 to 30 m in outcrop width, dip vertically, weather recessively, and are consequently marked by narrow, linear valleys. The dikes commonly display well-developed rectangular joint sets and spheroidal weathering surfaces. They generally produce weak linear magnetic anomalies.

The dike rock is a medium- to coarse-grained (2 to 4 mm) grey alkali-olivine diabase with a sub-ophitic texture. Thin section studies of the dikes from the map-area reveal that they consist of about 60 percent plagioclase (labradorite), 15 percent olivine, 12 percent pyroxene (titaniferous augite), 5 to 10 percent magnetite-ilmenite, and accessory apatite (see Table 6). Minor amounts of secondary chlorite and biotite are present. The plagioclase forms euhedral laths, which along with equant grains of olivine, are enclosed or partly enclosed in interstitial anhedral pyroxene. Most dikes display narrow chilled margins consisting of small plagioclase laths, commonly aligned parallel to the contact, in a very fine grained, aphanitic groundmass. Several narrow diabase dikes are distinctly porphyritic, and contain euhedral plagioclase phenocrysts up to 3 cm in length.

Most dikes have produced little or no contact metamorphic effects on the adjacent country rocks, although at several localities, the country rocks display reddish discolouration (presumably due to hematite) and a "baked", recrystallized texture that extends outward from the dike contacts for as much as 3 m.

Phanerozoic

CENOZOIC

Quaternary

PLEISTOCENE AND RECENT

Unconsolidated surficial deposits of Pleistocene and Recent age partly cover much of the Precambrian bedrock of the map-area. The distribution and characteristics of these deposits, mainly the products of Pleistocene continental glaciation, are shown on Figure 15 (Chart A, back pocket).

The map-area was covered by glacial ice of the Late Wisconsinan advance. The most recent retreat of the Labrador Sector of the Laurentide ice sheet allowed the area to become essentially ice-free between 10 000 and 11 000 years ago (Burwasser 1976).

A series of major east-west trending morainic belts were formed in the Lake Superior-Northern Ontario region between 11 000 and 10 000 years ago as a cold climate resulted in successive halts in the general ice-retreat (Saarnisto 1974). In the map-area, successive halts in the retreat of the ice sheet are marked by the Cartier I, II, and III Phases of the Cartier Moraine (Boissonneau 1965; 1968).

Ice-contact stratified drift deposits occur on the southern side of each phase of the Cartier Moraine. Esker and boulder train complexes trending south to southeast in the eastern part of the map-area, and trending south to southwest in the western part of the area, follow major topographic lineaments and form the cores of major drift complexes. These glaciofluvial outwash deposits mark major meltwater channels. In the western part of the map-area, these meltwater channels breach the I, II, and III Phases of the Cartier Moraine along the Agnes River, the Bluewater-Kennedy Lakes system, and the Spanish River.

Recent fluvial sand, gravel, and silt are represented by elevated stream terrace remnants, sand spits, and gravel bars, and are especially evident along the Agnes, Spanish, Bannerman, and Onaping drainage systems.

Swamp deposits include mud, muck, and peat and occur as small pockets within the main moraine belts.

Granular resources are confined to areas underlain by glaciofluvial deposits. Utilization of these resources has been restricted to local road building and landscaping.

Summaries of the Quaternary historical geology of the region are given by G.J. Burwasser (1976), A.N. Boissonneau (1965; 1968), and by M. Saarnisto (1974).

Surficial Deposits and Features

GLACIAL STRIAE

There is evidence, in the form of glacial striae, for ice movement in two directions (see Figure 15). In the eastern and central parts of the area, glacial striae are oriented south to S20°E, whereas in the west, glacial striae strike S20°W to S40°W. Crosscutting relationships were not observed within the map-area which suggests that one major glacial episode was responsible for all the preserved directional indicators. The apparent directional change from south in the east to southwest in the western part of the map-area may be the result of local topographic deflections of ice movement.

Ice polished surfaces and glacial striae are best preserved on metavolcanic and some Huronian clastic sequences.

TILL DEPOSITS

Mappable units of till occur throughout the map-area and are designated by Unit 2 on Figure 15. Unit 1 "Bedrock-drift complex" designates areas of exposed rock outcrop and thin discontinuous till cover. The major till units within the map-area are part of a major east-trending morainic belt, the "Cartier Moraine" described by Boissonneau (1965; 1968), Saarnisto (1974), and Burwasser (1976).

The till complex consists of sandy gravel, boulder sand, and lesser silty-clay till, and exhibits extreme textural and compositional variability. Clasts account for up to 30 percent of the till and range in size from 1 cm to 4 m. Erratics up to 10 m in maximum dimension were observed. Most of the larger clasts are similar to the underlying bedrock. This suggests that they have not travelled far. Most of these clasts, however, are subrounded to well rounded. This suggests that active and efficient "milling" occurred during their deposition. The till is non-sorted, lacks any significant stratification, and ranges in thickness from less than 1 m to about 30 m.

GLACIOFLUVIAL AND ICE-CONTACT DEPOSITS

Southeast-trending ice-contact and outwash deposits mark major meltwater channels and breach the Cartier Moraine in five locations within the map-area. The location of these deposits, which are designated by Units 3 and 4 on Figure 15, is strongly controlled by northwest-trending faults in the underlying Precambrian bedrock. Ice-contact stratified drift deposits are represented by kames, kame terraces, and eskers, and are confined for the most part to the major meltwater channels and to outwash which occurs immediately south of the Cartier I, II, and III phases. Kames and kame terraces are characterized by poorly sorted, irregularly bedded sandy gravel. Kames form small mounds or hills marginal to outwash deposits. Kame terraces have low relief and occur near the till-outwash interface.

Boulder trains occur predominantly in the eastern and western part of the map-area. Southeast of Carhess Lake also known as Green Lake, a boulder train complex occurring in glacial till is traceable for approximately 2 km and is up to 180 m wide. A ridge, composed of boulders which are generally well rounded, predominantly granitic in composition, up to 15 m in diameter, and average about 1.5 m in diameter, defines the boulder train. The composition of the clasts is essentially the same as the underlying and local bedrock. Also, the size of the clasts indicates a short transport distance. The rounding and sorting suggests strong fluvial action and the "train" may have been formed by the washing out of the fines in the glacial till along a confined channel.

Esker deposits trend southward parallel to the meltwater channel complexes and are composed of sandy gravel. Generally, the eskers have steep flanks and narrow crowns, and as such are well defined. In the central part of the map-area, especially along the Spanish River channel, esker deposits have steep east flanks and shallow west flanks with a relatively narrow crown. Others have broad, 20 m wide, flat crowns.

Outwash sand and gravel (Unit 4 on Figure 15) deposits are well defined within the map-area. The core areas of these deposits are usually finer grained than the marginal areas near the till-outwash interface. Sorting is evident, and in places, the outwash is well stratified. Southwest of Cartier, a large flat area of well-sorted and stratified outwash sand forms what is known locally as the Cartier sand plain. The outwash becomes progressively coarser grained and less sorted until there is formed a transitional interface with glacial till (Unit 2, Figure 15).

RECENT FLUVIAL DEPOSITS

Fluvial sand, silt, and clay occurs along all of the major water courses and are designated by Unit 5 on Figure 15. Alluvial deposits are developed in outwash deposits, and as a consequence they are composed predominantly of fine sand and silt with lesser amounts of clay and organic material. The largest deposits occur along the Spanish River System. East of Spanish Lake are numerous elevated sand bars, spits, and terraces that indicate an early drainage course much larger than the present Spanish River.

SWAMP DEPOSITS

Swamps, marshes, and bogs are generally small and are associated with streams, rivers, and poorly drained low-lying areas within till complexes. Numerous small swamp deposits including mud, muck, and peat are a result of spring run-off. These deposits tend to dry up during the summer months. Just north of the Geneva Lake road on the west side of Highway 144, a small deposit of black loamy peat is developed. From ditch excavations, the peat deposit is at least 1 m thick and covers a surface area of about 2.6 km^2.

STRUCTURAL GEOLOGY

Regional Setting

The map-area is situated in the southern part of the Abitibi Subprovince of the Superior Province, a short distance north of the main contact of the Superior and Southern Provinces of the Canadian Shield. The southern boundary of the map-area is a few kilometres north of the Sudbury Structure. The southeastern part of the area was affected by the brecciation that accompanied the formation of this structure.

The rocks of the map-area record a series of igneous, intrusive, deformational, and metamorphic events ranging in age from Early to Late Precambrian. After deposition of the Early Precambrian metavolcanics and metasediments, probably on a basement of older sialic rocks, there was deformation, regional metamorphism, and emplacement of granitic plutons during the Kenoran Orogeny some 2500 m.y. or more ago (Stockwell *et al.* 1970). This was followed, in the latter part of the Early Precambrian and the early part of the Middle Precambrian, by a period of tensional tectonics with emplacement of mafic dike swarms, faulting, and foundering of Early Precambrian crustal blocks, and deposition of Huronian clastic sedimentary rocks in a series of shallow epicratonic basins.

The Huronian supracrustal rocks were deformed during the Middle Precambrian, probably at the same time as major deformation occurred to the south in the Southern Province.

Later events include: 1) the brecciation that accompanied the formation of the Sudbury structure some 1840 m.y. ago (Krogh and Davis 1974); 2) emplacement of lamprophyre dikes and lamprophyric breccias; and 3) emplacement of diabase dikes of the Sudbury Swarm during the Late Precambrian approximately 1250 m.y. ago (Van Schmus 1965).

Faults

Faults of several major systems are present in the map-area (Figure 16, Chart A, back pocket). Most, if not all, originated in the Early Precambrian, but were periodically reactivated during subsequent Middle and Late Precambrian deformational events.

North-northwest (N15°W to N30°W) faults of the Onaping System include the Agnes River, Bluewater Lake, Kennedy Lake, Spanish River, and Bannerman Creek Faults. These structures are marked by prominent topographic lineaments and lake and stream systems. Their pronounced topographic expression is probably attributable to the fact that these faults are approximately parallel to the direction of Pleistocene glacial ice movement and were consequently the loci of Pleistocene erosion. The faults forming the Onaping System are relatively straight and apparently dip vertically. Movements on these structures have resulted in progressive northward displacements of the Benny Belt from east to west. Apparent right-hand horizontal displacements of contacts of 300 to 2000 m have occurred. Faults of the Onaping System apparently controlled the emplacement of Early Precambrian dike swarms, indicating that the faults originated during the Early Precambrian. The faults were subsequently reactivated after deposition of the Huronian sequence and emplacement of the Nipissing Diabase intrusions.

Northwest-striking faults (N50°W to N70°W), including the Gilbert Lake, Bannerman Lake, and Munster Lake Faults are parallel to the regional faults of the Timiskaming System to the east of the Benny map-area. Movements on the northwest faults have also resulted in right-hand apparent horizontal displacements of Early and Middle Precambrian rock units of 300 to 600 m. Late Precambrian diabase dikes are approximately parallel to these faults, and not uncommonly dikes occupy the fault zones.

Northeast faults (N55°E to N70°E), the Maltese Lake, Benny, Downes Lake, Geneva Lake, and Clear Lake Faults[1], are parallel to major regional structures such as the Flack Lake Fault and Montreal River Fault to the west of the Benny map-area. Movements on the northeast faults in the Benny map-area have resulted in right-hand and left-hand apparent horizontal displacements of Early, Middle, and Late Precambrian rock units of 150 to 300 m. Early normal movements on the northeast faults probably controlled Huronian depositional patterns in the map-area to a large extent.

A few relatively minor north-northeast (N25°E) faults are also present.

Structure of the Early Precambrian Rocks

The Benny Metavolcanic-Metasedimentary Belt is a remnant, some 2 to 4 km wide and approximately 40 km long, of a previously more extensive supracrustal sequence. The belt is bounded by Early Precambrian granitic intrusions, older foliated and migmatitic granitoid rocks, and younger, massive quartz monzonite plutons. The Benny Belt probably represents a south-facing homoclinal sequence. Although minor folds in bedding are prevalent, no major fold repetitions were discerned. The dominant tectonic foliation, a regional

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[1] The Clear Lake Fault, locally known as the Hess Lake Fault, was renamed at the insistence of the Nomenclature Section.

penetrative cleavage or schistosity, is mainly subconcordant to primary stratification in the metavolcanic sequence, and strikes approximately parallel to the length of the belt. In the eastern half of the Benny Belt, the foliation dips uniformly southward. In the western half of the Benny Belt, the foliation dips southward in the north, is approximately vertical in the central part, and dips steeply northward in the southern part of the belt. The primary stratification in the metavolcanic-metasedimentary sequence gives no indication of a synformal structure. Locally in the south it can be seen that foliation and bedding are discordant. Foliation in the enclosing granitic rocks, a cataclastic cleavage, displays a similar pattern, striking east and dipping southward to the north of the Benny Belt and northward to the south.

The Benny metavolcanic-metasedimentary sequence, as well as some of the bordering granitic rock, have been flattened in a north-south direction and elongated in the east-west plane and subvertically. Foliation is defined by oriented minerals and flattened pillows and lithic fragments. These elements are shortened normal to the foliation plane and elongated east-west; down-dip elongation in the foliation gives rise to a rodding lineation. Deformed pillows and lithic fragments have the form of triaxial ellipsoids with ratios on the order of 1:3:3 to 1:10:15.

There are local deflections in the foliation trends from east to northwest. In the area between Highway 144 and the Geneva Lake Mine, the foliation strikes northwest-southeast and dips southward. East of the mine, and west of the highway, the foliation strikes approximately east-west. Drag-folds, both S and Z types which involve the primary bedding, are prevalent. A few northeast- and northwest-striking non-penetrative cleavages and kink bands involving both the bedding and the east-west foliation are present. They are generally adjacent and parallel to the northwest and northeast faults.

Structure of the Middle Precambrian Rocks

The Middle Precambrian rocks of the map-area are relatively little deformed or metamorphosed. The Huronian supracrustal rocks form a series of erosional, commonly fault-bounded remnants that outline a discontinuous arcuate belt north of and approximately parallel to the northern boundary of the Sudbury Nickel Irruptive.

The Huronian strata have been variably and erratically deformed. This is probably a result of vertical movements of basement blocks and consequent passive deformation of the Huronian cover. This deformation occurred prior to emplacement of the Nipissing Diabase intrusions some 2150 m.y. ago. These bodies are clearly discordant with respect to tectonic structures in the Huronian sequence. The Huronian displays rapid variations in intensity and style of deformation. In some localities, flat-lying Huronian strata rest unconformably on Early Precambrian basement. In other areas, sometimes only short distances away, the Huronian strata are vertical or locally overturned. The contacts between the Early Precambrian basement and Huronian cover are commonly steeply-dipping faults. In a number of localities, especially in the north, no clearly-defined faults are present even though the Early Precambrian-Middle Precambrian contact cannot be a normal, flat-lying unconformity. It is possible that some of the Huronian outliers represent allocthonous blocks, remnants of gravity slides, or thrust sheets.

The Hart Township and Geneva Lake Synclines in the southeastern part of the map-area form parts of a faulted, discontinuous synclinal structure in the Huronian strata. The structure is arcuate, the axial trace trends northeast to east-northeast, and is asymmetric with limbs dipping at various angles ranging from about 10° to near vertical.

Minor structures present in the Huronian rocks include early, non-penetrative bedding plane foliation, drag-folds, and later, steeply dipping non-penetrative cleavages striking northeast and northwest.

METAMORPHISM

Rocks in the Benny map-area, with the exception of the late diabase dikes and the matrices of the Sudbury-type breccias, have been regionally metamorphosed. During the Kenoran Orogeny, the Early Precambrian volcanic and sedimentary rocks of the Benny Belt and the surrounding gneissic, felsic, plutonic, and migmatitic rocks were metamorphosed under conditions corresponding to the greenschist and amphibolite facies of the low pressure-intermediate facies series of regional metamorphism (Winkler 1967). Metamorphism was coincident with the deformation of these rocks and occurred prior to the emplacement of the late felsic plutons approximately 2500 to 2600 m.y. ago.

During the Middle Precambrian, there was a second period of low rank regional metamorphism that affected the Early Precambrian mafic dikes (Matachewan-type), the Huronian sedimentary rocks, and the Nipissing Diabase intrusions. This event also produced sporadic retrograde alteration of preexisting metamorphic and igneous mineral assemblages in the Early Precambrian rocks. Metamorphic mineral assemblages in the Middle Precambrian rocks correspond to the lower and middle greenschist facies of the low pressure intermediate facies series (Winkler 1967). The Middle Precambrian metamorphism occurred after emplacement of the Nipissing Diabase some 2150 m.y. ago (Van Schmus 1965) and prior to the formation of the Sudbury-type breccia some 1840 m.y. ago (Krogh and Davis 1974). It probably occurred about 1900 m.y. ago during the Penokean Orogeny (Van Schmus 1976).

Early Precambrian Metamorphic Zones and Mineral Assemblages

The volcanic, intrusive, and sedimentary rocks of the Benny Belt have metamorphic mineral assemblages diagnostic of the middle to upper greenschist facies and lower amphibolite facies. There are two small areas, one in the east, the other in the west, having assemblages diagnostic of the middle to upper greenschist facies; the remainder of the belt has amphibolite facies assemblages (Figure 17). Typical assemblages in mafic and intermediate volcanic and intrusive rocks of the amphibolite facies include the following assem-

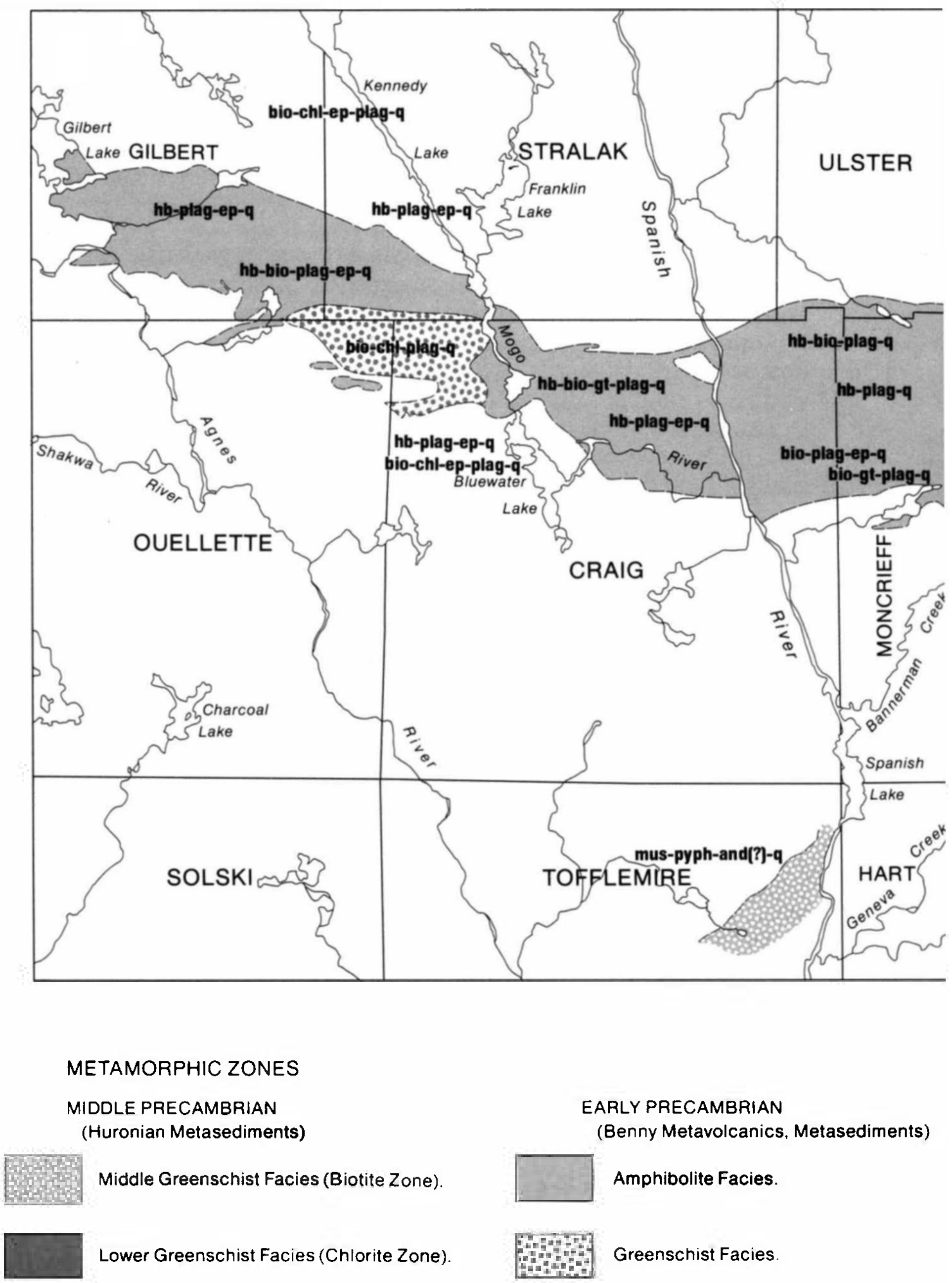
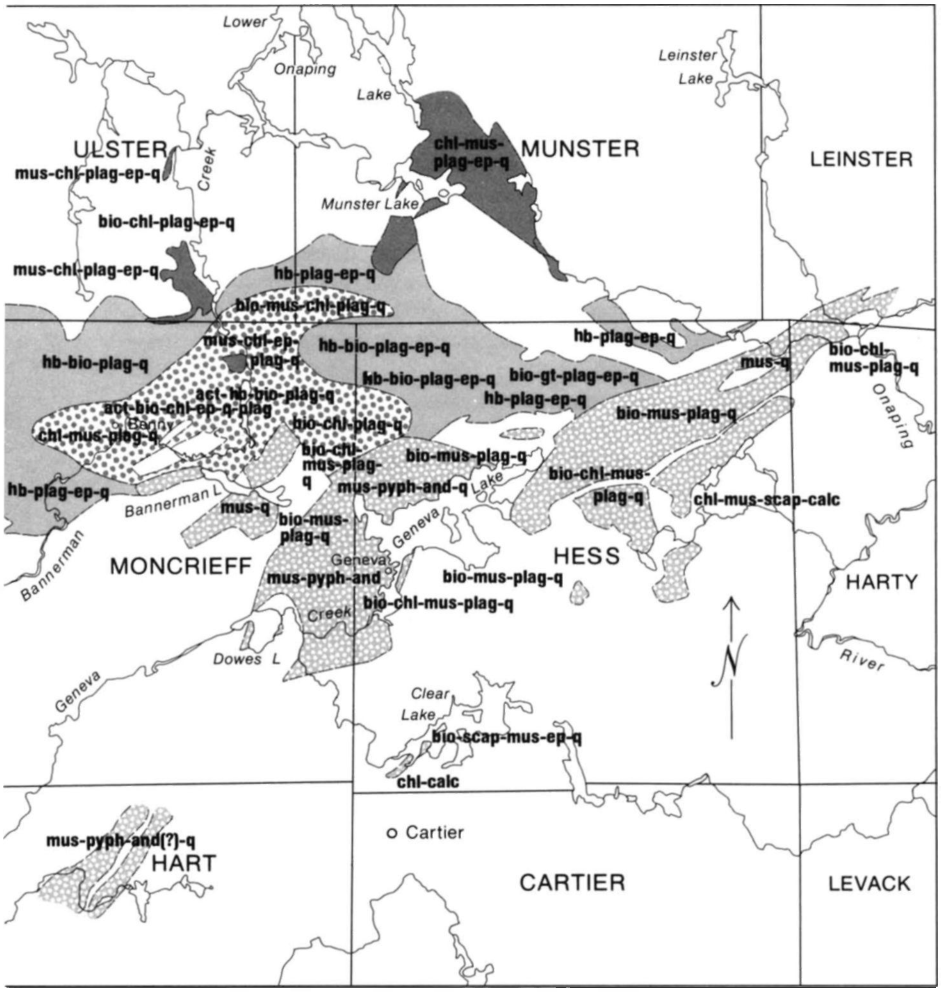
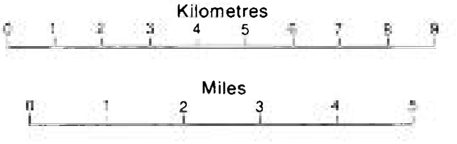


Figure 17–Metamorphic map of the Benny Area.



METAMORPHIC MINERAL ASSEMBLAGES

act	Actinolite.	**hb**	Hornblende.
and	Andalusite.	**mus**	Muscovite.
bio	Biotite.	**plag**	Plagioclase.
chl	Chlorite.	**pyph**	Pyrophyllite.
ep	Epidote.	**q**	Quartz.
gt	Garnet.	**scap**	Scapolite.



SMC 14313

blages: hornblende-plagioclase; hornblende-plagioclase-epidote-quartz; and hornblende-biotite-garnet-plagioclase-epidote-quartz.

In addition to the foregoing minerals, chlorite, iron-titanium oxides, sphene, and sulphide minerals are common minor constituents. The hornblende, a blue-green variety, forms ragged porphyroblasts oriented with respect to the tectonic foliation and lineation. The plagioclase is oligoclase or andesine.

The felsic metavolcanics consist essentially of plagioclase, potassic feldspar, and quartz with lesser amounts of biotite, hornblende, chlorite, epidote, iron oxides, and sulphides.

The pelitic metasediments consist essentially of biotite, hornblende, plagioclase, quartz, chlorite, and epidote. Graphite, pyrite, and pyrrhotite are common constituents.

Typical assemblages present in the mafic rocks in the greenschist facies zones include the following assemblages: chlorite-muscovite-plagioclase-epidote-quartz; and biotite-chlorite-muscovite-epidote-plagioclase-quartz; amphibole-biotite-chlorite-epidote-plagioclase-quartz.

The plagioclase is albite or oligoclase. The amphibole is mainly actinolite, but blue-green hornblende is also present. Garnet is present locally, and iron oxides, sphene, and sulphides are common minor constituents.

The felsic metavolcanics in the greenschist facies zones consist of these assemblages of: muscovite-plagioclase-potassic feldspar-quartz; chlorite-muscovite-feldspars-quartz; biotite-muscovite-feldspar-quartz. Epidote is common.

The metasedimentary assemblages include: muscovite-chlorite-plagioclase-quartz; and biotite-muscovite-chlorite-plagioclase-quartz. Epidote, sulphides, and graphite are also present.

Metamorphic mineral assemblages present in the gneissic and migmatitic rocks include such assemblages as: biotite-hornblende-plagioclase-potassic feldspar-quartz; biotite-chlorite-plagioclase-quartz; hornblende-plagioclase-quartz; and biotite-plagioclase-potassic feldspar-quartz.

Epidote, muscovite, chlorite, and iron oxides are common minor constituents. These assemblages are generally indicative of amphibolite facies metamorphic conditions.

Middle Precambrian Metamorphism

The Early Precambrian mafic dikes (Matachewan-type) and the Middle Precambrian Huronian metasediments and Nipissing Diabase intrusions display metamorphic mineral assemblages characteristic of the low to middle greenschist facies. To the south of the Benny Belt, the Middle Precambrian rocks were metamorphosed under middle greenschist facies conditions (biotite grade), whereas to the north of the Benny Belt, they contain assemblages corresponding to the low greenschist facies (chlorite grade).

Typical mineral assemblages in the middle greenschist facies zone in the south are as follows in:

1) *Huronian pelitic metasediments*: biotite-muscovite-plagioclase-quartz; biotite-chlorite-plagioclase-quartz and biotite-chlorite-muscov-

ite-plagioclase-quartz. Albite and oligoclase are present, and epidote, iron-oxides, carbonate minerals, sphene, and sulphides are common minor constituents.

2) *Huronian aluminous metasandstones*: kaolinite-muscovite-quartz; muscovite-quartz; muscovite-pyrophyllite-quartz; and muscovite-pyrophyllite-andalusite-quartz.

3) *Huronian calcareous metasediments*: biotite-muscovite-calcite (dolomite); biotite-chlorite-muscovite-epidote-calcite (dolomite); chlorite-muscovite-epidote-scapolite-calcite (dolomite); and biotite-muscovite-epidote-quartz-scapolite-calcite (dolomite).

4) *Nipissing Diabase and Matachewan-type mafic dikes*: actinolite-plagioclase; and actinolite-hornblende-plagioclase.

In some of the samples examined unaltered magmatic plagioclase (labradorite) is present, but for the most part it has been extensively saussuritized.

In the lower greenschist facies zone to the north of the Benny Belt, Huronian pelitic metasediments consist of these assemblages: muscovite - chlorite - albite - quartz; and muscovite - chlorite - albite - epidote - quartz.

Nipissing Diabase intrusions are relatively little altered, but where such alteration has occurred, they consist of actinolitic amphiboles and albite.

GEOPHYSICAL CHARACTERISTICS

Magnetic Characteristics

Examination of Aeromagnetic Map 1524G (GSC 1965c) reveals that the metavolcanics and metasediments of the Benny Belt are mainly magnetically unresponsive with levels of 2100 and 2300 gammas. A notable exception is the thin unit of iron formation in north-central Craig Township that produces a linear magnetic anomaly of approximately 2500 gammas. To the north of the Benny Belt, the older gneissic granitic and migmatitic rocks are magnetically similar to the metavolcanics, whereas the younger quartz monzonite plutons are somewhat more responsive giving rise to anomalies that vary from 2400 to 2500 gammas. A weak anomaly (2300 to 2500 gammas) in south-central Ulster Township is situated over an outlier of the Gowganda Formation.

Another small anomaly (2400 gammas) at the contact of the metavolcanics with the granitic rocks in southwestern Ulster Township has no apparent explanation in the surface geology.

To the south of the Benny Belt, parts of the younger quartz monzonite plutons in the west produce aeromagnetic responses in the range 2400 to 2500 gammas. In the southeast, the younger felsic plutons produce magnetic responses in the range 2200 to 2300 gammas and locally up to 2400 gammas. Veinlets and fractures filled with magnetite were observed in these rocks at several localities.

In Tofflemire Township, mainly to the south of the map-area, there are rocks that give rise to aeromagnetic anomalies in the range 2600 to 3000 gammas. A circular anomaly near the south boundary of Tofflemire Township is correlated with an alkalic rock-carbonatite complex. These aeromagnetic patterns indicate the possibility of similar intrusions or zones of fenitization in southern Tofflemire Township immediately south of the area.

In Moncrieff and Hart Townships, west of the village of Cartier, there is a distinct aeromagnetic anomaly of 2400 to 3000 gammas. The anomaly is rectangular, approximately 1.5 km wide and 8 km long, and its long axis is oriented northeast southwest. The area is extensively drift covered, but there are exposures of quartz monzonite, Nipissing Diabase, and Huronian rocks. The cause of this anomaly is not obvious, although the granitic rocks are extensively brecciated and contain numerous magnetite veinlets. A short distance to the east, the magnetite deposit in L.G. Bardswich's (1)[1] property gives rise to a small, moderate (2400 gammas) anomaly.

Gravity characteristics

Information on the earth's gravity field in the Benny map-area is provided by a Bouguer anomaly map and derivative gravity maps of the Sudbury region by J. Popelar (1971). The second vertical gravity derivative map covering the eastern half of the map-area is the most revealing. The Benny Belt gives rise to a linear positive anomaly and within the belt, there are two concentrations of mass, one south of Stralak, the other near the Geneva Lake Mine in Hess Township. There is a correlation between concentrations of mass as revealed by the gravity field and the only known mineral deposits of some significance in the belt. The mass concentrations possibly represent centres of volcanism.

To the north and south of the Benny Belt, there are scattered, weak gravity highs and lows. The quartz monzonite plutons and Huronian rocks produce weak lows, whereas some of the weakly positive anomalies are associated with Nipissing Diabase intrusions.

Electromagnetic Characteristics

An airborne electromagnetic survey by Tex-Sol Limited covering most of the Benny Belt reveals a number of linear and single intercept electromagnetic anomalies (Resident Geologist's Files, Ontario Ministry of Natural Resources, Sudbury). Several of these anomalies are 1 to 6 km in length and are attributable to stratabound sulphide-bearing units in the metavolcanic-metasedimentary sequence. The strongest anomalies are associated with rocks that contain graphite as well as pyrite and pyrrhotite.

The zone containing sphalerite-pyrite-galena-chalcopyrite mineralization near Stralak gives rise to a weak linear electromagnetic anomaly. In Hess Township, northwest of the Lake Geneva Mine, there is a weak, northwest-trending electromagnetic anomaly over a drift-covered area with several small

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[1] The number in parentheses indicates the property number on Map 2435, back pocket.

ponds. It is possible that this anomalous zone represents the extension of the Lake Geneva Mine zone.

ECONOMIC GEOLOGY

Exploration has been carried out in the map-area for zinc, lead, copper, nickel, iron, silver, gold, and uranium. Stratabound and vein-type deposits containing base-metal sulphides occur at a number of locations in the Benny metavolcanic-metasedimentary sequence. The major known deposit, the Geneva Lake Mine[1], Hess Township, was discovered by John Collins in 1924, and from 1941 to 1944 produced some 4 717 000 kg (10 400 000 lbs) of zinc, and 1 632 900 kg (3 600 000 lbs) of lead, and silver valued at $28,416. The present property owners, Geneva Metals Incorporated, have continued to explore the property in recent years. Other sulphide occurrences in the metavolcanic-metasedimentary sequence, notably the following properties once known collectively as the "Stralak deposit", H. Barry (Stralak Deposit East) (2) and Confederation Mining Corporation Limited (Stralak Deposit West) (4)[2] in Craig Township, have been tested periodically by trenching, diamond drilling, and geological and geophysical surveys. An airborne electromagnetic survey covering much of the Benny Belt was conducted by Tex Sol Limited in 1972. Ground checking, including geological and geochemical surveys of anomalies outlined by the airborne survey, was carried out by Chevron Standard Limited in subsequent years. Replacement-type deposits consisting of variable proportions and combinations of magnetite, sphalerite, chalcopyrite, pyrite, and galena occur in the Huronian sequence, particularly in calcareous rocks of the Espanola Formation at or near contacts with Nipissing Diabase intrusions. Magnetite occurrences in southwestern Hess Township and southern Munster Township, and base-metal sulphides in Hart Township have been tested by surface exploration, diamond drilling, and geophysical surveys. During the course of mapping performed by the survey party disseminated pyrite, chalcopyrite, sphalerite, and galena were discovered in calcareous rocks of the Espanola Formation in central Hess Township.

A mafic dike containing nickel-copper sulphide mineralization in east-central Hess Township was tested by diamond-drilling which was done by the Canadian Nickel Company in 1966 to 1967. This dike probably represents the westward extension of the Foy Offset, a dike-like offshoot from the Sudbury Nickel Irruptive.

Exploration for uranium has been carried out in the area in the 1950s and the late 1960s. Exploration was concentrated mainly on the lower part of the Huronian sequence, but recently Hollinger Mines Limited discovered minor amounts of uranium in the Early Precambrian granitic rocks in Moncrieff Township. A sample of country rock composed of metavolcanic and granitic material taken during the present survey from the Geneva Lake Mine dump

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[1] This is Geneva Metals Incorporated (Geneva Lake Mine) (5) on Map 2435, back pocket.

[2] The numbers in parentheses refer to the properties listed on Map 2434, back pocket.

TABLE 9 ASSESSMENT DATA FOR BENNY AREA, RESIDENT GEOLOGIST'S FILES, SUDBURY

CRAIG TOWNSHIP

1. ALLMORE EXPLORATIONS LIMITED
   - 1a 1970: Prospectus GL rept. claims loc. map; GL loc. map and log.
   - 1b 1971: GP, EM and Mag surveys
     cls. S281943 to 51 incl., S269066 to 74 incl.
   - 1c 1972: Mech., Manual work.
2. CANADIAN NICKEL COMPANY LIMITED
   - 1968: 1 DDH 52.7 m (173 feet), cl. S143257 loc.
3. CHEVRON STANDARD LIMITED
   - 1975: Geochem. survey, cls. S355686 to 9 incl.
     cls. S444112 to 23 incl.
     cls. S355703 to 4 incl.
   - 1976: Geol. — all of Chevron's claims.
4. CONFEDERATION MINING CORPORATION
   - 1974: Manual and plugger work, trenching, loc. map.
5. HATCH-BURTON-DAWSON
   - 5a 1942: 6 DDH 310.3 m (1,018 feet), assays Zn, Cu, Pb, Ag, Au
   - 5b 1948: Geol. rept.
   - 5c 1949: DDH rept. cls. S55043, S551307, S551319
     9 DDH 565.6 m (1,855.8 feet) cls. S51307 and loc.
   - 5d 1951: Geol. rept.
   - 5e 1952: DDH sections
6. MINING CORP. OF CANADA LIMITED
   - 6a 1964: 11 DDH 1089.4 m (3,574.3 feet) assays Ag, Zn, Pb, Cu
   - 6b 1965: GL rept. cls. S5042 to 43, cls. S122101 to 122181 incl. and cls. S124082 to 83
     GP surveys, EM and Mag, rept. and maps
7. OAKRIDGE MINING CORPORATION
   - 1952: Geol. Rept. and maps cls. S57549, 50, 53, 55, 59, 60.
     8 DDH 635.5 m (2,085 feet), plan.
8. TEX-SOL EXPLORATIONS LIMITED.
   - 1974: EM survey cls. S355686 to 89 incl.
9. TRI-BRIDGE CONSOLIDATED GOLD MINES LIMITED
   - 1973: Prospectus
10. WILSON
    - 1974: EM survey cls. S355703-to 04.

CARTIER TOWNSHIP

11. FALCONBRIDGE NICKEL MINES LIMITED
    - 1956: 2 DDH 121.9 m (400 feet) cls. S76124 and S86666, locs.
    - 1958: 3 DDH 219.5 m (720 feet) Cl. S86666, loc.
    - 1960: 2 DDH 73.1 m (240 feet) Cl. S86666, loc.
    - 1961: 1 DDH 73.1 m (240 feet) Cl. S86666, loc.
12. PACEMAKER MINES AND OIL LIMITED
    - 1958: Prospectus
13. TAYLOR
    - 1955: 16 DDH 876.66 m (2,876.2 feet), Cl. S61542, loc., plans

MONCRIEFF TOWNSHIP

14. BEAUDOIN
    - 1974: Mag survey, cls. S355613, 14, 17.

15. BENNER
    1968: 5 DDH 1934.6 m (6,347 feet), cls. S147259, 67, 92, A7293, locs.
    4 DDH 798.9 m (2,621 feet), Cls. S147220 to 4, and S147218, locs.

16. CANADIAN NICKEL COMPANY LIMITED
    (Hess and Munster Twps.)
    1968: 3 DDH 291.4 m (956 feet), Cls. S143086 to 103 incl. locs.

17. CHEVRON STANDARD LIMITED
    1975: Mag survey — all of claim group
    1975, 76: Geochem. survey, soils, 3,851 assays for Cu, Pb, Zn and 15 assays for Ni

18. CHRISTMAN
    1957: 3 DDH 29.3 m (96 feet), Cls. S96571, S99352, S97066, locs.

19. HUYCKE
    1974: SP survey rept., plans, Cls. S345702, 5, 6, S345691, 5, 8, 9, and Cl. 385613.

20. MONCRIEFF URANIUM MINES LIMITED (Hess Twp.)
    1969: Geol. rept., all claims
    1970: Geol. rept., all claims

21. PERRIER
    1974: EM and Mag. surveys, Cls. S357912, 3, 5, 8.

NOT ON MAP
    HOLLINGER MINES LIMITED
    1976: Geol. survey of total claim group

HESS TOWNSHIP

22. BARDSWICH
    1973: Mag survey, rept., plan, Cl. S359823
    1974: stripping
    1975: Power stripping, mech. work
    1976: Geol. maps, 11 DDH 333.8 m (1,095 feet), rept., loc., sections assays Fe, Cu

23. CANADIAN NICKEL COMPANY LIMITED
    23a 1966:3 DDH 257.3 m (844 feet) Cls. S133442, 41, locs.
    23b 1967:27 DDH 2725 m (8,940 feet) Cls. S133441, 42, and S143096, locs.

24. DOME EXPLORATION (CANADA) LIMITED
    1975: Airborne Rad and Mag surveys, repts., plans, on total claim group

25. GENEVA METALS INCORPORATED
    1972: Prospectus, Property rept., Geol. map, plans, Mag and EM surveys, assays Au, Pb, Zn — total claim group

26. GREEN
    1957: 9 DDH 122.8 m (404 feet), Cl. S96481, property plan

27. JAYBEE LANDRY EXPLORATION AND MINING COMPANY LIMITED
    (Cartier Twp.)
    1966: Mag survey and rept., Geol. survey, assays Fe, Cu and 8 DDH 159.9 m (524.5 feet), Cl. S132748, loc.
    1967: EM survey, loc.
    1969: 1 DDH 11.0 m (36 feet), loc.

28. MID-NORTH ENGINEERING SERVICES LIMITED
    1968: 2 DDH 791.9 m (2,598 feet), Cl. S147663, 64, loc.

29. ST. JOSEPH EXPLORATIONS LIMITED
    1975: Mag survey, rept. plans

Table 9 - continued on next page.

Table 9 continued

30. TEX-SOL EXPLORATIONS LIMITED
(Craig, Moncrieff, Munster, Ulster Twps.)
1972: Airborne EM survey and maps, all claims
1975: Mag and EM surveys, repts. and plans, all claims

HART TOWNSHIP

31. FALCONBRIDGE NICKEL MINES LIMITED
1956: 4 DDH 134.1 m (440 feet), Cl. S86677, loc.
1957: 5 DDH 577.0 m (1,893 feet), Cls. S86677, S86673, locs.

32. HOLMES
1953: Geology of Hart Township, unpub. Ph.D. Thesis

33. JAR-VIN MAGNETITE SYNDICATE
1973: Plugger drilling, blasting, trenching
1974: Summary of 1972-73 work credit reports

34. LACELLE
1961: 2 DDH 98.1 m (322 feet), Cls. S112796, 97
1962: 4 DDH 201.8 m (662 feet), Cls. S112797, S112801
1968: 3 DDH 175.9 m (577 feet), Cls. S148894, S148889
1970: 1 DDH 40.2 m (132 feet), Cl. S148889

35. LANDRY
1971: Drilling and mucking, Cl. S259544, loc.

36. MOGUL MINING CORPORATION
(now Consolidated Mogul Mines Limited)
1955: 1 DDH 234.1 m (768 feet), Cl. S66019, sections, plans.

MUNSTER TOWNSHIP

37. B & M EXPLORATIONS LIMITED (Hess Twp.)
1951: Mag survey, rept., plan, Cls. S556796 to 99 incl. and S556800 to 817 incl.
1956: 2 DDH 270.3 m (887 feet), locs., Cl. S591527
1958: 8 DDH 280.7 m (921 feet), locs., Cl. S91527

38. BARRY (Munster and Hess Twps.)
1951: Mag survey, rept.

39. CHEVRON STANDARD LIMITED
1975: Mag survey all claims (see 17)

40. VALLEE
1974: Mag survey, Cls. S342772, 3

41. VANNIER
1968: 2 DDH 93.3 m (306 feet), loc., Cl. S135376
1 DDH 57.9 m (190 feet), loc., Cl. S135377
3 DDH 143.3 m (470 feet), locs., Cls. S135369, S135377

ULSTER TOWNSHIP

42. BAZINET
1974: Mag survey, loc., Cl. S355728

43. DUPONT
1971: manual labour, Cl. S282040, trenching, assay, Cu
1973: Trench location
1974: Manual labour

44. THERIAULT (Ulster and Moncrieff Twps.)
1974: Mag survey, Cls. S355744, 45, 48

Table 9 continued

LEINSTER TOWNSHIP

45. CANADIAN NICKEL COMPANY
    1967: 2 DDH 170.4 m (559 feet), Cls. S144598 and 92, locs.

HARTY TOWNSHIP

46. CANADIAN NICKEL COMPANY (Harty, Leinster, Tyrone Twps.)
    1967: 9 DDH 721.8 m (2,368 feet), Cls. S144591, 92, S144584, 88
47. FALCONBRIDGE NICKEL MINES LIMITED
    1967: 5 DDH 85.3 m (280 feet)
    1968: 4 DDH 487.7 m (1,600 feet), Cl. S147627, plans

NOTE:
The following properties are not plotted on Figure 20: 9, 11, 12, 13, 31-34, 43, 44-47.

Abbreviations:

Cl(s).	- Claims
DDH	- Diamond-drill hole
EM	- Electromagnetic
Geochem.	- Geochemical
GL	- Geological
Geol.	- Geological
Geol. Rept.	- Geological Report
Loc. map	- Location map
Mag.	- Magnetic (ground)
Mech.	- Mechanical
Rad.	- Radiometer
Rept.	- Report
SP	- Self potential

yielded 0.032 percent U_30_8 upon assay by the Geoscience Laboratories, Ontario Geological Survey.

Minor amounts of molybdenite and fluorite are present in Early Precambrian granitic rocks in Moncrieff and Hess Townships.

Extensive sand and gravel accumulations, glacial moraine and outwash deposits, occur throughout the area, especially around Cartier. These deposits have been used for local road construction.

Descriptions of Properties

The known mineral deposits are described in the following section. The approximate outlines of claim groups held at various times by exploration companies and individuals and the locations of various mineral exploration surveys are given in Figure 18, Chart B (back pocket). The locations, metals, mineralogy, and host rock associations of the known mineral occurrences are also shown in Figure 18. Table 9 indicates information that is on file at the Resident Geologist's office, Ontario Ministry of Natural Resources, Sudbury.

ZINC, LEAD, COPPER

There are numerous stratabound sulphide occurrences consisting mainly of pyrite and pyrrhotite with variable amounts of sphalerite, galena, and chalcopyrite within the metavolcanic-metasedimentary sequence. Most of these sulphide occurrences are in schistose siliceous and graphitic rocks at the contacts between mafic and intermediate to felsic metavolcanics, both flows and pyroclastic rocks. There are a number of such sulphide-bearing units in the eastern and central parts of the belt extending from Hess Township to Ouellette Township. Individual zones with disseminated to massive sulphide mineralization are up to 30 m thick and several can be traced along strike for several kilometres. Within these zones there are lenses of massive sulphides up to 3 m thick. Mineral zoning is evident in one of these stratabound units, the Stralak deposit[1] in Craig Township. The footwall mafic metavolcanics are commonly rich in chlorite, epidote, and vein quartz and locally contain disseminated chalcopyrite. Above this is a zone of schistose graphitic metasediments with heavily disseminated to massive sulphides, mainly pyrite and pyrrhotite, but also at several localities, sphalerite and galena. The sphalerite-rich lenses commonly display a "buckshot" texture consisting of large (up to 1 cm), rounded grains of pyrite in a matrix of black sphalerite. Overlying the sulphide-rich zone, there are commonly quartz and muscovite-rich schists with disseminated and massive sulphide lenses, mainly pyrite and pyrrhotite. The hanging-wall rocks consist of felsic pyroclastics containing minor disseminated pyrite and pyrrhotite. The sulphides would appear to be of volcanogenic origin, deposited by volcanic exhalative processes penecontemporaneously with their host rocks.

The most important occurrences of this type are the Geneva Metals Incorporated (Geneva Lake Mine) (5) and the Stralak deposits [H. Barry (Stralak Deposit East) (2), Confederation Mining Corporaion Limited (Stralak Deposit West) (4)], both of which contain appreciable amounts of sphalerite and galena. Similar occurrences, although apparently containing no or only minor base metals, are located in northern Hess, southwestern Munster, northern and western Moncrieff, northern Craig and southeastern Gilbert Townships.

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[1] On Map 2434, back pocket, this "deposit" is listed as H. Barry (Stralak Deposit East) (2) and Confederation Mining Corporation Limited (Stralak Deposit West) (4).

H. BARRY (STRALAK DEPOSIT EAST) (2), AND CONFEDERATION MINING CORPORATION LIMITED (STRALAK DEPOSIT WEST) (4)

Exploration History

A zone of sulphide occurrences containing zinc, lead, copper, and silver in northeastern Craig Township and adjacent Ulster Township was discovered about 1886 shortly after construction of the transcontinental line of the Canadian Pacific Railway. Early exploration work consisted of surface pitting and trenching. In 1927 the Sudbury Concentrating and Mining Company carried out exploration in the area and discovered the westward extension of the mineralization zone. The company diamond-drilled five holes totalling 305 m in length that intersected zinc, lead, and copper mineralization over narrow widths. The company ceased operations in 1929. From 1928 to 1948, H.N. Kilpatrick carried out some surface exploration (Resident Geologist's Files, Ontario Ministry of Natural Resources, Sudbury).

In 1949, A. Burton and H.B. Hatch restaked the west zone and optioned the property to Bankfield Consolidated Mines Limited. This group conducted a magnetic survey, and drilled nine diamond-drill holes totalling 558 m in length, four in the west zone, five in the east zone.

In 1951, both zones were staked by B.W. Craig. In 1952, the property was optioned to Preston East Dome Mines, Limited who drilled 18 diamond-drill holes totalling 1543 m.

In 1964, the Mining Corporation of Canada, Limited carried out exploration consisting of geological, electromagnetic, and magnetic surveys, and drilled 11 holes totalling 1072 m in length. In 1974, Confederation Mining Corporation Limited did some surface trenching on the property.

The foregoing exploration work has outlined two zones of relatively high grade mineralization, an eastern zone approximately 255 m in strike length, and a western zone approximately 150 m long. In the eastern zone, the main mineralized zone is 0.3 to 2 m thick and assays ranging from 0.5 to 22 percent zinc, 0.05 to 0.08 percent lead, 0 to 2.3 percent copper and trace amounts to 3.8 ounces per ton of silver were reported. The western mineralized zone is 0.3 to 1.8 m thick, and is reported to contain 0.6 to 8 percent zinc, 0.3 to 1.3 percent lead, and 1.80 to 4.94 ounces of silver per ton. Preston East Dome Mines Limited estimated reserves for part of the deposit at 363,680 tons grading 3.18 percent zinc, 0.32 percent copper, and 0.68 ounce of silver per ton over an average width of 2.5 m to a depth of 47 m (Resident Geologist's Files, Ministry of Natural Resources, Sudbury).

Geology

The general geology of the Stralak area is shown on Map 2434 (in back pocket). The Stralak sulphide deposits occur in the northern part of the Benny metavolcanic-metasedimentary belt, at approximately the same stratigraphic horizon as the Geneva Lake Mine deposit. The sulphide mineralization occurs in a thin stratigraphic unit of chloritic, micaceous, and quartz-rich schistose rocks which probably represent sheared, metamorphosed tuffs and sedimentary rocks. This unit is underlain by mafic (basaltic) metavolcanics both pyroclastic rocks and flows, and overlain by felsic pyroclastic rocks. The country rocks are drag-folded and display a prominent foliation that strikes west and dips southward subparallel to the stratification. Within the foliation plane there is a rodding-type lineation that plunges southward. The sulphide mineralization displays foliation and lineation similar to that in the host rocks. This demonstrates that the sulphides were deformed along with their host rocks.

The sulphide zones are cut by a number of post-tectonic metagabbro and granitic dikes and are offset by northwest and northeast-striking faults.

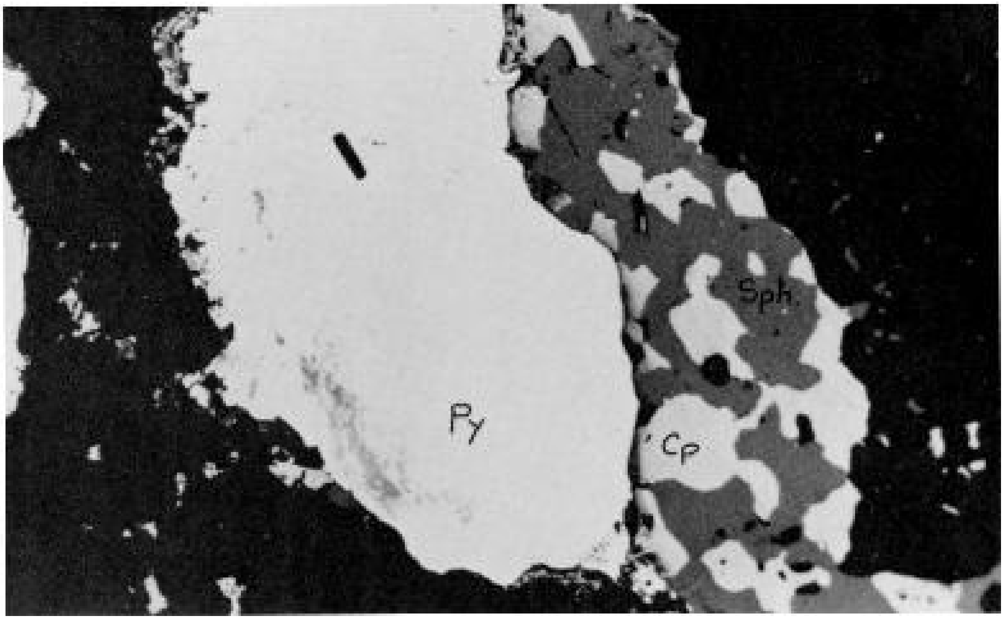
Character of the Mineralized Zones

The eastern mineralized zone is approximately 500 m long and up to 18 m thick and dips southward at angles of 45° to 55°. The main mineralized part of this zone is about 255 m long and up to 3 m thick with a number of massive sulphide lenses up to 2 m thick.

There are some ten pits along this zone, exposing disseminated and massive sulphides. In the eastern most pit, sulphides, mainly pyrite and pyrrhotite, are present in thinly laminated siliceous metasediments rich in sericite over a width of 3.6 m. The sulphides form stratabound disseminations and lenses.

In the next large pit to the west there is a lens of massive, sphalerite-rich sulphide mineralization 3 m thick. This pit displays a stratagraphic sequence typical of the better mineralized parts of both the east and west zones. This sequence is as follows:

1. *Footwall rocks*; mafic metavolcanics rich in chlorite, epidote, and quartz and commonly containing disseminated sulphides, including chalcopyrite, pyrite, and pyrrhotite.
2. Approximately 1.5 m of green and grey siliceous tuff and metasediment with disseminated pyrite and chalcopyrite.
3. *Main mineralized zone*; up to 3.6 m of massive and disseminated pyrite, sphalerite, chalcopyrite, and galena. The disseminated sulphides commonly display stratiform layering and are intercalated with light grey siliceous metasediment (chert).
4. About 9 to 12 m of laminated siliceous and micaceous metasediments and grey chloritic tuff with stratiform lenses and disseminations of sulphides, mainly pyrite.
5. *Hanging wall rocks*; light grey to pink, bedded felsic tuff with minor disseminated stratiform sulphides.



OGS 10 148

Photo 7–Photomicrograph of pyrite, sphalerite, and chalcopyrite mineralization, Stralak deposit, Craig Township. 10X Magnification. Abbreviations: cp - chalcopyrite; py - pyrite; sp - sphalerite. Galena does not occur in this sample.

The western zone, exposed over a strike-length of about 200 m is up to 15 m thick, and dips southward at angles of 50° to 65°. The main mineralized part of the zone is about 120 m long and approximately 1.8 m thick.

The massive sulphide lenses consist of pyrite, sphalerite, chalcopyrite, and galena in about that order of abundance (Photo 7). The sphalerite is an iron rich, dark brown to black variety. The pyrite is typically coarse grained and has a distinctive "buck shot" texture with large (5 mm to 1 cm), deformed rounded grains of pyrite in a fine-grained sphalerite-rich matrix. Where effects are visible, the pyrite grains have been fractured and elongated to form a rodding lineation.

Assays of grab samples taken by the writers from the Stralak deposits are given in Table 10.

Origin

The "Stralak deposits" have characteristics indicating that they are of volcanogenic origin, formed by volcanic exhalative processes (Sangster 1972) at approximately the same time as their host rocks. Evidence for this includes the position of the deposits at a mafic volcanic-felsic volcanic interface, their stra-

TABLE 10 ASSAYS OF SAMPLES, BENNY AREA.

Sample Number	Element							
	Cu (Percent)	Zn (Percent)	Pb (Percent)	Au (Ounces per ton)	Ag (Ounces per ton)	Fe (Percent)	Mo (Percent)	U (Percent)
109								0.032
110	0.10	10.3	1.05	0.01	1.25			
111	0.10			nil	nil			
112				nil	nil			
113				nil	nil			
114				nil	nil			
115	0.01	nil	nil					
116	0.07	nil	nil					
117	trace	nil	trace					
118	0.01	nil	nil					
119	0.03	nil	nil					
120	0.01	nil	0.02					
121	0.05	nil	0.04					
122	0.13	4.59	0.17	trace	0.50			
123				nil	nil			
124	0.39	10.4	0.56		2.22			
125	0.84	6.65	0.53	trace	1.12			
126	1.65	1.35	trace		1.32			
127				nil	nil			
128	trace	5.56	0.93	trace	0.80			
129				nil	nil			
130		12.3		nil	nil			
131	0.98	nil	0.13	trace	trace	5.42		
132	0.12	nil	0.50	trace	0.18			
133	0.08	nil	0.02	nil	trace			
134	0.04	nil	0.52	nil	trace			
135	0.97	10.6	4.95	trace	1.60			
136	0.04	0.58	0.02	nil	0.11			

Table 10 continued

137	< 0.01	0.33	0.08	nil	trace		
138	0.02	0.18	0.07	nil	trace		
139	0.01	trace	0.01			7.68	
140	trace	0.11	0.10	trace	0.12		
141	< 0.01	0.14	0.01	trace	trace	52.5	
142						36.2	
143	0.04						0.05

Sample Descriptions

Deposit and Sample Number			Description
3	109	GENEVA 75-1	Tuff with intrusive granitic material; Geneva Mine site (dump).
3	110	BI-73-G1	Massive sulphide (pyrite sphalerite, galena), N Central portion of Hess Tp., 1435 m N of NE end Geneva L., S of road Lot 7, Conc. 6, NW¼, N½.
23	111	BG-74-103	Stratabound sulphides in tuff-metasediment unit; SW portion of Stralak Tp., 185 m ENE of Kennedy L. - Tp. line crossing.
-	112	BG-74-30	Pyritic tuff; NW portion of Moncrieff Tp., 365 m SW of eastern tip of Straight L., Lot 11, Conc. 6, NW¼, N½.
-	113	BI-74-103	Pyritic tuff; NE portion of Moncrieff Tp., 2195 m NE of Benny, N of road, Lot 5, Conc. 6, NE¼, N½.
11	114	BI-74-118	Pyritic chert; N central portion of Moncrieff Tp., 915 m NE of Benny, Lot 6, Conc. 6, NE¼, N½.
6	115	BI-73-200	Sulphide-bearing tuffaceous metasediment; NW corner of Hess Tp., 260 m SE of NW Tp. corner, Lot 12, Conc. 6, NW¼, N½.
11	116	BI-73-142B	Sulphide-bearing tuff and metasediment; north central Moncrieff Tp., north of Benny road.
-	117	BI-73-94	Sulphide-bearing quartzitic metasediment, north central Hess Tp.
11	118	BI-73-142A	Sulphide-bearing tuff and metasediment; north central Moncrieff Tp., north of Benny road.
16	119	BI-73-74	Tuffaceous wacke with sulphides; southwestern Ulster Tp.
8	120	BC-73-110	Tuffaceous metasediment with pyrite; SW portion of Munster Tp., 1495 m NE of SW corner of Tp.
4	121	BC-73-87	Espanola limestone (mineralized); N central portion of Hess Tp., Lot 7, Conc. 4, NW¼, N½, 1160 m S of NE tip of Geneva L.
16	122	BI-74-13	Massive sulphide: (pyrite, sphalerite); NE portion of Craig Tp., 365 m NE of NE end of Copper L., Lot 1, Conc. 6, NE¼, N½.
19	123	BC-74-124	Massive sulphides (pyrrhotite, pyrite, sphalerite); 2045 m ENE of Kennedy-Bluewater L. narrows, Lot 7, Conc. 6, NW¼, N½, Craig Tp.

Table 10 - continued on next page.

Table 10 continued

15	124	BC-74-105	Pyritic chert; NE portion of Craig Tp., 760 m WSW of western tip of Capper L., Lot 2, Conc. 6, NE¼, N½.
16	125	BC-74-51	Massive sulphides (pyrite, sphalerite, chalcopyrite); Capper L., Lot 1, Conc. 6, NE¼, N½.
16	126	BC-74-49	Sericitic rhyolite; NE portion of Craig Tp., 120 m N of central Capper L., Lot 1, Conc. 6, NE¼, N½.
16	127	BC-74-47	Pyritic sericitic schist; NE portion of Craig Tp., 120 m N of Central Capper L., Lot 1, Conc. 6, NE¼, N½.
15	128	BB-74-50	Massive sulphides (pyrite, sphalerite, galena); NE portion of Craig Tp., 610 m SW of western tip of Capper L., Lot 2, Conc. 6, NE¼, N½.
21	129	BC-74-214	Disseminated sulphides; N central portion of Hart Tp., 2500 m SE of north Tp. line - Geneva Cr. junction.
21	130	BC-74-215	Espanola limestone (mineralized); N central portion of Hart Tp., 2990 m SE of N Tp. line - Geneva Cr. junction.
4A	131	BI-73-330	Espanola limestone (mineralized); 335 m SE of SW tip of Geneva L., Lot 11, Conc. 1, SW¼, S½, Hess Tp.
4	132	BI-73-184C	Espanola limestone (mineralized); N central portion of Hess Tp., 1340 m S of NE tip of Geneva L., Lot 7, Conc. 4, NW¼, N½.
4	133	BC-73-84	Espanola limestone (mineralized); N central portion of Hess Tp., 1160 m S of NE tip of Geneva L., Lot 7, Conc. 4, NW¼, N½.
4	134	BC-73-86	Espanola limestone (mineralized); N central portion of Hess Tp., 1160 m S of NE tip of Geneva L., Lot 7, Conc. 4, NW¼, N½.
4	135	BC-73-88	Espanola limestone (mineralized); N central portion of Hess Tp., 1160 m S of NE tip of Geneva L., Lot 7, Conc. 4, NW½, N½.
4	136	BC-73-91	Espanola limestone (mineralized); N central portion of Hess Tp., 1370 m S of NE tip of Geneva L., Lot 7, Conc. 4, NW¼, N½.
4	137	BC-73-90	Espanola limestone (mineralized); 1370 m S of NE tip of Geneva L., Lot 7, Conc. 4, N½, NW¼.
4	138	BC-73-89	Espanola limestone (mineralized); N central portion of Hess Tp., 1370 m S of NE tip of Geneva L., Lot 7, Conc. 4, N½, NW¼.
5	139	BC-73-120	Pyritic, mafic dike, S central portion of Munster Tp., 2745 m SE of SE end of Munster L.
17	140	BC-74-21	Pyritic chert; SW Ulster Tp., north of Straight Lake.
5	141	BC-73-119	Magnetite; S central portion of Munster Tp., 2655 m SE of SE end of Munster L.
18	142	BC-74-78	Iron formation; NE portion of Craig Tp., 1675 m SW of Spanish R.-Marion Cr. junction, Lot 5, Conc. 5, NE¼, N½.
2	143	BC-73-MOLY	Granitic dike; NE portion of Moncrieff Tp., 700 m NNW of NW tip of Bannerman L., Lot 5, Conc. 5, NE¼, N½.
21		F.F. Osborne (1929a)	Sulphide mineralization; Hart Township deposit.

Note: Assays by Geoscience Laboratories, Ontario Geological Survey.

tabound nature, and the layered stratiform character of the sulphides themselves. The sulphides have been deformed along with their host rocks and are clearly older than the post-tectonic metagabbro and granitic dikes. The "Stralak deposits" are basically similar to a number of other sulphide deposits in the Benny Belt and are remarkable only for their relatively high zinc, lead, and copper content.

GENEVA METALS INCORPORATED (GENEVA LAKE MINE) (5)

Exploration and Development

The Geneva Lake Mine in northern Hess Township was discovered by John Collins in 1924. Osborne (1929a) reported that one of the original pits, on the north shore of the swamp that covers much of the property, contained native gold. Exploration was begun in 1925 by the Collins-Babson Syndicate. In 1927, the Towagmac Exploration Company Limited carried out some 600 m of diamond drilling, and in 1928 a vertical shaft was sunk to a depth of 75 m with a level established at 60.5 m. The Lake Geneva Mining Company was incorporated in 1929 and development continued until 1930. In 1937 work began once again and the shaft was deepened to 120 m and additional working levels were established at the 94.5 m and 112.5 m levels. In 1943, an inclined winze was sunk below the ore zone from the 94.5 m level to a vertical depth of 192 m, and two more levels were established at 157.5 m and 184.5 m (Resident Geologists Files, Ontario Ministry of Natural Resources, Sudbury).

The mine produced lead and zinc concentrates during the period 1941 to 1944 which were sold to Metals Reserve Company, a United States Government agency. During this period 80,588 tons of ore grading 3.34 percent lead and 9.21 percent zinc were mined to produce 10 400 000 lbs of zinc, and 3 600 000 lbs of lead, and silver valued at $28,416. When the mine closed in 1944, an estimated 150 000 tons of ore were left in the workings (Resident Geologists Files, Ontario Ministry of Natural Resources, Sudbury).

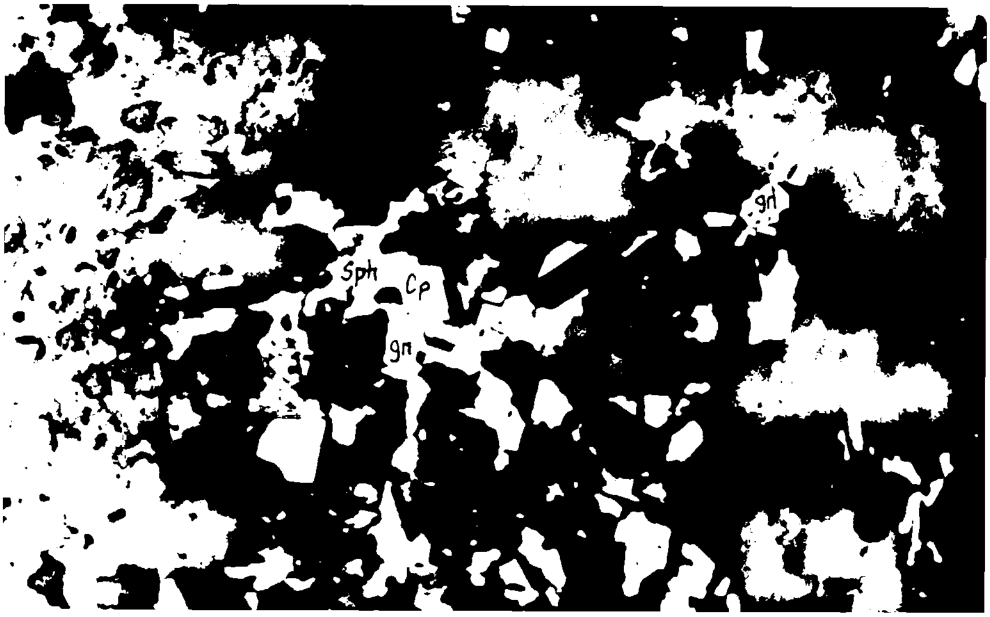
In 1949, the property was acquired by Bidgood Kirkland Gold Mines Limited who erected a 125 ton per day mill, dewatered and rehabilitated the underground workings, and carried out underground sampling and some 3600 m of diamond drilling. This work indicated reserves of some 114 000 tons of material grading 10 percent zinc, 3 percent lead, and 90 cents per ton precious metals (Resident Geologist Files, Ontario Ministry of Natural Resources, Sudbury). The property, consisting of 26 patented claims is presently held by Geneva Metals Incorporated who have carried out some diamond drilling in recent years (D.G. Innes, personal observation 1973).

The geology of the Geneva Mine has been described by T.T. Quirke (1920), Osborne (1929), Tuck (1931), and Hawley (1948). The deposit is a sheet-like body some 210 m long and 0.6 to 6 m thick. The average thickness of the ore was approximately 1.5 m and became narrower with depth. Drilling outlined the zone to a depth of about 300 m. The ore zone strikes northwest-southeast, dips 40° to 75° southwest, and is conformable with the stratification in the country rocks. The mineralization is in a thin unit of siliceous, micaceous metasediments and felsic tuffs at the contact between mafic and felsic metavolcanics. Quirke (1920) correlated the host rocks around the Geneva Mine with the Huronian Serpent Formation. Osborne (1929a) disagreed, classifying the rocks as pre-Huronian metavolcanics. The current mapping, as shown on Map 2435, and based on chemical and petrographic studies, demonstrates unequivocally that these rocks are part of the Early Precambrian metavolcanic-metasedimentary sequence.

In the area of the Geneva Lake Mine, stratification in the metavolcanic-metasedimentary sequence strikes northwest, whereas both to the east and west of the mine, the stratification strikes east. Thus, the deposit is located on the southeast flank of a large antiformal drag-fold. The country rocks north of the mine are extensively brecciated. This breccia resembles the "Sudbury - type" breccia in that it consists of rounded blocks of country rock in a fine-grained, rock flour matrix. The metavolcanics and metasediments in the mine area are also extensively intruded by granitic rocks, by metagabbro dikes, and by unaltered olivine diabase dikes. Tuck (1931) and Hawley (1948) concluded that the metagabbro was emplaced prior to the ore formation on the basis of an occurrence of minor amounts of sulphide in one of the dikes in contact with ore. Hawley (1948) also noted that veinlets containing the sulphides in the metagabbro were much coarser than those in the ore and were accompanied by abundant vein quartz and carbonate. The authors suggest that the metagabbro dikes are post-ore, as they clearly are at the similar Stralak deposit (properties 2 and 4, Map 2434, back pocket) in Craig Township. The sulphides in the metagabbro were probably formed by minor remobilization.

Osborne (1929a) stated that there is evidence for other zones of mineralization within the metavolcanic sequence immediately northeast of and parallel to the main zone. The authors examined core from diamond drilling done by Geneva Metals Incorporated that showed the presence of narrow zones of disseminated sulphide mineralization in the rocks to the south of the main zone. The ore is mineralogically simple, consisting of dark brown to black sphalerite, galena, and pyrite (Photo 8). Chalcopyrite, pyrrhotite, and arsenopyrite occur in negligible amounts. The contacts between the ore and the host rocks may be sharp, or more commonly, be gradational over a few metres. Most of the ore is massive, but locally the layering present is defined by ribbons of sphalerite, galena, and pyrite. This layering is parallel to the bedding and foliation in the country rocks.

The gangue minerals consist of chlorite, quartz, epidote, biotite, feldspar, and calcite. Tuck (1931) also noted the presence of diopside and garnet.



OGS 10 147

Photo 8–Photomicrograph of sphalerite, galena, and chalcopyrite mineralization, Lake Geneva Mine, Hess Township. 10X Magnification. Abbreviations: cp - chalcopyrite; gn - galena, sp - sphalerite.

Origin

Osborne (1929a,b), Tuck (1931), and Hawley (1948) concluded that the Geneva Lake Mine represented a hydrothermal deposit formed partly by fracture filling and partly by replacement along a zone of fracturing parallel to the bedding in the host rocks. The authors, in contrast, consider the Geneva Lake Mine deposit to be of volcanogenic origin, formed primarily by volcanic exhalative processes (Sangster 1972). Such an origin is indicated by: the location of the deposit at a mafic metavolcanic - felsic metavolcanic contact, the stratabound nature of the mineralization, and the presence of parallel zones of low grade mineralization. Layering in the ore probably in part represents original depositional layering, and in part, superimposed tectonic foliation that is also present in the metavolcanics. The ore has been tectonically deformed along with the country rocks. There may have been some tectonic remobilization and thickening of the ore in a dilatant zone formed by folding.

STRAIGHT LAKE OCCURRENCE (9)

The Straight Lake Occurrence is immediately north of Straight Lake and the Canadian Pacific Railway in southwestern Ulster Township. This occurrence is described as the "Turga Property' by Osborne (1929a). It probably represents the eastward continuation of the mineralized zone in which the Stralak deposits are located.

Disseminated sulphides occur in thin-bedded, siliceous metasediments and tuffs immediately south of a mafic metavolcanic unit. The sulphides, mainly pyrite but also minor sphalerite, galena, and chalcopyrite, form erratically distributed stratabound disseminations and massive lenses in a zone approximately 1.5 m thick and 120 m in length. The zone strikes east and dips approximately 60° south. The mineralization has been tested by a large pit approximately 3 m square and 4.5 m deep and several smaller pits and trenches of unknown origin.

Assays of mineralized grab samples taken by the writers are given in Table 10. The ground was open to staking at the time of this survey.

Other Sulphide Occurrences in the Metavolcanic-Metasedimentary Sequence

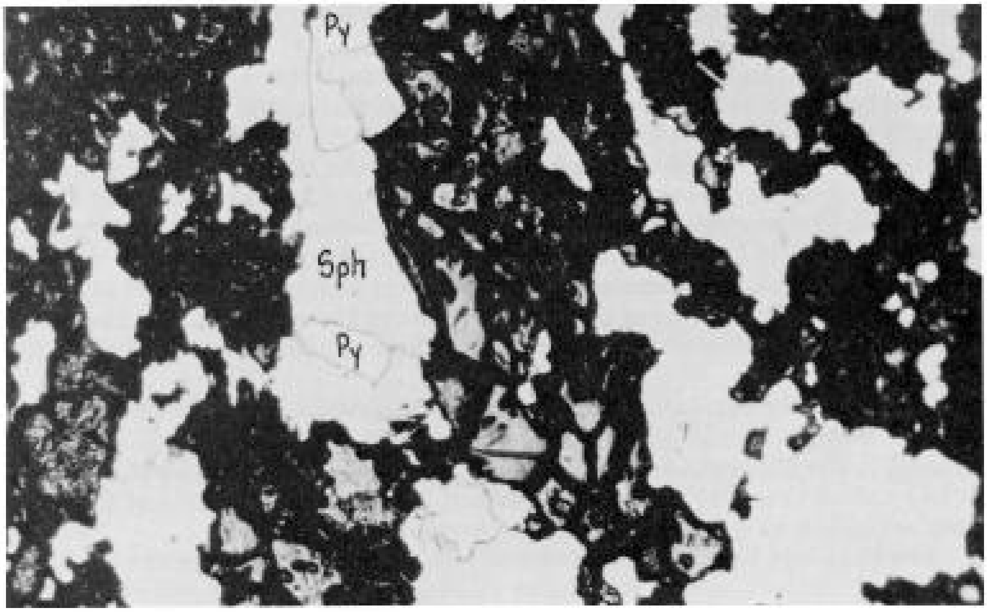
There are a number of other occurrences of sulphide mineralization in the Benny Metavolcanic-Metasedimentary Belt as shown on Figure 18 (see Chart B, back pocket) on which no exploration work has been recorded in the Assessment Files Research Office, Ontario Geological Survey, Toronto. All are essentially similar, consisting of disseminated sulphides and massive sulphide lenses in siliceous, micaceous, and graphitic metasediment-tuff units interstratified with mafic, intermediate, and felsic metavolcanics. The majority of the sulphide-bearing units occur between mafic or intermediate metavolcanics and felsic pyroclastic rocks. Pyrite and pyrrhotite are by far the most abundant sulphides present, but in a number of units, sphalerite, chalcopyrite, and galena are locally present in minor amounts.

There is a prominent zone of such sulphide-bearing units in the southern part of the belt that extends from central Moncrieff Township into Craig Township. Within this zone, there are four to six stratigraphic units that contain disseminated to massive pyrite and pyrrhotite. Individual sulphide-bearing zones are up to 30 m thick and several are at least 2.5 km long. Graphite is commonly present and as a consequence these units are conductive and give rise to electromagnetic anomalies. The mineralized zones have been tested sporadically by pitting and trenching. No sphalerite, galena, or chalcopyrite were observed during the present survey.

There is a second zone of sulphide-bearing units in the central part of the belt that extends intermittently from northwestern Hess Township through Moncrieff and Craig Townships into southeastern Gilbert Township (see Maps 2434 and 2435, back pocket).

Again, these units consist of siliceous, micaceous, and graphitic metasediments and tuffs with disseminated sulphides and massive sulphide lenses. Some massive sulphide lenses, (Maps 2434 and 2435, back pocket) are up to 1.5 m thick. Pyrite and pyrrhotite are most prevalent, but at several locations Maps 2434 and 2435, back pocket) minor amounts of other sulphides, including chalcopyrite, sphalerite, or galena are also present.

Assays and trace element analyses of samples taken by the authors are given in Table 10.



OGS 10 149

Photo 9–Photomicrograph of sphalerite and pyrite, Hart Township deposit. 10X Magnification. Note that sphalerite appears to replace pyrite. Abbreviations: sp - sphalerite; py - pyrite.

BASE-METAL AND IRON DEPOSITS IN HURONIAN ROCKS

Replacement-type base-metal deposits occur in Huronian metasediments, particularly in calcareous rocks of the Espanola Formation, near their contacts with Nipissing Diabase intrusions in central Hess Township, (see Map 2435, back pocket) and northern Hart Township (Jar-Vin Magnetite Syndicate (7), Map 2434, back pocket). The main sulphides present, pyrite, sphalerite, chalcopyrite, and galena, form disseminated and massive vein-type replacements in the metamorphosed Huronian rocks near the Nipissing Diabase intrusions (Photo 9). The sulphide deposits would appear to be genetically related to massive replacement-type magnetite deposits that also occur in the Huronian metasediments near Nipissing Diabase contacts in southwestern Hess Township and south-central Munster Township (Munster Township Occurrence (8); see Maps 2434 and 2435, back pocket).

CENTRAL HESS TOWNSHIP OCCURRENCE (3)

Sulphide mineralization containing zinc, lead, copper, and silver was discovered in carbonate rocks of the Espanola Formation in central Hess Town-

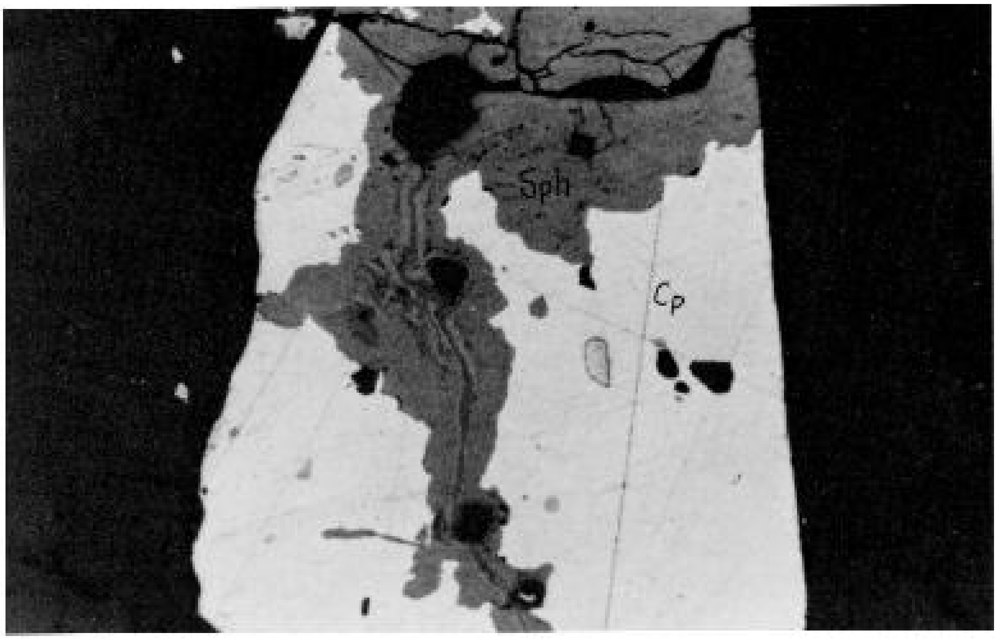


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Photo 10–Photomicrograph of sphalerite, and chalcopyrite, Hess Township, zinc-lead-copper deposit. 10X Magnification. Note replacement of chalcopyrite by sphalerite along fractures. Abbreviations: cp-chalcopyrite; sp-sphalerite.

and galena, occur as disseminations in dolostone and dolostone breccia.

Assays of samples from the Hess Township occurrences are given in Table 10. The genesis of this and similar deposits in the Huronian rocks will be discussed in a later section.

JAR-VIN MAGNETITE SYNDICATE (7)

In northern Hart Township, a replacement-type deposit containing zinc with minor copper, lead, cobalt, and nickel occurs in brecciated, contact-metamorphosed rocks of the Espanola and Serpent Formations as veins, disseminations, and massive lenses of mineralization which are erratically distributed in a zone approximately 300 m in length near a Nipissing Diabase intrusion.

This deposit, also known as the Iron Mask Cobalt Silver Mine (Osborne 1929a, 1929b), has been tested by surface trenching, diamond drilling, and a magnetometer survey, mainly by Mogul Mining Corporation Limited in 1955, Salem Exploration Limited in 1964, and Jar-Vin Magnetite Syndicate in 1973 to 1974. This work has outlined several zones of mineralization up to 1.4 m wide with assays ranging from 1.46 to 8.06 percent zinc and 0.03 to 0.12 percent cobalt. (Resident Geologists Files, Ontario Ministry of Natural Resources, Sudship during the current survey. The occurrences have been comprehensively described by A.E. Guthrie (1974).

The mineralization consists of disseminations, veins and masses of iron-rich and iron-poor varieties of sphalerite, galena, pyrite, and chalcopyrite in recrystallized, silicified, dolomite and dolomitic breccia of the lower part of the Espanola Formation (Photos 10 and 11). These rocks rest directly on a rotated, sheared, and brecciated unconformity developed on Early Precambrian quartz monzonite. The country rocks are intruded by a Nipissing Diabase body exposed approximately 200 m to the east of the main sulphide occurrence. Near the interpreted Nipissing-Huronian contact which is drift-covered, there is a magnetic anomaly. The source of this anomaly is not known, but the authors suspect that it is caused by a body of magnetite mineralization developed along the contact.

The Espanola Formation in this area rests directly on Early Precambrian granitic basement, and Espanola and basement rocks have been deformed. Bedding in the Espanola Formation faces northwest, dips at angles of N60°W to S75°E, and strikes N25°E in the northeast. The Espanola rocks and the basement rocks are cut and displaced by northwest-trending faults.

The Espanola Formation consists of a lower carbonate member some 40 to 70 m thick and an upper calcareous siltstone member approximately 60 m thick. The lower carbonate member is divisible into a lower sequence 1.5 m thick consisting of very thin bedded, silty calcitic dolostone with abundant siltstone interbeds, and a middle sequence 36 to 45 m thick consisting of thin-bedded (1 mm to 3 mm) dolostone with minor silty interbeds. Within this sequence, there are numerous thick units of massive, recrystallized dolostone lacking silty interbeds, and dolostone breccia consisting of angular dolostone and limestone chips in a dolostone matrix. Most of the known sulphide mineralization occurs in the middle sequence. The upper sequence is up to 22 m thick and consists of clean, fine-grained dolostone and calcitic dolostone with beds up to 30 cm thick. Several thick, recrystallized dolostone units are present in the upper sequence.

The main zone of sulphide mineralization is exposed for a distance of 4.5 m across strike in the Espanola metasediments but for only a short distance along strike on a small point on the north side of a large dry marsh. The sulphide minerals, sphalerite, galena, pyrite, and chalcopyrite, occur as massive pods and veins surrounded by a halo of veinlets and disseminations near the top of a thick, massive recrystallized dolostone unit.

To the north of the main zone, minor disseminated sulphides are present in dolostone over an outcrop width of 21 m.

To the south, across a drift-covered interval some 9 m wide, there is an exposure of recrystallized dolostone with minor disseminated pyrite, sphalerite, galena, and chalcopyrite over an outcrop width of 9 m. At the southeast end of this outcrop, the Espanola dolostone unconformably overlies granitic basement rocks.

Some 180 m to the east, minor disseminated sulphides, mainly pyrite and galena, are present in a small exposure of Espanola dolostone.

To the west, the strike of the Espanola Formation changes abruptly and approximately 200 m southwest of the main occurrence, sulphides are again present in the carbonate rocks. Pyrite and sphalerite, as well as minor chalcopyrite

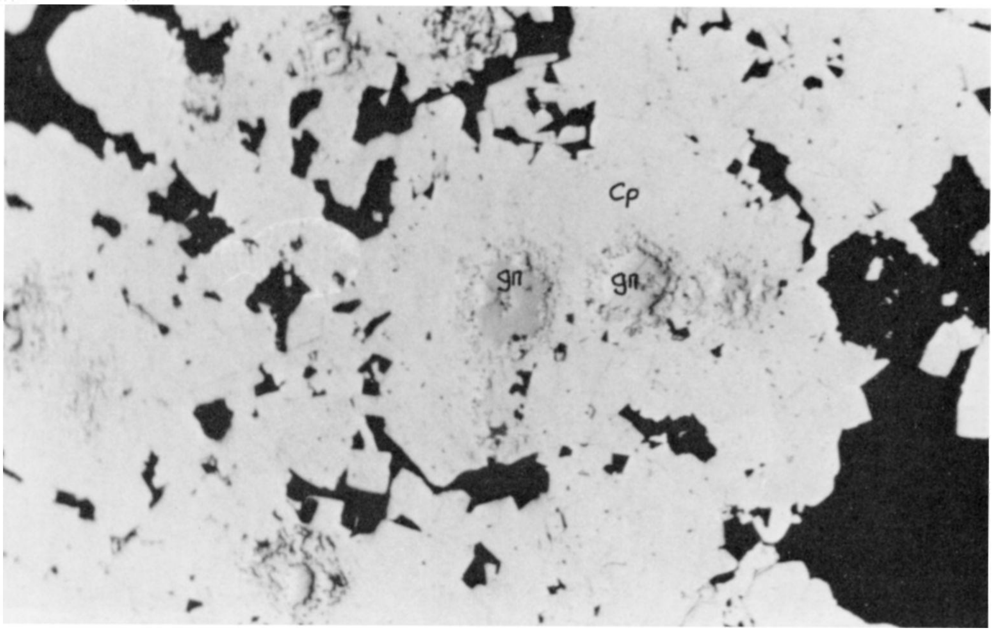

Photo 11-Photomicrograph of chalcopyrite and galena, Hess Township zinc-lead-copper deposit. 10X Magnification. Note the isolated "atolls" of galena within the chalcopyrite. Abbreviations: cp - chalcopyrite; gn - galena.

bury). The main zones of mineralization were held by Jar-Vin Magnetite Syndicate in 1974 under mining claims S66018, S66020, and S66022 (Map 2435, back pocket).

Assays reported by Osborne (1929b) and of samples taken by the authors are given in Table 10.

The sulphide minerals present include sphalerite, pyrite, chalcopyrite, and galena (see Photo 9). Osborne (1929b) also reported minor amounts of a cobalt mineral, presumably cobaltite or smaltite. Magnetite, in the form of veins and disseminations, occurs in a zone approximately 120 m long in the metasediments at the Nipissing Diabase contact. Chalcopyrite and pyrite mineralization occur further away from this contact, and still further from the contact, occur veins and disseminations of sphalerite and galena. According to Osborne (1929b), the cobalt mineralization occurs still further away from the Nipissing Diabase contact.

The metamorphosed calcareous rocks of the Espanola Formation, originally magnesian limestone, dolomite, and calcareous siltstone, contain carbonate minerals, garnet, diopside, wollastonite, quartz, biotite, and chlorite. The intrusive Nipissing Diabase is a metagabbro, consisting of metamorphic amphiboles and saussuritized plagioclase. A chemical analysis given in Table 6 shows that it is chemically similar to other Nipissing Diabase intrusions that occur throughout the region.

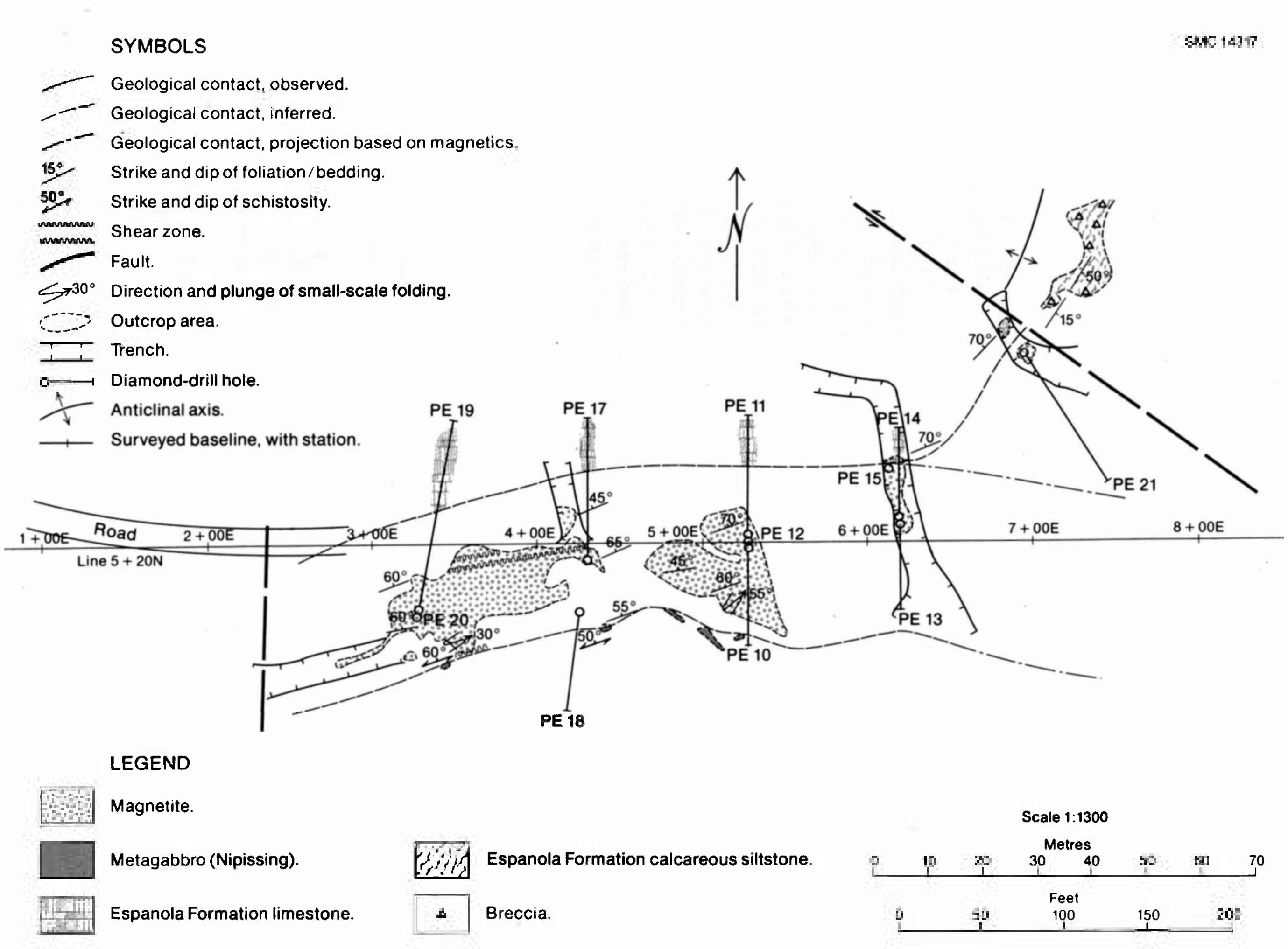

Figure 20–Plan view of the Bardswich Lake magnetite deposit, Hess Township.

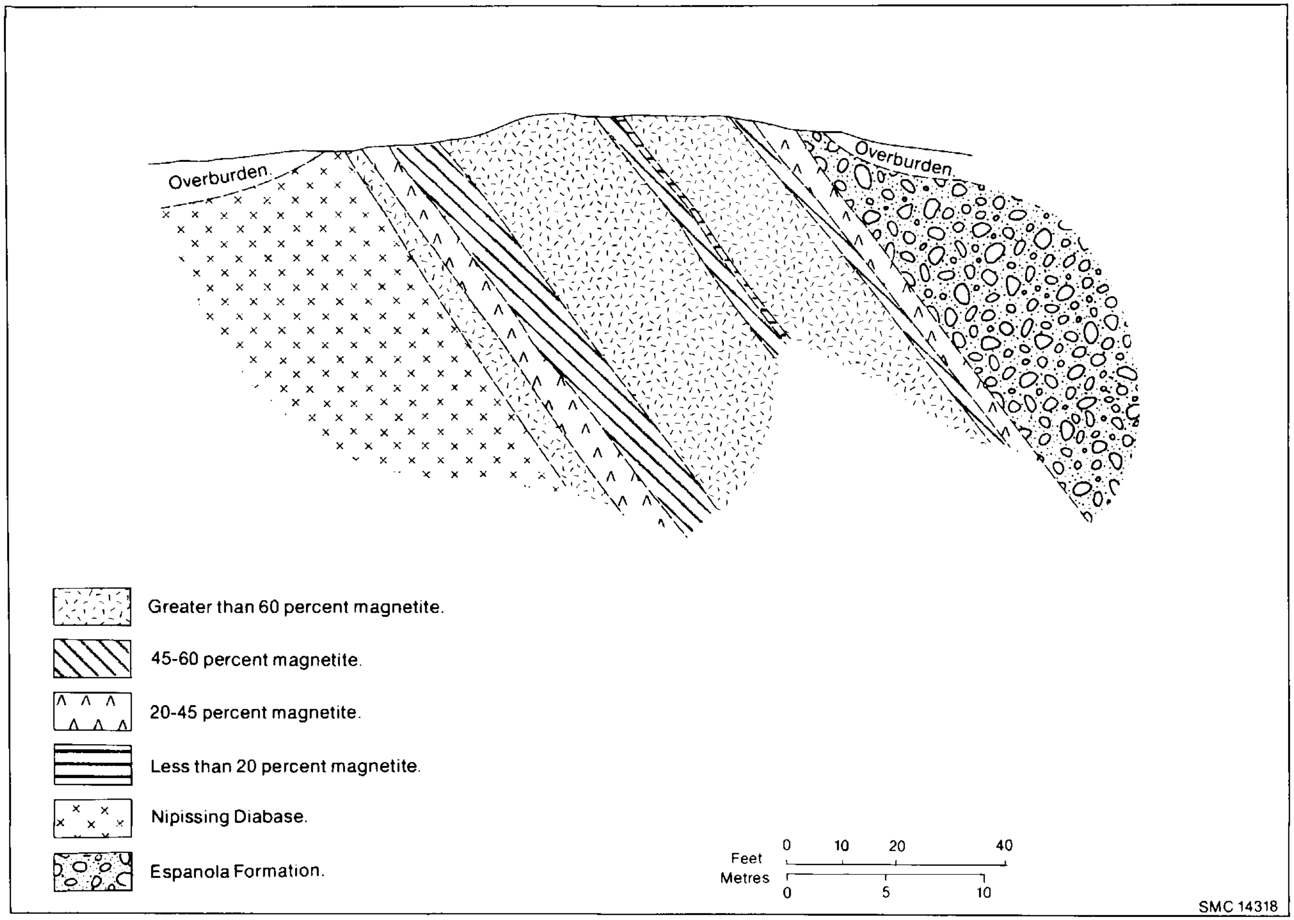

Figure 21–Cross-section of the Bardswich Lake magnetite deposit (after Masson 1976).

IRON

L.G. BARDSWICH (1)

Exploration History

The property, known as the Bardswich Deposit, is located at the southwestern end of Clear[1] Lake, Hess Township approximately 800 m east of the Canadian Pacific Railway track at Cartier. The deposit has been explored by Jaybee Landry Exploration and Mining Company in 1966, 1967, and 1969 by pitting, trenching, diamond drilling, and a magnetometer survey. During the period 1973 to 1975, exploration consisted of stripping, trenching, a magnetometer survey, assaying, mill testing, and the drilling of 11 diamond-drill holes totalling 334 m in length was conducted by the current owner of the property, L.G. Bardswich. This work has outlined a body of magnetite mineralization containing 456 800 long tons to a vertical depth of 30 m of rock grading 34 percent iron in the form of magnetite (Figures 20 and 21). The deepest diamond-drill hole has penetrated magnetite mineralization to a vertical depth of 41 m (Resident Geologists Files, Ontario Ministry of Natural Resources, Sudbury). Minor amounts of copper in the form of chalcopyrite are also present.

The deposit has been comprehensively described by S. Masson (1976). The property consisting of several unpatented mining claims, is held by Bardswich.

Geology

Magnetite mineralization replaces carbonate-rich rocks of the Espanola Formation that form a fault-bounded outlier enclosed within Early Precambrian granitic rock. The Espanola Formation is intruded by a Nipissing Diabase body on the south. The Espanola Formation comprises thin-bedded magnesian limestone, sandy limestone, and calcareous siltstone. The beds strike east to northeast, and near the Nipissing Diabase intrusion and the magnetite body, dip northward at angles of 60° to 70°.

The southern extensions of the Espanola Formation and the magnetite mineralization are drift-covered. The deposit is located at the northeastern end of a large aeromagnetic anomaly that extends southward from Clear Lake for approximately 8 km (GSC 1965c).

The Nipissing Diabase intrusion consists mainly of medium- to coarse-grained, fresh-textured metagabbro composed mainly of hornblende and saussuritized plagioclase. It is similar to other Nipissing metagabbros of the region. Near the contact with the magnetite body, the intrusion is sheared, fine grained, and rich in chlorite. The footwall contact between the altered gabbro

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[1] The lake is known in the region as Hess Lake, but was changed to Clear Lake at the insistence of the Nomenclature Section, Ontario Ministry of Natural Resources.

and the magnetite body is sharp, as is the hanging wall contact of the magnetite with the Espanola Formation. In the east, the contact is very sharp passing from magnetite with actinolite and chlorite to well-bedded limestone over a distance of 1 to 2 cm. In the western part of the zone, the magnetite mineralization ends abruptly, but there is a unit of altered limestone with disseminated pyrite and chalcopyrite a few metres thick along the contact.

The magnetite body is 144 m long and 22.5 to 30 m in width. It strikes approximately east-west and dips 60° to 70° north parallel to the bedding in the overlying Espanola Formation. The magnetite mineralization is distinctly layered at various scales ranging from metres to microscopic and this layering is conformable to the contacts and the bedding in the host rocks. The layers are defined by variations in the proportions of magnetite, silicates, and carbonate, and by the variations in grain size (Photo 12). The layering strongly implies *in situ* replacement of a bedded sequence of limestone and siltstone of variable composition.

Magnetite is the main oxide mineral present and forms granular aggregates, octahedral crystals, and tabular grains as much as 5 mm, in medium dimensions. Larger magnetite grains have inclusions of silicate and carbonate. Lesser amounts of hematite occur adjacent to the hangingwall and footwall and along fractures within the magnetite body. Chalcopyrite occurs as disseminations in the magnetite-rich parts of the body where it is associated with carbonate veining, and in the altered hangingwall carbonate rocks. Pyrite is ubiquitous.

The gangue minerals include carbonate, actinolite-tremolite, talc, quartz, chlorite, and epidote. Masson (1976) reported the presence of altered garnet.

MUNSTER TOWNSHIP OCCURRENCE (8)

A magnetite deposit located in south-central Munster Township has been explored by B and M Explorations Limited in 1951, 1956, and 1958 and by Eugene Vannier in 1968 by a number of shallow pits, an adit, geophysical surveys, and diamond drilling. This work has outlined two pod-like concentrations of mineralization, a western body measuring approximately 18 by 100 m and an eastern body 36 by 42 m. Diamond-drilling intersected up to 26 m of iron mineralization, and assays ranging from 15 to 44 percent iron over core lengths of 1.5 to 2.5 m were obtained (Resident Geologist's Files, Ontario Ministry of Natural Resources, Sudbury). In 1974, the ground covering the occurrences was open for staking.

The deposit is a replacement-type deposit and occurs at the contact of a mafic dike and Huronian metasediments. The metasediments are thinly bedded, fine-grained, greenish grey sandstone and siltstone tentatively correlated with the Gowganda Formation. Fragments of Espanola-type limestone are present in one of the dumps. The metasediments are silicified, chloritized, brecciated, and cut by numerous magnetite- and hematite-bearing quartz veins (Photo 13). The mafic dike is highly altered and chloritized. Concentrations of magnetite and hematite occur in both the dike and the metasediments. Pyrite samples taken by the authors show that minor to trace amounts of zinc, lead,

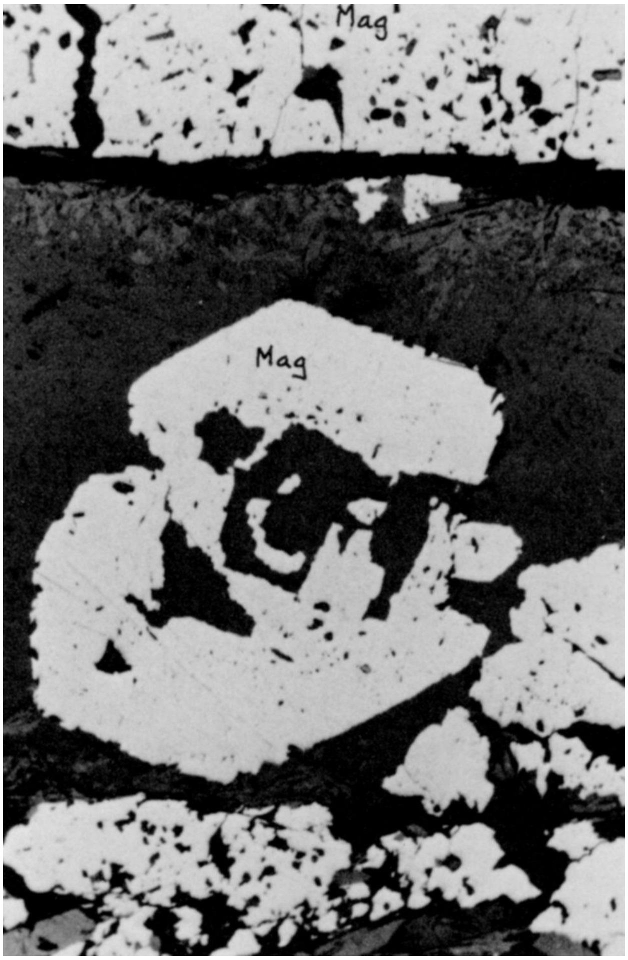

Photo 12–Photomicrograph of magnetite mineralization, Bardswich Lake magnetite deposit, Hess Township. 10X Magnification. Note the mineralogical layering with alternating magnetite-rich and gangue-rich layers with skeletal magnetite crystals.

copper, silver, and gold are present in addition to iron (see Table 10).

Approximately 0.8 km north of the main occurrence, brecciated Huronian metasediments are in contact with a mafic dike tentatively correlated with the dike to the south. Magnetite- and hematite-bearing quartz veins are present in the metasediments and as pods and disseminations in the altered dike.

ORIGIN OF IRON AND BASE-METAL DEPOSITS IN THE HURONIAN ROCKS

The Central Hess Township Occurrence (3), L.G. Bardswich (1), the Jar-Vin Magnetite Syndicate (7), and the Munster Township Occurrence (8) have

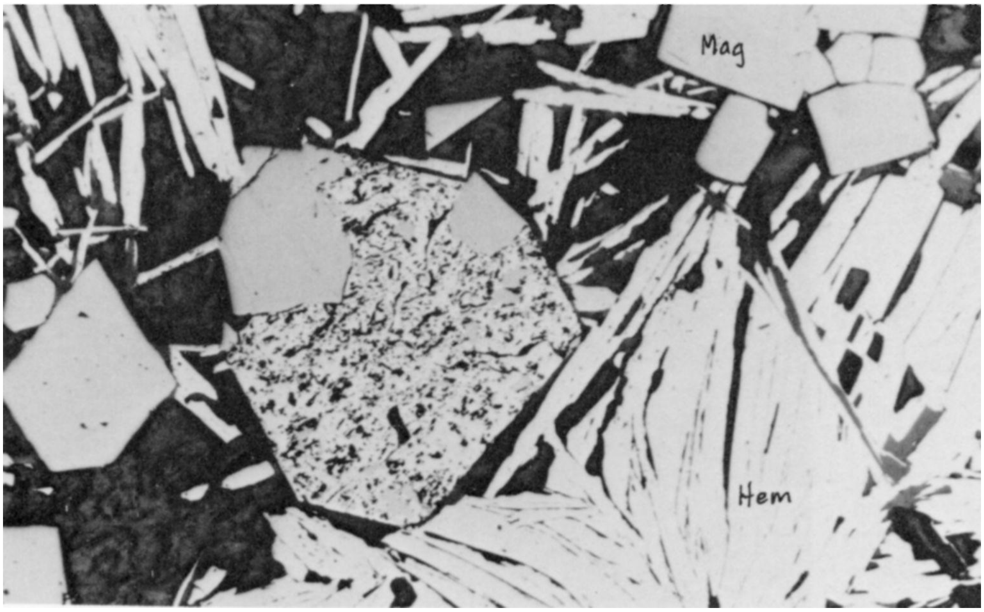

Photo 13–Photomicrograph of magnetite and hematite, Munster Township magnetite deposit. 10X Magnification. Note the partly replaced (by hematite) magnetite crystal in the centre of photograph. Abbreviations: Hem - Hematite, Mag - Magnetite.

many similarities which indicate a common origin. There are mineralogical similarities as all contain magnetite, sphalerite, and chalcopyrite though in differing proportions in different deposits. All are located in Huronian rocks, notably in dolomite and magnesian limestone of the Espanola Formation, where these rocks rest directly on Early Precambrian basement rocks. All the deposits are at or near the contacts of the metasediments with Nipissing Diabase intrusions. The oxide and sulphide minerals replace carbonate and silicate minerals of the host rocks, and there is evidence of mineral zoning. Magnetite concentrations occur nearest the Nipissing Diabase contacts and are followed successively outward by chalcopyrite, sphalerite, and galena mineralization.

The foregoing characteristics indicate that the deposits were formed by metal-bearing hydrothermal solutions coming in contact with and replacing carbonate rocks.

Nipissing Diabase is an obvious source for these metalliferous solutions which presumably originated as late stage emanations from the mafic magma. However, if this were the case, magnetite, sphalerite, and chalcopyrite mineralization should occur within the diabase itself. None is apparently present. Analyses of the Nipissing Diabase taken near the deposits do not show any bulk chemical or trace element anomalies (see Analysis 56, Table 6). The contacts of the Nipissing Diabase with the mineralization, where exposed, are sharp, not gradational as might be expected if the metal-rich solutions emanated from the Nipissing Diabase. As Masson (1976) postulated in the case of the L.G. Bardswich property (1), the Nipissing Diabase may not represent the source of the mineralizing fluids, but rather acted as a "heat engine" causing mobilization of metals from the country rocks. These metals were subsequently precipitated in the chemically favourable calcareous sediments.

OTHER IRON OCCURRENCES

A small lens of banded iron formation is present in the Early Precambrian Benny metavolcanic-metasedimentary sequence in northwestern Craig Township. The rock is a typical oxide-facies iron formation consisting of alternating magnetite-rich and silica-rich layers a few mm thick. It is interbedded with mafic and intermediate pyroclastic rocks and sulphide-bearing metasediments. The lens is approximately 400 m long and 9 m thick. A grab sample taken by the writers yielded 36.2 percent iron upon assay by the Geoscience Laboratories, Ontario Geological Survey, Toronto (see Table 10).

Veinlets and pods of magnetite and hematite are common in the Huronian metasediments and in the Early Precambrian rocks in the eastern half of the map-area, where they are apparently associated with breccia bodies. The most noteworthy of these are in Early Precambrian granitic rocks in northeastern Hess Township immediately north of the east end of Geneva Lake and east of the Geneva Lake Mine, and in Huronian rocks in northwestern Hart Township. In addition to magnetite, minor amounts of sulphide minerals including pyrite, pyrrhotite, and chalcopyrite, are commonly also present.

NICKEL, COPPER

INTERNATIONAL NICKEL COMPANY OF CANADA LIMITED (FOY OFFSET DEPOSIT) (6)

A mafic dike containing nickel and copper sulphide mineralization is exposed in east-central Hess Township and adjacent Harty Township. The dike strikes east-northeast, dips vertically, is 15 to 30 m wide, and intrudes altered, brecciated, silicified Early Precambrian granitic rocks. It probably represents part of the Foy Offset (Card and Meyn 1969), a dike extending north and west from the North Range of the Sudbury Nickel Irruptive.

Sulphide mineralization in the dike has been tested by Green in 1927 who drilled 9 holes totalling 121 m and by Canadian Nickel Company in 1966 who drilled 30 diamond-drill holes totalling 2935 m in length.

Sulphide minerals, including pyrrhotite, chalcopyrite, and pentlandite occur as disseminations and massive pods in the fresh-textured quartz diorite dike. The main sulphide occurrence in east-central Hess Township is exposed in three water-filled pits each approximately 3 metres square on the north side of a small pond. In 1974, this occurrence was held by INCO under mining claims S133441 and S133417.

URANIUM

Exploration for uranium was carried out in the map-area in 1969 to 1970 by R. Benner and Moncrieff Uranium Mines Limited. The Huronian rocks in eastern Moncrieff Township and western Hess Township were tested by surface exploration and diamond drilling, apparently with negative results.

Dome Exploration (Canada) Limited carried out a combined airborne radiometric-magnetometer survey covering part of the northwestern Hess Township and adjacent parts of Harty, Leinster, and Munster Townships in 1974. Subsequent to the present survey, Hollinger Mines Limited discovered radioactivity in coarse, porphyritic biotite quartz monzonite of Early Precambrian age approximately 300 m south of the Canadian Pacific Railway tracks in Moncrieff Township. The radioactivity occurs in a narrow, sheared, brecciated zone in the granitic rocks. Assays by Hollinger Mines Limited are reported to have yielded up to 0.17 percent U_30_8, (Personal communication, 1975, Resident Geologist, Ontario Ministry of Natural Resources, Toronto).

A sample consisting partly of metavolcanic material and intrusive granitic material taken by the writers from the Geneva Lake Mine dump was later discovered to be radioactive. The sample yielded 0.032 percent U_30_8 upon assay (see Table 10).

MOLYBDENITE AND FLUORITE

Minor amounts of molybdenite and fluorite are present in the Early Precambrian quartz monzonite that intrudes the Benny metavolcanics in Moncrieff Township along Highway 144. A few flakes of molybdenite and some fluorite coatings on joint planes were observed in the rocks in the road-cut.

Osborne (1929a) also reported minor amounts of molybdenite in the granitic rocks in Hess Township. Molybdenite occurs as small, disseminated flakes in the granitic rocks and in quartz veins. Fluorite occurs as disseminations and as fracture coatings.

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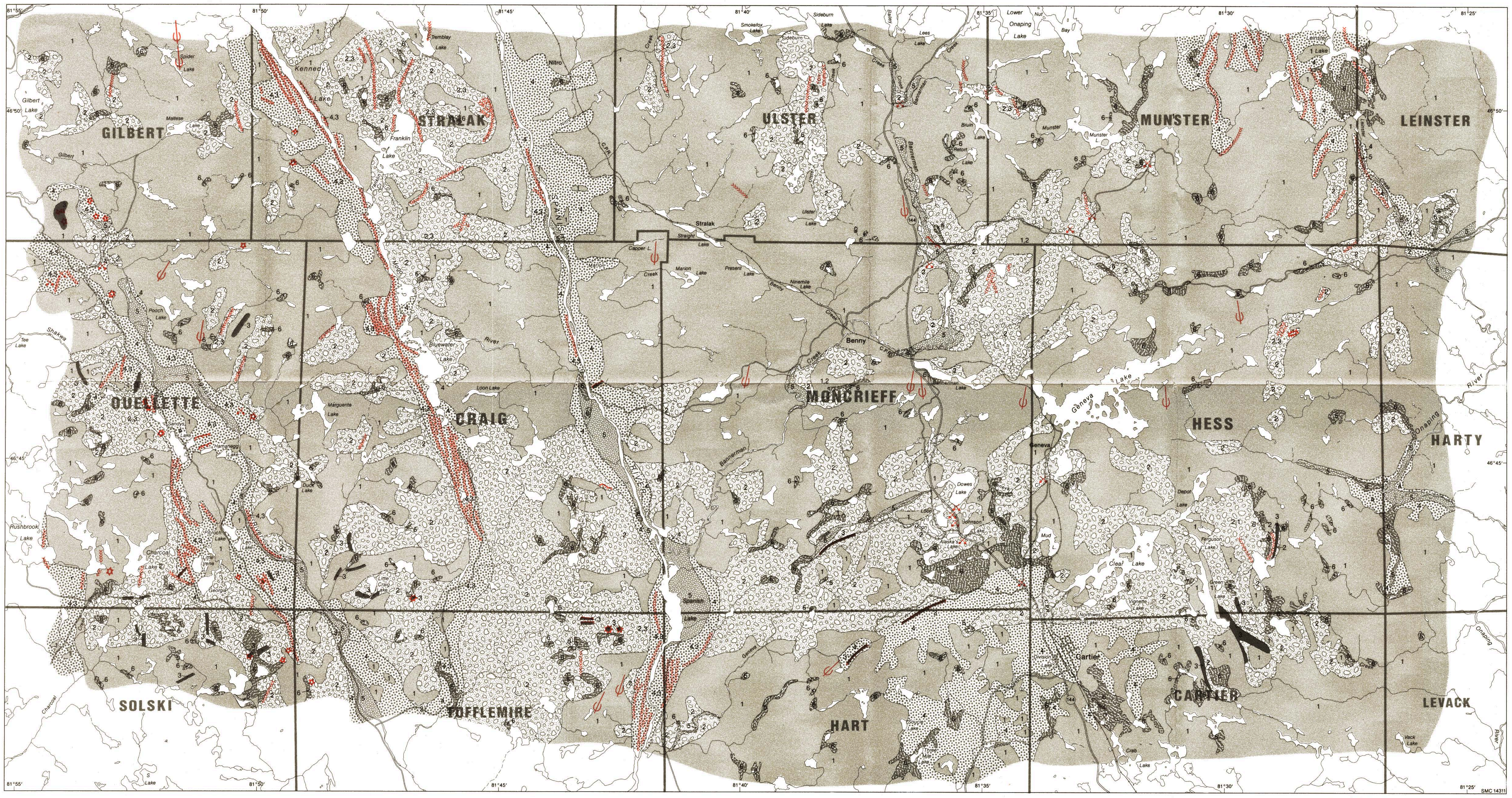


Figure 15 – Surficial geology of the Benny area.

LEGEND

QUATERNARY

RECENT

6 Swamp deposits; mud, muck, peat. Mixed paludal and modern lacustrine sediments in areas of marsh overgrowth.

5 Fluvial deposits; sand, gravel, silt, elevated stream terrace remnants, sand spits, gravel bars.

PLEISTOCENE

4 Glaciofluvial deposits; outwash sand, silt, gravel, valley trains and terraces, deltaic deposits modified by lake action, transitional to lacustrine deposits.

3 Ice contact deposits; kames, eskers, sand, gravel, boulder trains.

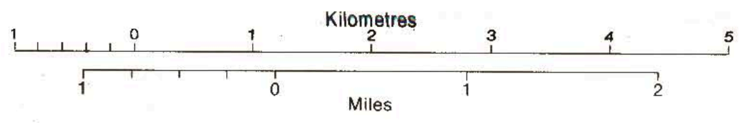
2 Glacial till deposits; gravel, boulder and cobble gravels, sand.

1 Bedrock-drift complex; thin ground moraine, exposed bedrock.

SYMBOLS

- Geological boundary; actual or interpreted.
- Sand or gravel pit.
- Glacial striation; ice movement direction indicated.
- Esker; current direction indicated.
- Terrace escarpment.
- Kame deposit.

Scale 1:63 360 or 1 inch to 1 mile



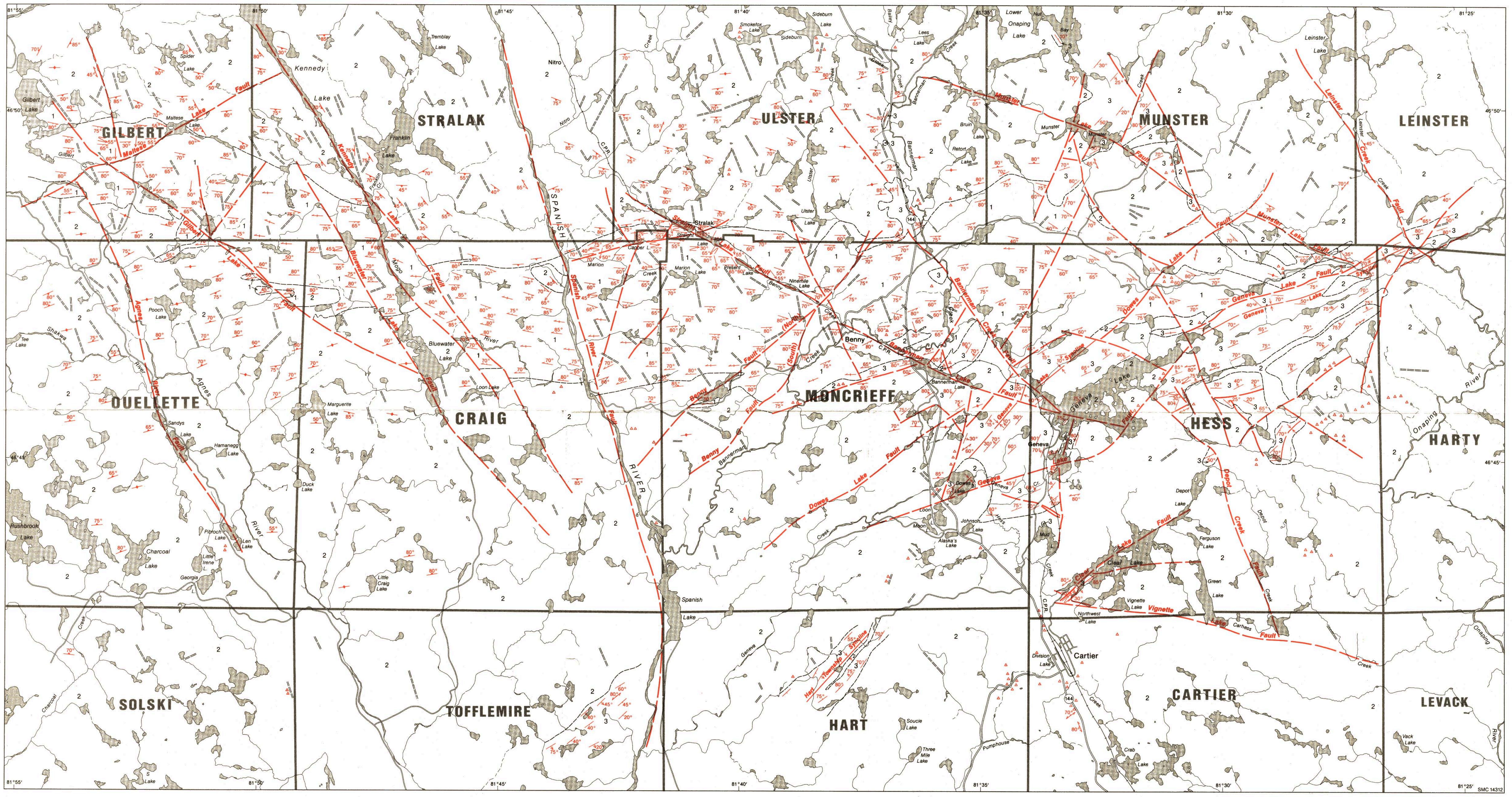


Figure 16 – Structural geology of the Benny area.

LEGEND

MIDDLE PRECAMBRIAN

3 Huronian Supergroup.

EARLY PRECAMBRIAN

Mafic and felsic dikes.

2 Granitic rocks.

1 Metavolcanic and metasedimentary rocks.

SYMBOLS

- Geological boundary.
- Fault.
- Axial trace of syncline.
- Axial trace of anticline.
- △ Breccia.
- 60° Stratiform foliation, penetrative schistosity.
- 60° Cleavage, non-penetrative foliation.
- 60° Gneissosity, penetrative cataclastic foliation.
- 60° Lineation.
- 60° Minor fold, with plunge.
- Minor fold, plunge unknown.
- 60° Bedding; inclined, vertical, horizontal.
- 60° 60° Bedding; top indicated by arrow; inclined, overturned.

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Chart B
Figures 18 and 19

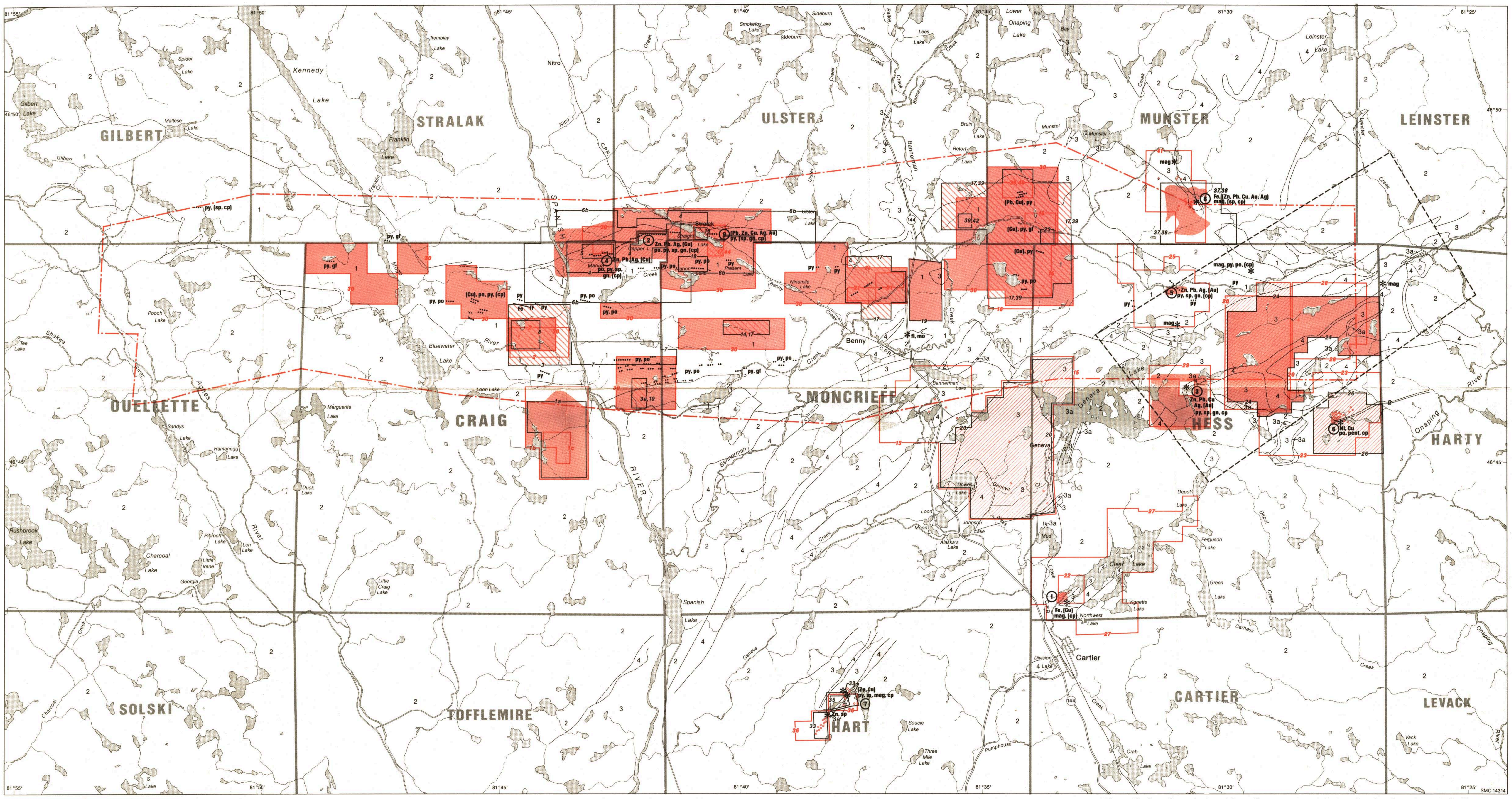

Figure 18 – Locations of mineral deposits, properties, and mineral exploration surveys in the Benny area.

LEGEND

MIDDLE PRECAMBRIAN

5	Foy Offset.
4	Nipissing Diabase.
3	Huronian Supergroup. 3a – Espanola Formation.

EARLY PRECAMBRIAN

2	Felsic plutonic and migmatitic rocks.
1	Metavolcanic and metasedimentary rocks.

SYMBOLS

Geological boundary.
Location of diamond-drill hole.

DEPOSIT TYPES

*	Vein and lode deposits.
IF	Algoma-type, oxide facies iron formation.
....	Stratabound volcanogenic sulphide deposits, disseminated and massive.

METALS

Ag	Silver.
Au	Gold.
Cu	Copper.
Fe	Iron.
Ni	Nickel.
Pb	Lead.
Zn	Zinc.
( )	Minor or trace amounts.

MINERALS

cp	Chalcopyrite.
fl	Fluorite.
gf	Graphite.
gn	Galena.
mag	Magnetite.
mo	Molybdenite.
po	Pyrrhotite.
py	Pyrite.
sp	Sphalerite.
( )	Minor or trace amounts.

SURVEYS[a]

▨	Area of geological survey.
🟥	Area of geophysical survey.
▨	Area of geochemical survey.
— — —	Boundary of Dome Exploration (Canada) Ltd. aeromagnetic and radiometric survey.
— · —	Boundary of Tex-Sol Explorations Ltd. aeromagnetic survey.

PROPERTIES

—17— —30—	Property boundary, approximate position only.[b]
⑤	Location of property or mineral deposit.[c]

[a] These surveys are on file in the Resident Geologist's files, Ontario Ministry of Natural Resources, Sudbury.

[b] Number refers to company name and assessment file reference in Table 9. These properties include unpatented claim groups no longer in good standing in 1974.

[c] Number refers to list of properties and mineral deposits on Maps 2434 and 2435.

Scale 1:63 360 or 1 inch to 1 mile

Kilometres 1 0 1 2 3 4 5

Miles 1 0 1 2

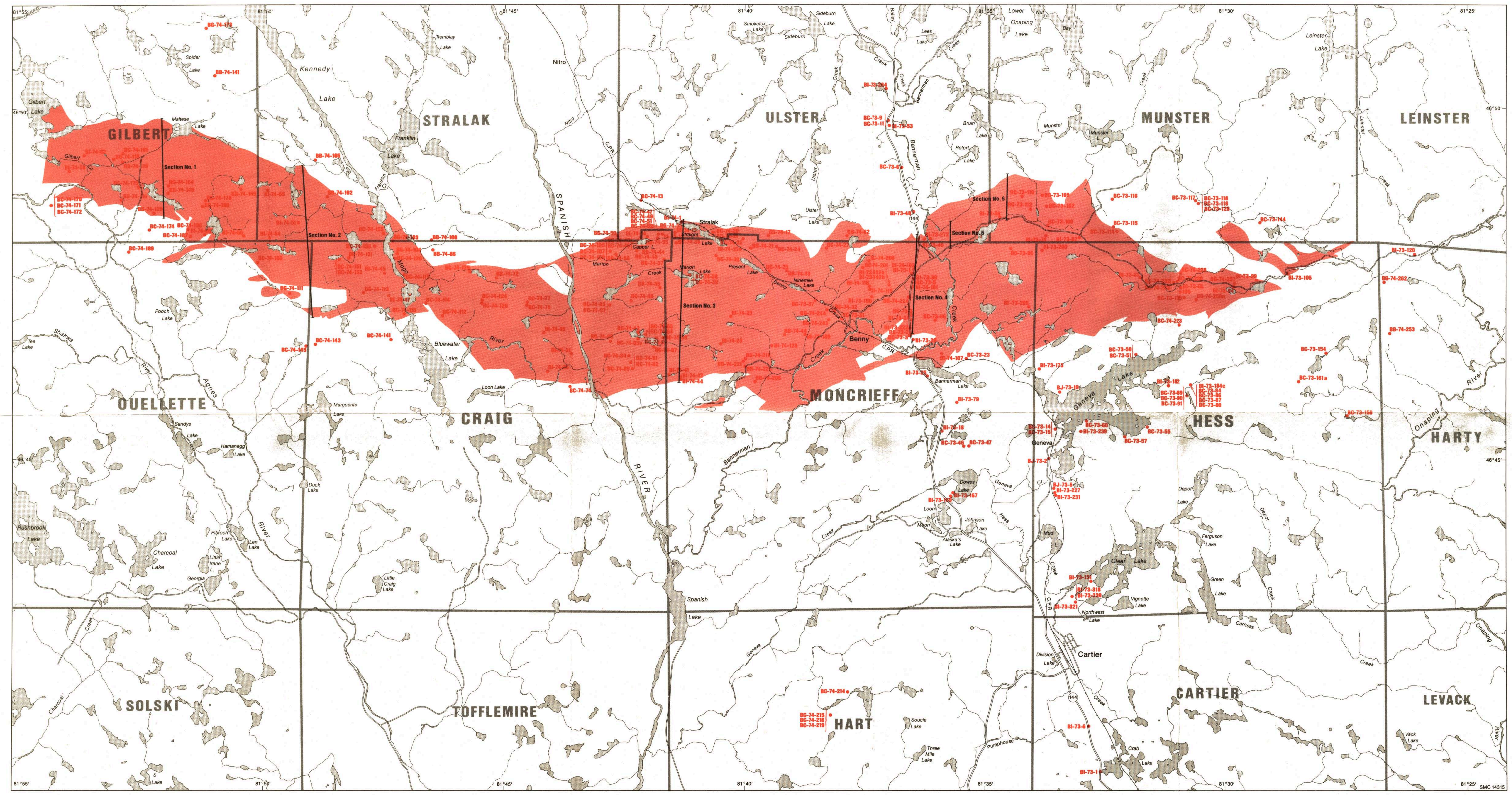

Figure 19 – Locations of analyzed rocks, mineral samples, and stratigraphic sections in the Benny area.

SYMBOLS

● BI-73-120	Location of analyzed rock and/or mineral sample.
⊢—⊣	Location of stratigraphic section.
🟥	Benny belt.

BENNY AREA
Chart C
Table 2

TABLE 2 CHEMICAL ANALYSES, NORMS, AND MODAL ANALYSES OF METAVOLCANIC FLOW ROCKS, BENNY AREA.
CHEMICAL ANALYSES BY GEOSCIENCE LABORATORIES, ONTARIO GEOLOGICAL SURVEY.

Reference or Sample Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	BG-74 -164	BB-74 -102	BI-74 -44	BB-74 -119
Major Components in Weight Percent																										
SiO_2	51.10	51.80	52.40	53.10	53.50	55.10	57.50	58.20	58.70	58.80	59.20	59.70	59.80	59.70	60.10	61.10	61.20	63.40	63.60	66.30	74.20	75.10				
Al_2O_3	14.20	14.80	13.50	16.20	12.90	15.60	16.00	16.30	11.50	15.50	13.70	16.00	1.48	16.30	16.60	16.20	14.60	14.60	15.60	15.50	11.70	14.90				
Fe_2O_3	1.55	2.80	2.36	2.06	3.47	1.07	1.00	1.29	3.21	1.21	2.69	2.15	4.62	1.20	1.27	1.21	2.40	1.13	0.56	1.08	1.04	0.86				
FeO	7.21	4.54	12.00	6.35	11.10	7.15	6.32	4.95	9.62	5.03	7.21	4.52	0.00	4.95	4.88	4.37	4.74	4.62	4.14	3.57	1.38	0.65				
MgO	9.60	2.93	3.77	5.78	4.09	4.36	4.28	3.55	3.50	3.95	3.64	4.06	3.35	2.95	3.50	4.15	4.45	2.38	2.50	0.77	0.33	0.65				
CaO	10.60	13.10	9.52	6.92	6.84	9.08	7.80	9.39	5.78	8.41	4.08	5.43	9.59	7.82	3.59	7.29	3.96	6.70	7.80	5.02	1.24	0.68				
Na_2O	2.59	2.62	3.00	4.50	3.10	4.15	3.42	3.64	3.66	3.51	4.22	4.32	4.36	3.24	4.69	3.24	3.90	3.21	3.80	4.35	3.24	0.30				
K_2O	0.14	0.58	0.36	1.09	0.78	0.94	1.06	0.84	0.42	1.06	1.88	1.49	0.72	1.09	1.98	1.00	2.08	1.04	0.43	0.96	4.73	4.36				
TiO_2	0.53	0.85	1.65	0.99	1.75	0.92	0.94	0.70	1.79	0.97	1.18	0.83	0.64	0.79	0.98	0.58	0.76	0.66	0.54	0.92	0.22	0.38				
P_2O_5	0.06	0.19	0.10	0.25	0.16	0.09	0.20	0.06	0.29	0.19	0.26	0.19	—	0.14	0.23	0.12	0.19	0.06	0.05	0.30	0.05	0.05				
S	0.01	0.02	0.07	0.01	0.12	0.04	0.01	0.01	0.03	0.02	0.04	0.01	—	0.02	0.02	<0.01	0.01	0.03	0.02	0.01	0.06	0.01				
MnO	0.16	0.05	0.27	0.17	0.23	0.17	0.14	0.20	0.23	0.17	0.15	0.11	—	0.11	0.11	0.11	0.12	0.11	0.12	0.10	0.02	0.01				
CO_2	0.07	4.07	0.15	0.08	0.10	0.35	0.15	0.10	0.06	0.15	0.06	0.08	—	0.30	0.06	0.11	0.24	0.10	0.15	0.30	0.47	0.10				
H_2O^+	0.58	1.39	1.25	1.47	1.24	1.69	1.21	1.08	0.92	1.16	1.20	0.48	—	1.26	1.80	0.80	1.02	0.94	0.69	0.92	0.38	1.50				
H_2O^-	0.37	0.23	0.34	0.41	0.52	0.39	0.11	0.29	0.74	0.08	0.53	0.58	—	0.10	0.51	0.34	0.65	0.39	0.31	0.33	0.16	0.23				
Total	98.80	100.00	100.70	99.40	99.90	101.10	100.10	100.60	100.50	100.20	100.00	100.00	97.90	100.00	100.30	100.60	100.30	99.40	100.30	100.40	99.20	99.80				
S.G.	2.97	2.96	3.04	2.86	2.98	2.86	2.89	2.85	2.91	2.83	2.83	2.80	—	2.85	2.75	2.80	2.81	2.79	2.75	2.73	2.62	2.71				
Minor Elements in Parts per Million (ppm)																										
Ba	40	360	120	280	150	260	180	170	100	380	240	260	—	220	360	140	300	420	190	240	1220	750				
Co	40	20	35	30	40	30	30	20	35	25	30	25	—	30	20	20	25	20	15	9	< 5	< 5				
Cr	520	75	30	250	20	130	120	55	15	150	< 5	100	—	70	110	100	130	85	110	15	8	10				
Cu	55	10	85	40	220	50	45	30	55	45	20	35	—	55	40	30	30	80	40	5	10	< 5				
Ga	10	20	20	9	8	20	10	20	10	20	11	10	—	10	8	10	15	20	20	30	10	20				
Li	8	7	30	25	15	15	15	10	10	7	10	20	—	8	15	15	10	15	7	40	< 3	15				
Ni	100	65	35	100	20	60	95	65	20	90	20	60	—	70	45	70	65	55	60	10	6	85				
Pb	< 10	< 10	25	10	< 10	55	< 10	110	< 10	< 10	25	< 10	—	< 10	< 10	< 10	< 10	20	95	30	< 10	< 10				
Sc	35	50	35	20	20	20	30	20	25	30	20	20	—	30	20	15	15	20	20	15	< 10	< 10				
Sn	< 1	< 1	10	< 1	< 1	25	< 1	15	< 1	< 1	< 1	< 1	—	< 1	< 1	< 1	< 1	8	15	7	3	3				
Sr	50	300	20	300	50	200	300	200	50	300	100	200	—	400	200	200	200	200	200	300	200	40				
V	100	200	200	100	150	150	200	150	50	200	100	80	—	300	80	70	60	150	100	60	40	40				
Y	< 10	30	35	15	25	25	30	15	40	20	15	30	—	< 10	15	< 10	< 10	25	15	25	40	40				
Zn	55	80	140	100	120	100	100	80	120	85	150	90	—	85	45	70	110	70	70	95	35	25				
Zr	10	100	30	70	90	200	100	90	100	100	100	100	—	200	100	50	90	150	80	200	80	40				
Norms (Molecular)																										
Quartz		7.756	4.881		8.070	1.627	8.814	9.107	15.649	10.827	10.512	9.863	11.147	14.425	9.446	14.936	12.923	21.378	18.498	23.636	32.801	53.270				
Corundum															0.847							9.893				
Orthoclase	0.839	3.694	2.212	6.547	4.840	5.624	6.378	5.024	2.589	6.367	11.424	8.892	4.344	6.613	11.878	5.971	12.516	6.368	2.579	5.805	28.930	27.281				
Albite	23.573	25.333	27.988	41.028	29.202	37.690	31.237	33.047	34.245	32.003	38.925	39.136	39.930	29.841	42.708	29.367	35.623	29.834	34.600	39.929	30.081	2.849				
Anorthite	27.083	28.988	23.186	21.112	19.920	21.412	25.617	25.951	14.293	23.776	13.240	20.049	19.067	27.410	16.541	26.968	16.470	23.149	24.590	20.384	3.516	3.223				
Diopside	15.190	17.423	8.321	6.652	5.484	10.698	5.936	10.258	5.240	9.058	2.622	3.362	18.868	5.340		4.793	1.278	4.722	6.437	0.911	0.993					
Hedenbergite	5.484	10.441	11.855	3.024	6.190	8.157	4.004	6.357	5.655	4.814	2.027	1.345	2.191	3.826		2.214	0.526	3.966	5.027	1.550	1.013					
Enstatite	16.474		6.654	9.439	9.105	6.827	9.052	4.781	7.450	6.545	9.013	9.629		5.685	9.800	9.170	11.859	4.441	3.781	1.718	0.446	1.898				
Ferrosilite	5.947		9.480	4.291	10.276	5.205	6.105	2.963	8.041	3.478	6.968	3.853		4.073	5.490	4.235	4.883	3.730	2.953	2.925	0.455					
Forsterite	2.099			2.579																						
Fayalite	0.758			1.173																						
Wollastonite		1.939											1.261													
Magnetite	1.643	2.646	2.564	2.187	3.565	1.132	1.064	1.364	3.498	1.285	2.879	2.268	2.282	1.287	1.347	1.277	2.404	1.223	0.594	1.154	1.124	0.728				
Ilmenite	0.749	1.275	2.389	1.401	2.558	1.297	1.332	0.986	2.599	1.372	1.689	1.167	0.909	1.129	1.385	0.816	1.077	0.952	0.763	1.310	0.317	0.560				
Hematite																						0.149				
Apatite	0.127	0.428	0.218	0.532	0.351	0.191	0.426	0.127	0.633	0.404	0.559	0.401		0.301	0.488	0.254	0.405	0.130	0.106	0.642	0.108	0.111				
Pyrrhotite	0.035	0.075	0.253	0.035	0.437	0.140	0.035	0.035	0.109	0.071	0.143	0.035		0.071	0.070		0.035	0.108	0.070	0.035	0.215	0.037				
Differentiation	24.41	36.78	35.08	47.57	42.11	44.94	47.57	47.18	52.48	49.20	60.86	57.89	55.42	50.88	64.03	50.27	61.06	57.58	55.68	69.37	91.81	83.40				
Colour Index	48.34	31.79	41.26	30.75	37.18	33.32	30.75	26.71	32.48	26.55	25.20	21.62	24.25	21.34	18.02	22.50	22.03	19.03	19.56	9.57	4.35	3.34				
Modal Analyses in Volume Percent, Estimated and Measured																										
Amphibole	A		55.8	A	53.4	A	AB	28.6	A		C	B			C	B	C	B	A		53.4		48.6	76.2		X
Plagioclase	A		26.8	A	31.4	A	A	49.6	A		A	A			A	A	A	A	A	B	31.4		26.0	22.8	37.2	39.2
Potassic Feldspar															BC					B						
Quartz			15.0		9.7	C	BC	18.2	BC		BC	C			C	BC	BC	AB	AB	A	9.7		23.8	0.6	40.0	53.6
Chlorite	C		X	C		C	C	X	B		C	C			BC	C	C	C	C	C	2.0		X		22.8	
Biotite							B				B	B				C				X						
Muscovite																	B	BC		X				X		X
Epidote								3.6																0.4	X	X
Sphene																					0.7		1.6	X	X	
Iron-titanium Oxide			2.4		2.8		X														2.8			X	X	X
Sulphides																									X	
Carbonate																	X			X						

Sample Description

	Field Sample Number	
1.	STRALAK-75	F.g. to m.g. weakly foliated, dark, greenish grey metabasalt flow; Craig Tp.
2.	BC-73-112	F.g., dark grey, poorly foliated, 1 cm dark coloured amygdules, amyg. metabasalt; SW portion Munster Tp., 1400 m NE of SW corner of Tp.
3.	BC-74-175	Metabasalt flow; SE portion of Gilbert Tp., 152 m W of Agnes-Gilbert Cr. junction.
4.	BC-74-39	F.g., non-foliated, dark green, amyg. metabasalt; Marion L., northwest Moncrieff Tp.
5.	BI-74-58	F.g. foliated, black metabasalt; SW portion of Gilbert Tp., 460 m NW of Agnes-Gilbert Cr. junction.
6.	BI-74-23	Andesite; NW portion of Moncrieff Tp., 1769 m SE of SW end of Marion R., Lot 10, Conc. 5, NW¼, N½.
7.	BI-73-87	F.g., dark grey, poorly foliated, small epidote seam, metabasalt; SW portion of Munster Tp., ENE of SW Tp. corner, S of Hwy.
8.	BI-74-47	Amyg. meta-andesite; 610 m NW of Kennedy-Bluewater L. Narrows, Lot 10, Conc. 6, NW¼, N½ Craig Tp.
9.	BC-74-181	F.g., weakly foliated, dark greenish grey pillowed metabasalt; S central Gilbert Tp., 1189 m WSW of SW tip of Maltese L.
10.	BI-73-81	F.g. foliated, dark grey amyg. metabasalt with light pink phenocrysts (1 cm); 1982 m NW of NE end of Geneva L., S of Hwy., Lot 8, Conc. 6, NW¼, N½ Hess Tp.
11.	BC-74-230	F.g., non-foliated, greenish black metabasalt; 1586 m N of NE end of Geneva L., N of Hwy., Lot 7, Conc. 6, NW¼, N½ Hess Tp.
12.	BC-74-22	Fine to med. g., weakly foliated, black metabasalt; northwest Craig Tp.
13.	BB-74-72	Porphyritic flow; 2470 m NE of Kennedy-Bluewater L. narrows, Lot 6, Conc. 6, NE¼, N½ Craig Tp.
14.	BC-73-95	F.g. dark grey, non-foliated vesicular metabasalt with 1 cm phenocrysts of white mineral and smaller black mineral; 700 m WSW of NE corner of Tp., Lot 1, Conc. 6, NE¼, N½ Moncrieff Tp.
15.	BC-74-85A	V.f.g., non-foliated, med. grey rhyolite flow breccia; 1525 m NE of Spanish-Mogo Rivers junction, Lot 1, Conc. 5, NE¼, N½ Craig Tp.
16.	BC-74-42	F.-med.g., non-foliated, dark grey porphyritic dacite; 1645 m NE of the Spanish-Mogo Rivers junction, Lot 1, Conc. 5, NE¼, N½ Craig Tp.
17.	BC-74-228	F.g., non-foliated, black amyg. metabasalt; 1830 m N of NE end of Geneva L., N of Highway, Lot 7, Conc. 6, NW¼, N½ Hess Tp.
18.	BC-74-58	Metabasalt; 1403 m SW of southwestern end of Marion L., Lot 1, Conc. 5, NE¼, N½ Craig Tp.
19.	BI-74-45	Porphyritic andesite; 795 m S of Kennedy L.-Tp. line crossing, Lot 10, Conc. 6, NW¼, N½ Craig Tp.
20.	BB-74-35	Metavolcanic; 520 m SW of northwestern tip of Marion L., Lot 1, Conc. 5, NE¼, N½, Craig Tp.
21.	BI-73-58	V.f.g., dark pink, non-foliated with a buff weathering, rhyolite; 700 m NNE of SW corner of Tp., N of Hwy., SW corner of Munster Tp.
22.	BI-73-150	F.g. light grey, foliated-schistose rhyolite; 760 m NE of Benny, Lot 6, Conc. 6, NE¼, N½ Moncrieff Tp.
	BG-74-164	Amygdaloidal andesite, Gilbert Township.
	BB-74-102	Metabasalt, southwest Stralak Township.
	BI-74-44	Porphyritic dacite, Moncrieff Township.
	BB-74-119	Dacite, Gilbert Township.

Abbreviations

amyg. — amygdaloidal
A,B,C, — scale of abundance; A — 20 to 60 percent, B — 10 to 20 percent, C — 1 to 10 percent
f.g. — fine grained
v.f.g. — very fine grained
f.-med.g. — fine to medium grained
X — trace amounts
< — less than

BENNY AREA
Chart D
Table 3

TABLE 3 CHEMICAL ANALYSES AND MODAL ANALYSES OF METAVOLCANIC PYROCLASTIC ROCKS, BENNY AREA. CHEMICAL ANALYSES BY GEOSCIENCE LABORATORIES, ONTARIO GEOLOGICAL SURVEY.

Major Components in Weight Percent

Sample Number	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
SiO_2	54.10	52.30	58.50	57.50	49.80	58.10	55.80	53.10	61.20	58.90	56.90	61.70	62.40	64.70	65.00
Al_2O_3	15.60	13.00	15.70	15.10	15.00	14.30	12.60	15.70	15.70	16.20	15.60	19.50	18.80	14.80	15.90
Fe_2O_3	9.22	14.80	1.60	1.73	2.72	2.78	2.95	2.32	6.80	1.51	2.75	1.38	1.29	5.55	2.16
FeO			5.25	7.36	9.25	6.41	10.40	7.54		5.38	5.68	2.77	4.22		3.28
MgO	5.06	4.50	3.59	3.93	5.51	4.71	3.49	4.29	3.50	4.72	4.80	1.83	2.05	2.95	1.86
CaO	8.29	9.22	7.81	7.26	10.70	5.87	8.40	7.96	6.52	6.13	5.54	1.33	1.15	5.95	3.26
Na_2O	3.78	2.70	4.14	3.10	2.03	3.85	2.75	3.34	3.34	3.28	5.11	9.17	1.87	3.38	5.64
K_2O	0.87	0.36	0.95	1.21	1.12	0.65	0.44	0.75	1.30	1.18	0.42	0.23	3.99	1.10	0.96
TiO_2	0.80	1.63	0.87	1.01	1.13	1.04	1.73	1.57	0.67	0.84	1.08	0.29	0.86	0.64	0.77
P_2O_5	—	—	0.22	0.26	0.10	0.28	0.19	0.37	—	0.16	0.29	0.10	0.14	—	0.24
S	—	—	0.01	< 0.10	0.08	0.05	< 0.01	0.06	—	0.01	0.01	< 0.01	0.24	—	0.02
MnO	—	—	0.15	0.19	0.28	0.19	0.23	0.15	—	0.12	0.16	0.07	0.07	—	0.09
CO_2	—	—	0.07	0.14	0.07	0.15	0.07	0.11	—	0.06	0.08	0.14	0.08	—	0.09
H_2O^+	—	—	0.50	1.09	1.34	1.64	0.52	2.35	—	1.30	0.91	1.31	2.20	—	1.17
H_2O^-	—	—	0.42	0.34	0.78	0.46	0.38	0.12	—	0.81	0.62	0.35	0.56	—	0.55
Total	97.70	98.50	99.80	100.20	99.90	100.50	100.00	99.70	99.00	100.60	100.00	100.20	99.90	99.10	101.00
Specific Gravity	—	—	2.87	2.88	3.00	2.88	3.03	2.91	—	2.79	2.83	2.63	2.78	—	2.75

Sample Number	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	52A
SiO_2	61.80	67.00	64.40	65.40	60.10	64.40	65.80	75.70	76.60	76.70	74.40	68.30	74.10	72.40	74.70	52.70
Al_2O_3	15.20	16.50	15.10	14.00	15.40	14.50	16.30	14.80	12.50	11.50	12.40	16.60	12.80	13.90	11.60	11.20
Fe_2O_3	2.85	4.53	0.72	1.48	1.93	1.55	0.70	0.02	0.52	1.26	0.40	0.37	0.52	0.48	0.64	18.60
FeO	3.21		6.32	3.98	4.22	4.37	3.40	0.44	0.88	1.02	1.54	1.70	1.22	2.60	2.68	—
MgO	3.20	2.37	1.62	2.64	3.87	4.61	1.76	0.18	0.43	0.82	1.15	0.85	0.63	0.85	1.81	1.45
CaO	6.43	0.20	4.44	3.21	6.40	1.28	4.18	0.66	0.43	2.15	2.25	2.13	1.99	1.49	1.60	1.30
Na_2O	3.53	5.30	3.10	4.88	3.24	4.34	2.81	5.55	3.17	5.24	3.69	6.13	4.26	2.70	2.78	3.02
K_2O	1.29	0.99	1.26	1.28	1.88	0.84	2.51	3.49	4.67	0.17	1.76	1.40	1.71	3.26	1.95	1.33
TiO_2	0.73	0.36	0.86	0.76	0.54	0.56	0.70	0.04	0.09	0.21	0.13	0.22	0.29	0.55	0.50	0.13
P_2O_5	0.15	—	0.16	0.04	0.06	0.19	0.06	0.02	0.03	0.03	0.02	0.06	0.06	0.10	0.04	0.02
S	0.02	—	0.13	0.14	0.07	—	0.07	0.01	0.01	0.09	0.01	0.08	0.02	0.09	0.03	11.10
MnO	0.10	—	0.14	0.11	0.13	0.10	0.06	0.02	0.02	0.07	0.02	0.03	0.03	0.04	0.08	0.34
CO_2	0.10	—	0.11	0.10	0.10	0.11	0.10	0.09	0.10	0.34	0.10	0.22	0.16	0.10	0.10	0.10
H_2O^+	1.15	—	2.00	1.58	1.08	2.81	1.25	0.01	0.29	0.14	0.59	0.94	0.63	1.81	1.24	3.71
H_2O^-	0.42	—	0.13	0.36	0.40	0.49	0.33	0.30	0.73	0.58	0.16	0.16	0.11	0.06	0.45	0.42
Total	100.20	97.30	100.50	100.00	99.40	100.20	100.00	101.30	100.50	100.30	99.19	99.60	98.50	100.40	100.20	—
Specific Gravity	2.81	—	2.82	2.76	2.81	2.71	2.70	2.58	2.63	2.68	2.67	2.67	2.66	2.70	2.67	—

Trace Elements in Parts per Million (ppm)

Sample Number	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
Ag															
Be			< 1	2	< 1	2	3	< 1		< 1	< 1	3	< 1		< 1
Ba			220	200	240	220	80	140		170	90	40	410		240
Co			25	25	45	30	35	30		25	25	7	25		10
Cr			120	120	290	150	8	180		65	150	< 5	70		< 5
Cu			35	25	100	40	15	30		8	30	10	40		40
Ga			10	10	10	10	10	20		10	10	6	15		10
Li			10	15	10	15	20	8		50	9	25	20		15
Ni			65	60	150	70	25	80		75	75	7	60		9
Pb			< 10	< 10	< 10	< 10	< 10	< 10		< 10	40	10	10		< 10
Sc			15	20	15	20	25	30		20	20	< 5	15		10
Sn			< 1	< 1	< 1	< 1	< 1	< 1		< 1	14	< 1	24		< 1
Sr			200	200	50	200	200	300		200	200	100	100		300
V			70	80	60	80	150	300		90	80	15	80		60
Y			25	25	10	25	35	50		< 10	20	30	20		20
Zn			85	100	110	95	100	110		75	90	180	100		60
Zr			100	100	10	100	100	200		80	100	80	100		100

Sample Number	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	52A
Ag																29
Be	< 1		< 1	< 1	2	3	< 1	3	< 1	< 1	< 1	< 1	< 1	< 1	< 1	2
Ba	180		250	430	600	80	660	90	560	60	340	330	420	560	440	2
Co	20		25	30	20	10	10	< 5	< 5	15	< 5	< 5	< 5	9	10	15
Cr	85		85	110	200	130	100	< 5	< 5	< 5	8	20	10	45	20	9
Cu	55		50	40	35	5	50	< 5	9	30	10	9	6	25	50	1100
Ga	10		20	20	25	10	25	10	9	7	20	10	20	20	25	10
Li	10		15	15	45	30	55	6	20	4	4	5	4	10	25	15
Ni	50		< 5	50	55	75	40	< 5	< 5	< 5	9	8	50	25	15	15
Pb	< 10		20	110	110	< 10	25	20	10	45	10	150	< 10	70	90	880
Sc	15		20	25	20	10	30	< 5	< 5	< 5	< 10	< 10	< 10	< 10	15	< 5
Sn	< 1		< 1	10	10	< 1	25	< 1	< 1	3	1	< 1	2	1	9	3
Sr	200		300	80	300	50	300	50	50	200	300	300	200	200	100	300
V	60		400	150	150	40	150	< 5	< 5	< 5	100	70	60	40	90	10
Y	15		40	25	10	< 10	20	< 10	20	25	40	< 10	20	70	20	15
Zn	75		130	110	110	50	80	15	55	130	70	370	70	160	80	300
Zr	70		300	150	30	70	100	< 10	50	150	200	30	30	300	200	200

Modal Analyses in Volume Percent (Estimated and Measured)

Sample Number	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
Amphibole			B	B	A	B	A					B	B		
Plagioclase			A	A	AB	A	A					A	A	A	AB
Potassic Feldspar															
Quartz			C	BC	C	BC	C					BC	C	C	A
Chlorite			C	C	C	BC						BC	C	B	B
Biotite				BC	C							C	C		B
Muscovite															
Epidote															
Carbonate						C									
Sphene															
Iron-Titanium Oxides															
Sulphides															

Sample Number	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	52A
Amphibole		C	BC		C	C	18.0									
Plagioclase		A	A		A	A	43.2	A	A	A	A	A	65.7	25.4	24.8	
Potassic Feldspar										B	A		0.1			
Quartz		AB	B		A	A	26.4	AB	A	A	A	A	22.9	61.4	33.2	
Chlorite		C	C		B	C		C	C		C	C	4.9			
Biotite							9.3						2.8	13.2	21.6	
Muscovite													1.9	X	3.0	
Epidote			C		B	BC	3.0	C	AB	C	C			X		
Carbonate												C	0.3	X		
Sphene													0.9	X		
Iron-Titanium Oxides													0.5		18.2	
Sulphides							X									

	BC-73-2	BB-74-16	BC-73-139	BC-73-105	BI-74-62	BC-74-120	BI-73-34	BC-73-114	BB-74-129
Amphibole	1.6	8.0	47.2	40.0	57.2	18.8			
Plagioclase	18.8	29.7	33.2	28.0	4.6	44.2	68.9	12.9	40.4
Potassic Feldspar								12.1	
Quartz	38.0	46.4	11.9	16.2	36.0	28.6	19.7	53.2	59.2
Chlorite			X	2.0		1.0	5.0	X	X
Biotite	39.8						6.3		X
Muscovite							X	19.7	0.4
Epidote	X	10.5	5.9	9.0	2.2		X	X	X
Carbonate		4.4	0.2						
Sphene	X	1.0	1.4	2.3	X	5.5			
Iron Ore	1.8	X	0.2	2.6	X	1.9	0.1	X	X
Sulphides				X			X		X

Sample Descriptions

No.	Sample	Description
23.	BG-74-50	Mafic tuff; SE corner of Stralak Tp., 152 m N of SE Tp. Corner.
24.	BC-74-77	Mafic tuff; 1615 m SW of Spanish R.-Marion Cr. junction, Craig Tp.
25.	BC-74-37	F. med.g., weakly foliated, dark greenish grey agglomerate; 580 m SE of eastern tip of Capper L., Craig Tp., Lot 1, Conc. 6, NE¼, N½.
26.	BC-74-80	F. med.g., non-foliated, dark greenish grey block tuff; 1130 m E of Spanish-Mogo R. junction, Lot 2, Conc. 5, NE¼, N½, Craig Tp.
27.	BC-74-178	F.g., non-foliated, greenish black mafic tuff; SE portion Gilbert Tp. 1710 m NW of SE Tp. corner.
28.	BB-74-44	Med. g., weakly foliated, dark greyish green mafic tuff; 45 m S of western part of Capper L., Lot 1, Conc. 6, NE¼, N½, Craig Tp.
29.	BB-74-140	F.g., weakly foliated, greenish black mafic tuff; SE portion of Gilbert Tp., 1370 m S of SW tip of Maltese L.
30.	BI-73-105	F.g., dark grey, foliated-gneissic appearance with cross-cutting epidote (?) seams; 2530 m SW of NE corner of Tp., Lot 3, Conc. 6, NE¼, N½, Hess Tp.
31.	BI-74-35	Mafic tuff; 1555 m NW of Spanish-Mogo R. junction, Lot 5, Conc. 5, NE¼, N½, Craig Tp.
32.	BC-74-186	F. med.g., weakly foliated, dark grey intermediate tuff; SE portion of Gilbert Tp., 1830 m WNW of SE corner of Tp.
33.	BB-74-46	F.g. non-foliated, dark green ash tuff?siltstone?; 150 m SWS of SW end of Capper L., Lot 1, Conc. 6, NE¼, N½, Craig Tp.
34.	BC-74-52	Gneissic, grey felsic lapilli tuff; SW portion of Ulster Tp., 120 m N of central Capper L.
35.	BI-75-1	F.g. weakly foliated, dark grey ash tuff; 2165 m NE of Benny, N of Hwy., Lot 5, Conc. 6, NE¼, N½, Moncrieff Tp.
36.	BI-74-33	Intermediate tuff; central Craig Tp.
37.	BC-74-38	F. med.g., weakly foliated, med. greyish green intermediate lapilli tuff, northwestern Moncrieff Tp.
38.	BC-74-25	F. med.g., weakly foliated, med. grey andesitic tuff; 120 m NE of NE end of Present L., Lot 9, Conc. 6 NW¼, N½, Moncrieff Tp.
39.	BB-74-226	Intermediate tuff; 2805 m SW of Benny, Lot 10, Conc. 4, NW¼, N½, Moncrieff Tp.
40.	BI-73-322	Med. grey with whitish bands, f.g., tuff; 640 m NNW of NW tip of Bannerman L., Lot 5, Conc. 5, NE¼, N½, Moncrieff Tp.

Sample Descriptions — continued

No.	Sample	Description
41.	BB-74-206	Intermediate lapilli-tuff; 2745 m SW of Benny, Lot 10, Conc. 4, NW¼, N½, Moncrieff Tp.
42.	BC-74-129	Lapilli-tuff; 2015 m NE of Bluewater L. narrows, Lot 7, Conc. 6, NW¼, N½, Craig Tp.
43.	BC-74-156	F. med. g., weakly foliated, dark greyish green intermediate tuff; 270 m SSW of Kennedy L. Tp. line crossing, Lot 10, Conc. 6, NW¼, N½, Craig Tp.
44.	BC-74-160	Intermediate tuff, NE portion of Tp. 115; 1495 m SW of NE corner of Ouellette Tp.
45.	BC-74-82	V.f.g., non-foliated, light grey lapilli-tuff; 1100 m E of Spanish-Mogo R. junction, Lot 2, Conc. 5, NE¼, N½, Craig Tp.
46.	BC-74-187	F.g., foliated, light grey felsic tuff; 1770 m WNW of SE corner of Tp., SE portion Gilbert Tp.
47.	BC-74-232	F. med. g., non-foliated, greenish grey felsic tuff; 1585 m N of NE end of Geneva L., N of KVP road, Lot 7, Conc. 6, NW¼, N½, Hess Tp.
48.	BC-73-102	V.f.g., light grey, foliated felsic tuff (banded); SW portion of Munster Tp., 1770 m NE of SW corner of Tp.
49.	BC-73-3	Med. g., light grey, foliated rock with short, irregular bands of dark mineral, felsic tuff; 1555 m E of Benny, Lot 5, Conc. 5, NE¼, N½, Moncrieff Tp.
50.	BI-73-272	F. to v.f.g., med. grey, poorly foliated, buff weathering dacitic tuff; 152 m N of S Ulster Tp. line, E shore of Moncrieff Cr., SE¼, S½, Ulster Tp.
51.	BI-73-39	F.g., light grey foliated lithic tuff with thin quartz vein shear plane; 1980 m NE of Benny, S of Benny Road, Lot 5, Conc. 6, NE¼, N½, Moncrieff Tp.
52.	BB-74-250A	Intermediate lapilli-tuff; 1159 m NNE of NE end of Geneva L., Lot 7, Conc. 5, NW¼, N½, Hess Tp.
52A.	BC-74-233	Pyritic, felsic tuff; Lake Geneva Mine area, Hess Township.
	BC-73-2	Tuff-breccia; Moncrieff Township.
	BB-74-116	Tuff-breccia; Gilbert Township.
	BC-73-139	Mafic tuff; Hess Township.
	BC-73-105	Mafic tuff; Munster Township.
	BI-74-62	Mafic lapilli-tuff; Gilbert Township.
	BC-74-120	Intermediate tuff; Craig Township.
	BI-73-34	Felsic tuff; Moncrieff Township.
	BC-73-114	Felsic tuff; Munster Township.
	BB-74-129	Felsic tuff; Gilbert Township.

Abbreviations:

A,B,C, — Scale of abundance; A-20 to 60 percent, B-10 to 20 percent, C-1 to 10 percent
S.G. — Specific Gravity
X — Not detected
f.g. — Fine grained
v.f.g. — Very fine grained
f. to v.f.g. — Fine to very fine grained
f. med g. — Fine to medium grained
< — Less than

LEGEND

PHANEROZOIC

CENOZOIC[a]

QUATERNARY

PLEISTOCENE AND RECENT

Swamp deposits, gravel, sand, silt, clay.

UNCONFORMITY

PRECAMBRIAN[b]

LATE PRECAMBRIAN

MAFIC INTRUSIVE ROCKS

18	*18 Diabase, olivine diabase.*

INTRUSIVE CONTACT

MIDDLE PRECAMBRIAN

SUDBURY NICKEL IRRUPTIVE—FOY OFFSET†

17	*17 Unsubdivided.* *17a Quartz diorite.* *17b Metagabbro.*

LAMPROPHYRE AND BRECCIA

16	*16 Unsubdivided.†* *16a Lamprophyre.†* *16b Lamprophyric breccia.†* *16c Pseudotachylite breccia (Sudbury Type).*

INTRUSIVE CONTACT

NIPISSING DIABASE

15	*15 Unsubdivided.* *15a Pyroxene gabbro.* *15b Hornblende metagabbro.* *15c Granophyric metagabbro, granophyre.*

INTRUSIVE CONTACT

HURONIAN SUPERGROUP

COBALT GROUP

LORRAIN FORMATION

14	*14 Unsubdivided.* *14a Feldspathic sandstone, arkose.* *14b Green, micaceous pebbly sandstone.* *14c Buff and red hematitic sandstone.* *14d White quartz sandstone.* *14e Quartz and jasper-pebble conglomerate.* *14f Siltstone.*

GOWGANDA FORMATION

13	*13 Unsubdivided.†* *13a Polymictic paraconglomerate.†* *13b Polymictic orthoconglomerate.* *13c Quartz-feldspar sandstone.†* *13d Wacke, siltstone.†* *13e Laminated, siltstone.†* *13f Sandstone-siltstone slump breccia.†*

QUIRKE LAKE GROUP

SERPENT FORMATION†

12	*12 Unsubdivided.* *12a Quartz-feldspar sandstone.* *12b Hematitic sandstone.* *12c Siltstone, wacke.* *12d Conglomerate, conglomeratic sandstone.* *12e Calcareous sandstone.*

ESPANOLA FORMATION†

11	*11 Unsubdivided.* *11a Limestone.* *11b Dolostone, dolomitic limestone.* *11c Siltstone, calcareous siltstone.* *11d Sandstone, calcareous sandstone.* *11e Scapolite and diopside-wollastonite hornfels.*

BRUCE FORMATION†

10	*10 Unsubdivided.* *10a Conglomerate.* *10b Sandstone, siltstone.*

HOUGH LAKE GROUP

MISSISSAGI FORMATION†

9	*9 Unsubdivided.* *9a Quartz-feldspar sandstone.* *9b Conglomerate.*

UNCONFORMITY

EARLY PRECAMBRIAN

LATE MAFIC INTRUSIVE ROCKS[c]

8	*8 Unsubdivided.* *8a Metagabbro.* *8b Porphyritic metagabbro.* *8c Granophyric metagabbro.* *8d Composite intrusions—granodiorite, syenodiorite, gabbro, feldspathic pyroxenite.*

INTRUSIVE CONTACT

FELSIC INTRUSIVE AND METAMORPHIC ROCKS

MASSIVE FELSIC INTRUSIVE ROCKS

7	*7 Unsubdivided.* *7a Fine- to medium-grained quartz monzonite.* *7b Coarse-grained quartz monzonite.* *7c Porphyritic, leucocratic quartz monzonite.* *7d Porphyritic, biotitic quartz monzonite, monzonite.* *7e Pegmatite.* *7f Aplite.*

INTRUSIVE CONTACT

FOLIATED FELSIC PLUTONIC AND MIGMATITIC ROCKS

6	*6 Unsubdivided.* *6a Gneissic and foliated trondhjemite, granodiorite.* *6b Augen gneiss.* *6c Xenolithic, agmatitic trondhjemite, granodiorite.* *6d Leucocratic migmatitic orthogneiss, paragneiss.* *6e Mafic migmatitic orthogneiss.*

INTRUSIVE CONTACT

MAFIC INTRUSIVE ROCKS

5	*5 Unsubdivided.* *5a Gneissic metagabbro.*

INTRUSIVE CONTACT

METAVOLCANICS AND METASEDIMENTS

METASEDIMENTS[d]

4	*4 Unsubdivided.* *4a Tuffaceous wacke, siltstone.* *4b Quartz-feldspar sandstone.* *4c Schistose, micaceous, chloritic metasediments, tuff.* *4d Graphitic siltstone, graphitic schist.* *4e Chert, siliceous metasediments.* *4f Sulphide-bearing micaceous, chloritic, siliceous metasediments, tuff.*
IF	*IF Oxide-facies iron formation.*

METAVOLCANICS

FELSIC METAVOLCANICS

3	*3 Unsubdivided.* *3a Rhyolite, porphyritic rhyolite.* *3b Dacite, porphyritic dacite.* *3c Tuff, lapilli-tuff, crystal tuff.*

INTERMEDIATE METAVOLCANICS

2	*2 Unsubdivided.* *2a Tuff-breccia.* *2b Lapilli-tuff.* *2c Tuff.†*

MAFIC METAVOLCANICS

1	*1 Unsubdivided.* *1a Basalt.* *1b Andesite.* *1c Pillowed basalt, andesite.* *1d Amygdaloidal basalt, andesite.* *1e Mafic tuff.*

△ △ △ △	*Breccia.†*

Ag	*Silver.*
Au	*Gold.†*
cp	*Chalcopyrite.*
Cu	*Copper.*
Fe	*Iron.*
fl	*Fluorite.†*
gf	*Graphite.*
gn	*Galena.*
mag	*Magnetite.†*
mo	*Molybdenite.†*
Ni	*Nickel.†*
Pb	*Lead.*
po	*Pyrrhotite.*
py	*Pyrite.*
S	*Sulphide mineralization.*
sp	*Sphalerite.*
Zn	*Zinc.*

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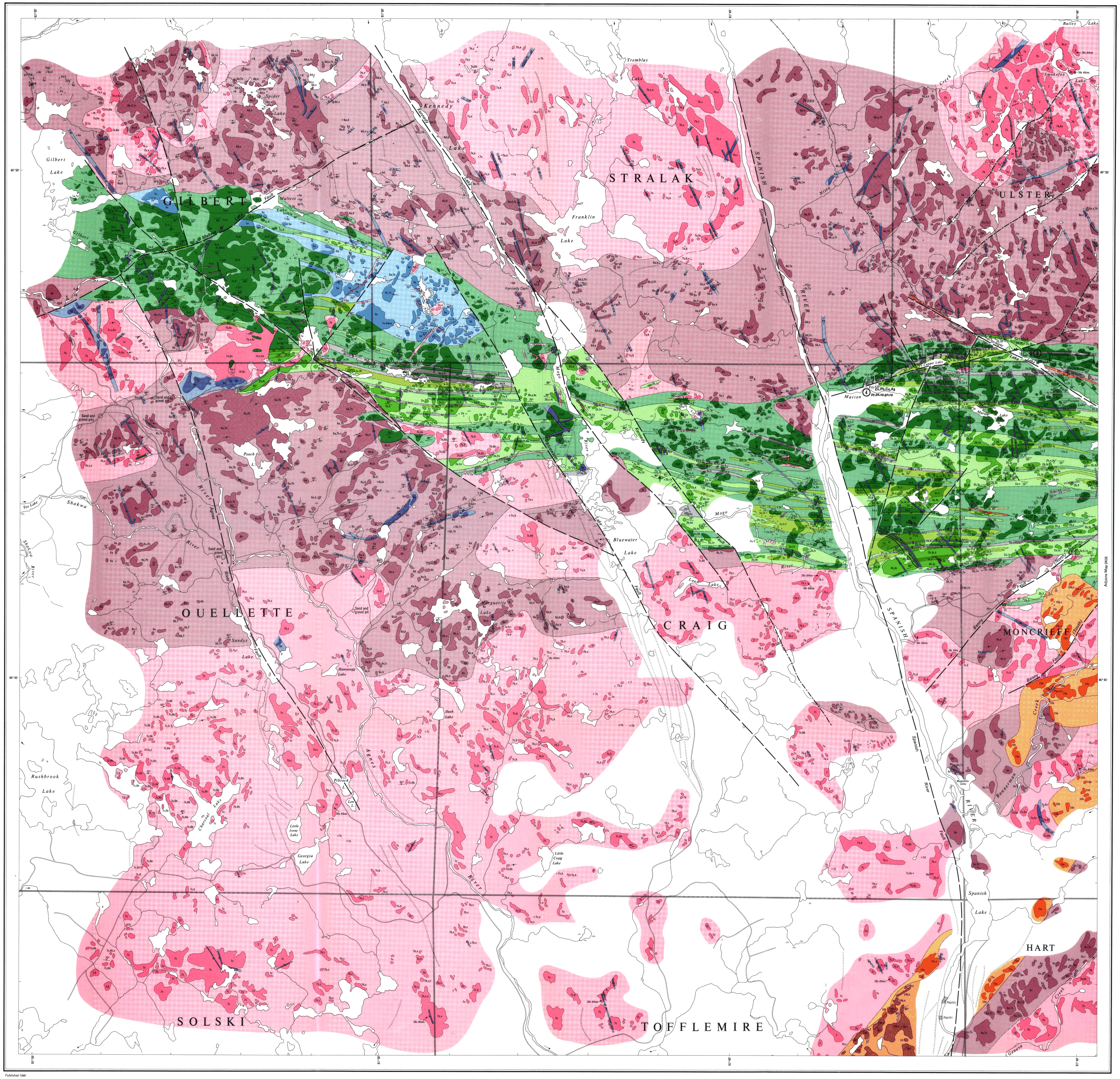
[a] *Unconsolidated deposits. Cenozoic deposits are represented by the lighter and uncoloured parts of the map.*

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

[c] *May include some Middle Precambrian mafic intrusive rocks equivalent in age to Nipissing Diabase or younger.*

[d] *Includes some fragmental metavolcanics; deformation and metamorphism has made it difficult to distinguish between fragmental metavolcanics and metasediments.*

† *Appears only on companion sheet Map 2435.*



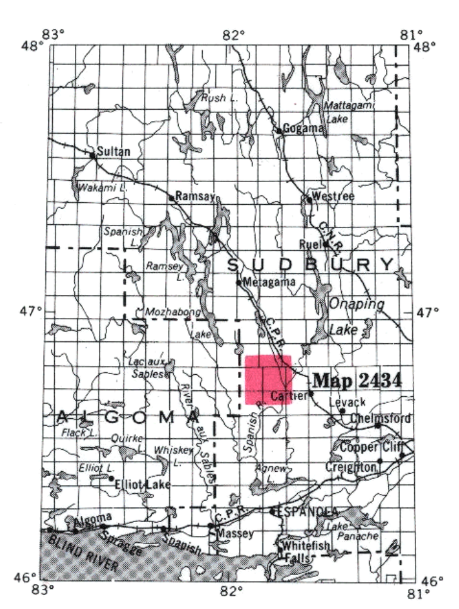
Published 1980

Adjoins Map 2435

SYMBOLS

- *Glacial striae.*
- *Esker.*
- *Small bedrock outcrop.*
- *Area of bedrock outcrop.*
- *Bedding, top unknown; (inclined, vertical).*
- *Bedding, top indicated by arrow; (inclined, vertical, overturned).*
- *Bedding, top (arrow) from grain gradation; (inclined, vertical, overturned).*
- *Bedding, top (arrow) from cross bedding; (inclined, vertical, overturned).*
- *Gneissosity; (horizontal, inclined, vertical).*
- *Foliation; (horizontal, inclined, vertical).*
- *Stratiform foliation.*
- *Lineation with plunge.*
- *Geological boundary, observed.*
- *Geological boundary, position interpreted.*
- *Geological boundary, deduced from geophysics.*
- *Fault; (observed, assumed). Spot indicates down throw side; arrows indicate horizontal movement.*
- *Lineament.*
- *Drag folds with plunge.*
- *Anticline, syncline, with plunge.*
- *Swamp.*
- (144) *Motor road. Provincial highway number encircled where applicable.*
- *Other road.*
- *Trail, portage, winter road.*
- *Building.*
- *Township boundary, with milepost, approximate position only.*
- *District or Regional Municipality boundary, approximate position only.*
- 5 *Mining property, surveyed; approximate position only.*
- ③ *Mineral deposit; mining property, unsurveyed.*
- *Surveyed line, approximate position only.*

Ontario Geological Survey
Map 2434
Bluewater Lake



Scale 1 inch to 50 miles.

N.T.S. reference 41I/12, 41I/13.

PROPERTIES, MINERAL DEPOSITS

1. *Bardswich, L.G.†*
2. *Barry, H. (Stralak deposit east).*
3. *Central Hess Tp. occurrence.†*
4. *Confederation Mining Corp. Ltd. (Stralak deposit west).*
5. *Geneva Metals Inc. (Geneva Lake Mine).†*
6. *International Nickel Co. of Canada Ltd.†*
7. *Jar-Vin Magnetite Syndicate.†*
8. *Munster Tp. occurrence.†*
9. *Straight Lake occurrence.*

Information current to December 31, 1974.

Former properties on ground now open for staking are shown only where exploration data is available—the date in square brackets indicates last exploration activity on that property. For further information see report.

† *Appears only on companion sheet Map 2435.*

SOURCES OF INFORMATION

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Geology is not tied to surveyed lines.

Geophysical and geological maps and reports of mining companies.

ODM-GSC Aeromagnetic maps 1524G, 1525G.

Geological Survey of Canada Map 1865 Geneva, Summer Report, 1920.

Ontario Ministry of Natural Resources (ODM) Map 38h, Cartier-Stralak Area, Annual Report, Vol. 38.

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Base map derived from maps of the Forest Resources Inventory, Surveys and Mapping Branch, with additional information by K. D. Card and D. G. Innes.

Magnetic declination in the area was approximately 8°W in 1974.

Parts of this publication may be quoted if credit is given. It is recommended that reference to this map be made in the following form:

K. D. Card, D. G. Innes.
1980: Bluewater Lake; Ontario Geological Survey Map 2434, Precambrian Geology Series, scale 1 inch to ½ mile, 1:31,680. Geology 1974.

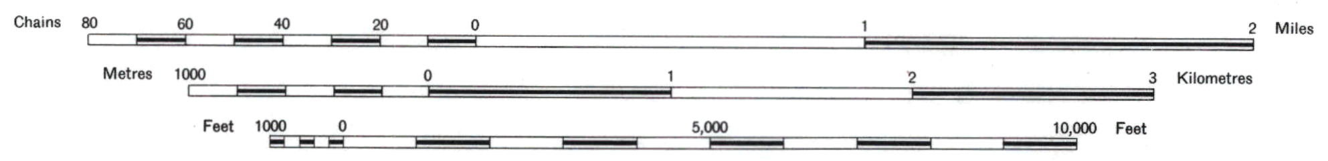
Ontario
Ministry of
Natural
Resources

Hon. James A. C. Auld
Minister

Dr. J. K. Reynolds
Deputy Minister

Ontario Geological Survey
Map 2434
BLUEWATER LAKE
SUDBURY DISTRICT

Scale 1:31,680 or 1 Inch to ½ Mile



Ontario Geological Survey
Map 2435
Geneva Lake

LEGEND

PHANEROZOIC
CENOZOIC[a]
QUATERNARY
PLEISTOCENE AND RECENT
Swamp deposits, gravel, sand, silt, clay.

UNCONFORMITY

PRECAMBRIAN[b]
LATE PRECAMBRIAN
MAFIC INTRUSIVE ROCKS

18 *Diabase, olivine diabase.*

INTRUSIVE CONTACT

MIDDLE PRECAMBRIAN
SUDBURY NICKEL IRRUPTIVE—FOY OFFSET

17 *Unsubdivided.*
17a *Quartz diorite.*
17b *Metagabbro.*

LAMPROPHYRE AND BRECCIA

16 *Unsubdivided.*
16a *Lamprophyre.*
16b *Lamprophyric breccia.*
16c *Pseudotachylite breccia (Sudbury Type).*

INTRUSIVE CONTACT

NIPISSING DIABASE

15 *Unsubdivided.*
15a *Pyroxene gabbro.*
15b *Hornblende metagabbro.*
15c *Granophyric metagabbro, granophyre.*

INTRUSIVE CONTACT

HURONIAN SUPERGROUP
COBALT GROUP
LORRAIN FORMATION

14 *Unsubdivided.*
14a *Feldspathic sandstone, arkose.*
14b *Green, micaceous pebbly sandstone.*
14c *Buff and red hematitic sandstone.*
14d *White quartz sandstone.*
14e *Quartz and jasper-pebble conglomerate.*†
14f *Siltstone.*

GOWGANDA FORMATION

13 *Unsubdivided.*
13a *Polymictic paraconglomerate.*
13b *Polymictic orthoconglomerate.*
13c *Quartz-feldspar sandstone.*
13d *Wacke, siltstone.*
13e *Laminated, siltstone.*
13f *Sandstone-siltstone slump breccia.*

QUIRKE LAKE GROUP
SERPENT FORMATION

12 *Unsubdivided.*
12a *Quartz-feldspar sandstone.*
12b *Hematitic sandstone.*
12c *Siltstone, wacke.*
12d *Conglomerate, conglomeratic sandstone.*
12e *Calcareous sandstone.*

ESPANOLA FORMATION

11 *Unsubdivided.*
11a *Limestone.*
11b *Dolostone, dolomitic limestone.*
11c *Siltstone, calcareous siltstone.*
11d *Sandstone, calcareous sandstone.*
11e *Scapolite and diopside-wollastonite hornfels.*

BRUCE FORMATION†

10 *Unsubdivided.*
10a *Conglomerate.*
10b *Sandstone, siltstone.*

HOUGH LAKE GROUP
MISSISSAGI FORMATION

9 *Unsubdivided.*
9a *Quartz-feldspar sandstone.*
9b *Conglomerate.*

UNCONFORMITY

EARLY PRECAMBRIAN
LATE MAFIC INTRUSIVE ROCKS[c]

8 *Unsubdivided.*
8a *Metagabbro.*
8b *Porphyritic metagabbro.*
8c *Granophyric metagabbro.*
8d *Composite intrusions—granodiorite, syenodiorite, gabbro, feldspathic pyroxenite.*†

INTRUSIVE CONTACT

FELSIC INTRUSIVE AND METAMORPHIC ROCKS
MASSIVE FELSIC INTRUSIVE ROCKS

7 *Unsubdivided.*
7a *Fine- to medium-grained quartz monzonite.*
7b *Coarse-grained quartz monzonite.*
7c *Porphyritic, leucocratic quartz monzonite.*
7d *Porphyritic, biotitic quartz monzonite, monzonite.*
7e *Pegmatite.*
7f *Aplite.*

INTRUSIVE CONTACT

FOLIATED FELSIC PLUTONIC AND MIGMATITIC ROCKS

6 *Unsubdivided.*
6a *Gneissic and foliated trondhjemite, granodiorite.*
6b *Augen gneiss.*
6c *Xenolithic, agmatitic trondhjemite, granodiorite.*
6d *Leucocratic migmatitic orthogneiss, paragneiss.*
6e *Mafic migmatitic orthogneiss.*

INTRUSIVE CONTACT

MAFIC INTRUSIVE ROCKS†

5 *Unsubdivided.*
5a *Gneissic metagabbro.*

INTRUSIVE CONTACT

METAVOLCANICS AND METASEDIMENTS
METASEDIMENTS[d]

4 *Unsubdivided.*
4a *Tuffaceous wacke, siltstone.*
4b *Quartz-feldspar sandstone.*
4c *Schistose, micaceous, chloritic metasediments, tuff.*
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4e *Chert, siliceous metasediments.*
4f *Sulphide-bearing micaceous, chloritic, siliceous metasediments, tuff.*†

IF *Oxide-facies iron formation.*†

METAVOLCANICS
FELSIC METAVOLCANICS

3 *Unsubdivided.*
3a *Rhyolite, porphyritic rhyolite.*
3b *Dacite, porphyritic dacite.*
3c *Tuff, lapilli-tuff, crystal tuff.*

INTERMEDIATE METAVOLCANICS

2 *Unsubdivided.*
2a *Tuff-breccia.*
2b *Lapilli-tuff.*
2c *Tuff.*

MAFIC METAVOLCANICS

1 *Unsubdivided.*
1a *Basalt.*
1b *Andesite.*
1c *Pillowed basalt, andesite.*
1d *Amygdaloidal basalt, andesite.*
1e *Mafic tuff.*

△ △ △ △ *Breccia.*

Ag	*Silver.*
Au	*Gold.*
cp	*Chalcopyrite.*†
Cu	*Copper.*
Fe	*Iron.*
fl	*Fluorite.*
gf	*Graphite.*
gn	*Galena.*†
mag	*Magnetite.*
mo	*Molybdenite.*
Ni	*Nickel.*
Pb	*Lead.*
po	*Pyrrhotite.*
py	*Pyrite.*
S	*Sulphide mineralization.*
sp	*Sphalerite.*†
Zn	*Zinc.*

---

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

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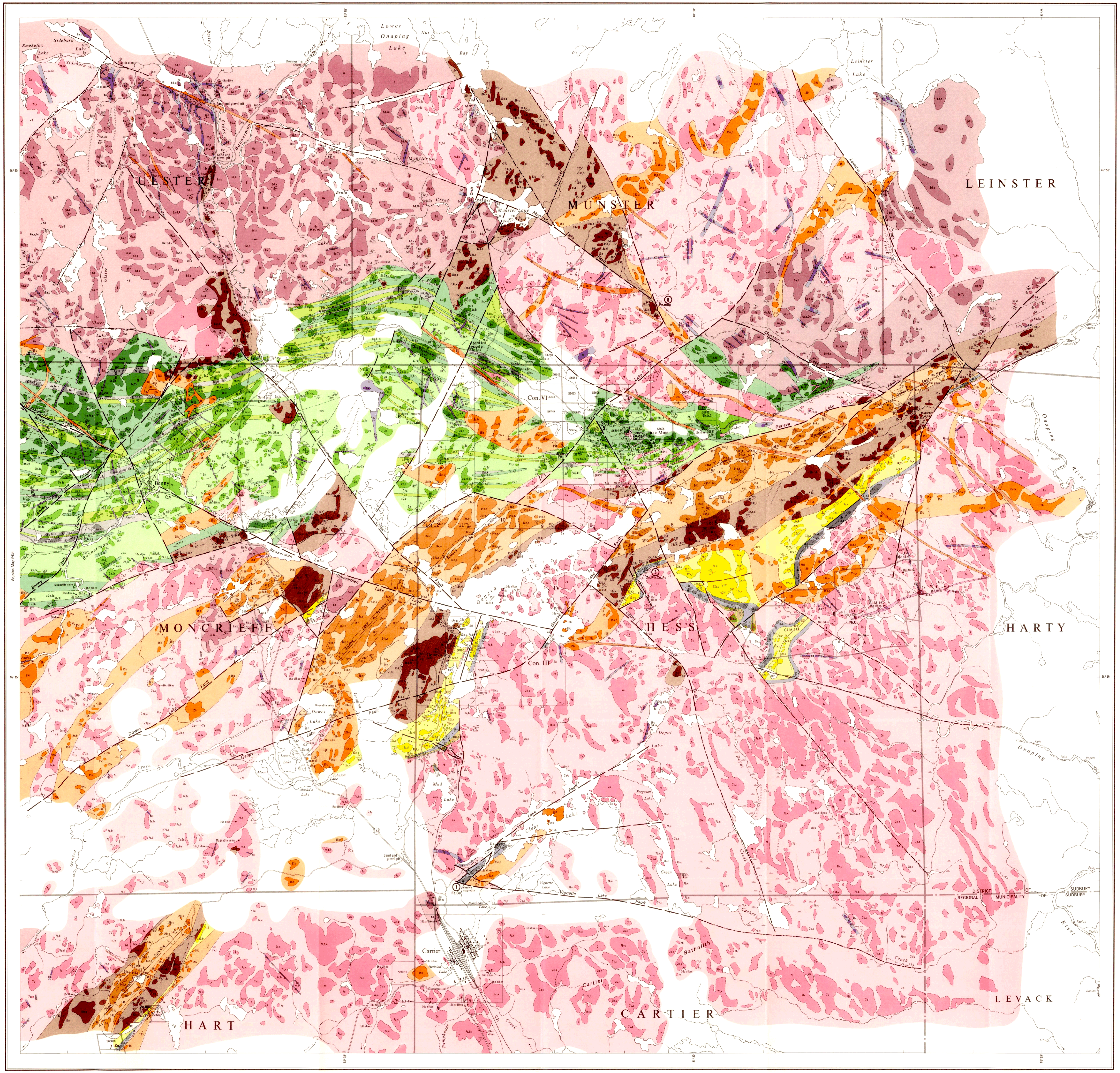

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N.T.S. reference 41I/11, 41I/12, 41I/13, 41I/14.

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Ontario
Ministry of
Natural
Resources

Hon. James A. C. Auld
Minister

Dr. J. K. Reynolds
Deputy Minister

Ontario Geological Survey
Map 2435

GENEVA LAKE

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