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Miscellaneous Paper 96

Summary of Field Work, 1980 by the Ontario Geological Survey

edited by
V. G. Milne, O. L. White, R. B. Barlow, J. A. Robertson and A. C. Colvine

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Ontario
Ministry of Natural Resources
Hon. James A. C. Auld
Minister
Dr. J. K. Reynolds
Deputy Minister

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Preface

During 1980, the Geological Survey carried out a large number of independent geological, geophysical, geochemical, geochronological and mineral deposit studies. In addition studies were undertaken in cooperation with the ministry's regional geological staff, the Geological Survey of Canada, the University of Manitoba and several private consulting firms. Funding for a number of regional stimulation projects was provided by the Ontario Ministry of Northern Affairs and the Federal Department of Regional Economic Expansion. Project involvement is summarized in the section introductions which follow and funding acknowledgments are given in the individual summaries.

The locations of the areas investigated are shown on two maps of the Province at the beginning of this report. The preliminary results of the work are outlined in this summary, which contains reports prepared by leaders of each of the projects. In these reports, some emphasis has been placed on the economic aspects of the different investigations. It is the hope of the Ontario Geological Survey that the information thus provided will help in the mineral resource evaluation of these areas and so will be a valuable aid to mineral prospecting and resource planning in the Province. Also as a direct result of this summer's work, research was undertaken on a number of theses at the B.Sc. and graduate level.

Coloured maps and final detailed reports covering most of the field projects are being prepared for publication. In the interim, however, uncoloured preliminary geoscience maps with comprehensive marginal notes will be released for distribution, mainly during the winter of 1980-81. Notices of the releases will be mailed to all persons or organizations on the Mineral Resources Group notification list, and will be published in the technical journals and other media.

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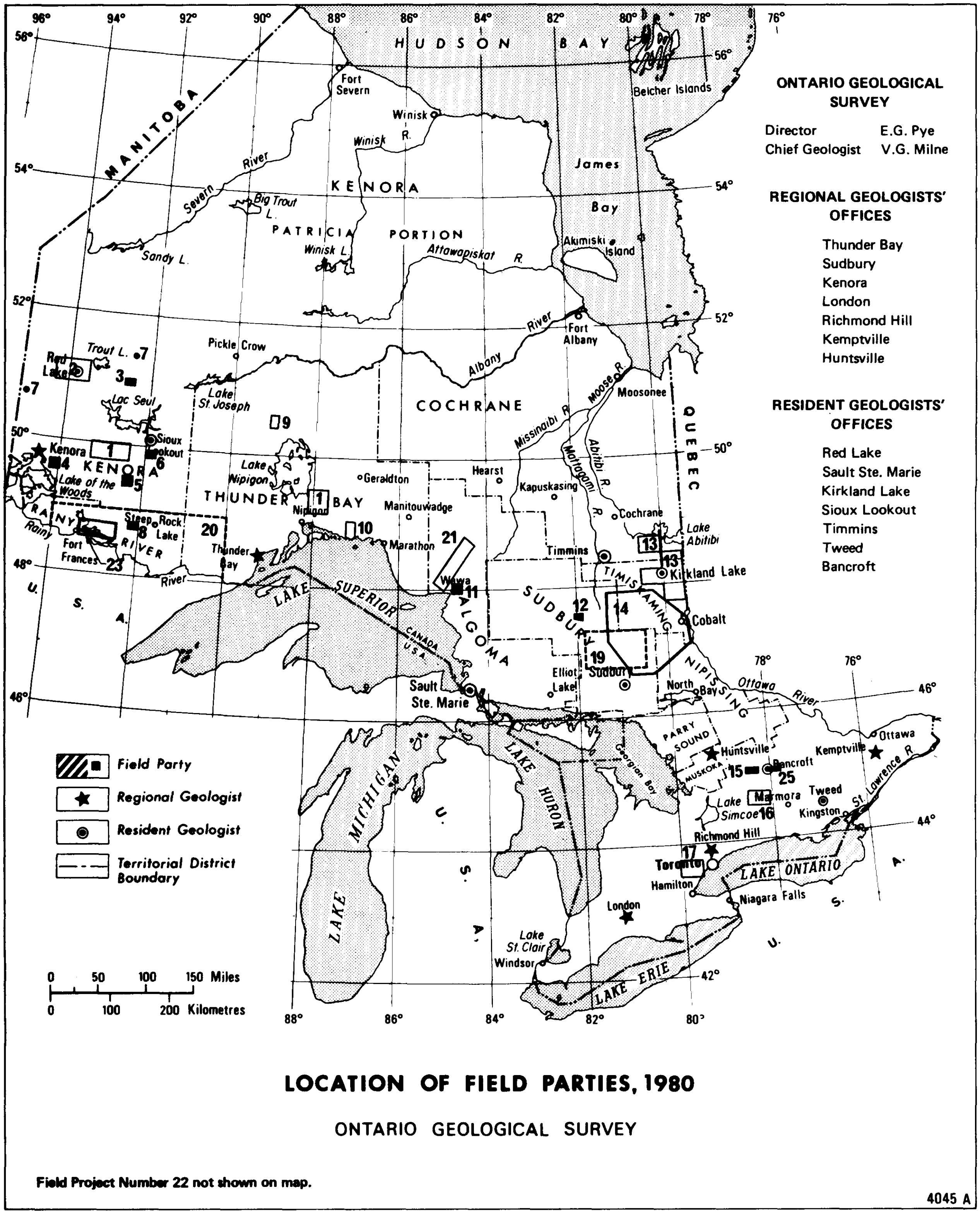
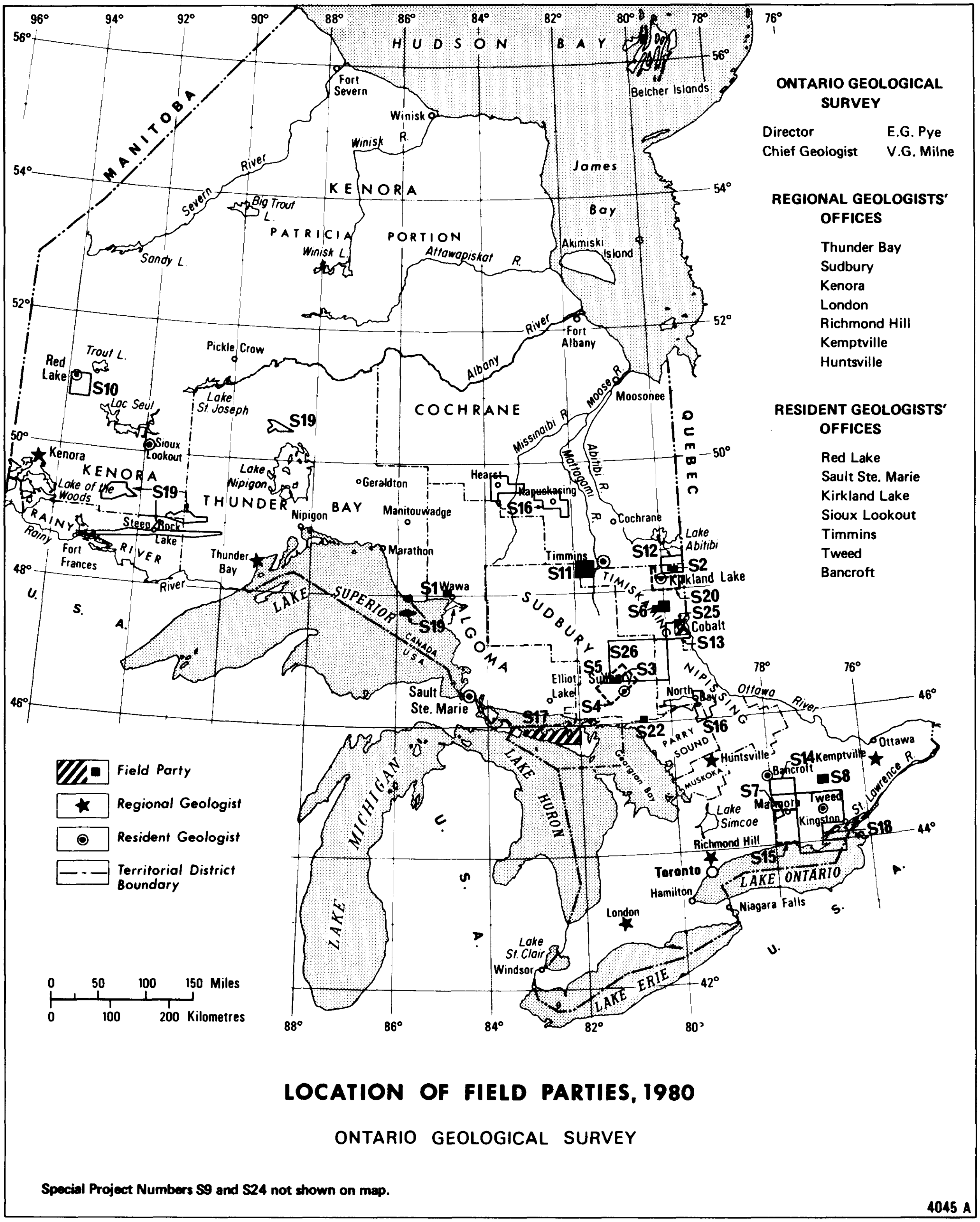


Location of Field Parties of the Ontario Geological Survey, 1980.



Location of Special Projects of the Ontario Geological Survey, 1980.

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.

Precambrian Geology Programs

Precambrian Geology Programs, 1980

V.G. Milne[1]

A total of 25 field survey projects were undertaken during the 1980 field season. Section staff directed 17 projects, seven were operated by contract project leaders and one was carried out by a Resident Geologist. In the Section's basic program, about 2100 km^2 were mapped at a detailed scale (1:31 680) and 6 special and synoptic projects (Nos. 1, 2, 7, 13, 14, 16) were undertaken. An additional 1500 km^2 of detailed scale mapping were completed and three special projects (Nos. 18, 20, 25) continued under programs partially supported by the Ontario Ministry of Northern Affairs and the Federal Department of Regional Economic Expansion (DREE).

Of the total projects undertaken, 16 comprise the Section's component of the ongoing program of the Ontario Geological Survey, Mines Group, Ministry of Natural Resources. The objectives of this base program are to provide geologic data, geologic interpretation and concepts which will increase the effectiveness of mineral exploration and mineral resource potential evaluation and management throughout the 650 000 km^2 of Ontario which is underlain by Precambrian bedrock. Due to the size of the area involved, survey projects are currently directed at high to moderate mineral potential sectors of six major geologic domains across the Province. The principal sectors being examined are (1) the Uchi Belt west of Pickle Lake, (2) the eastern and western parts of the Wabigoon Belt, (3) the Wawa Belt adjacent to Lake Superior, (4) the Abitibi Belt from Kirkland Lake to Chapleau, (5) the Cobalt Embayment from Cobalt to Sudbury, and (6) the Grenville Province of southeastern Ontario.

In the Uchi Belt, detailed (1:31 600) scale mapping was completed in the Slate Lake area (No. 3), thereby extending knowledge of the mineralized Confederation Lake area (Thurston 1978)southwards and towards Red Lake. In the Red Lake area, recent geological surveys (Pirie 1979), and gravity (1976) and airborne electromagnetic and magnetic (1978) surveys by the Geophysics/Geochemistry Section are being interpreted under a synoptic program (No. 2), currently in its first full year of operation. As a result of this summer's work, relatively extensive, previously unrecorded, ultramafic metavolcanics have been outlined in the central and western parts of the area, possibly raising interesting parallels with the Abitibi Belt gold association (Pyke 1975). With regard to base metals in the Uchi Belt, the special study of felsic volcanic centres (No. 7) is aimed at chemically and petrologically characterizing mineralized and non-mineralized volcanic sequences. Preliminary results indicate that, based upon a detailed knowledge of the volcanic stratigraphy and physical volcanology of an area, the rare earth trace element chemistry of the volcanic rocks can provide an indication of the mineral potential of various rock suites. A limited comparison with rocks in the Abitibi Belt suggests that this method may have general applicability.

In the Wabigoon Belt, detailed mapping continued to the west in the Lake of the Woods (No. 4), Bending Lake (No. 5) and Atikokan (No. 8) regions and, to the east, north of Lake Nipigon in the Caribou Lake (No. 9) region. The western Wabigoon, although not exhaustively tested, has recently been widely examined (Trowell *et al.* 1980) and appears to be devoid of ultramafic metavolcanics comparable with rocks in the Abitibi Belt (Jensen 1979; Pyke 1980). Mapping, to 1979, in the eastern Wabigoon had indicated a similar character to the western Wabigoon, but work this summer in the Caribou Lake region (Fletcher Lake area, No. 9) has identified ultramafic volcanic rocks. Whether these are exceptional, or exist more extensively in the eastern Wabigoon, has yet to be determined, but they illustrate once more the hazards of simple generalization in major belts.

In the Wawa Belt, detailed mapping has been underway for some time in several high potential metavolcanic belts adjacent to Lake Superior. In 1980, mapping continued in the

[1]Chief Geologist, Ontario Geological Survey, Toronto.

Heron Bay-Schreiber Belt (Terrace Bay area, No. 10) and in the Wawa-Renabie Belt (Wawa area, No. 11). These belts have high mineral potential and are highly significant to the economic development of the Lake Superior area.

In the Abitibi Belt, detailed mapping (No. 12) and synoptic surveys (No. 13) continued with the objectives of providing basic data for unmapped portions of the belt and extending and improving stratigraphic and mineralization concepts developed in 1979 for the Timmins-Kirkland Lake section of the Abitibi Belt.

Work in the Southern Province was confined to the Cobalt Embayment with the continuation of a regional study of the stratigraphy, structure and sedimentology of the Embayment (No. 14). This work is now being complemented by mapping and special studies carried out by the Precambrian Geology Section and Mineral Deposits Section as part of the satellite programs supported by other Ministries and referred to below. An integrated view of the metallogeny of the region has been proposed (Innes and Colvine 1979), but is still evolving. In 1980, some interesting aspects of the Embayment project (No. 14) indicate 1) the tidal flat character of the Gordon Lake Formation and the possibility of metal concentration at the base of the unit; 2) the apparent relationship of stratabound mineralization with fluvial and lacustrine units of the Gowganda Formation, and thus the need to improve discrimination between these and glacially transported units; and 3) the distinct contrast in provenance between the lower and upper parts of the Mississagi Formation, north of Lake Wanapitei, and its significance to concentration of economic mineralization in the lower part.

In the southern Grenville Province, one detailed mapping project was completed (No. 15), and a synoptic survey was initiated in the Burleigh Falls area (No. 16) with the objective of tracing sedimentary and volcanic stratigraphy associated with stratabound mineralization in other areas.

The remaining nine projects are funded

1) by the Ontario Ministry of Northern Affairs (NOGS);

2) jointly by the Federal Department of Regional Economic Expansion and the Ontario Ministry of Northern Affairs under the Community and Rural Resources Development Subsidiary Agreement (KLIP); or

3) jointly by the Federal Department of Regional Economic Expansion and the Ontario Ministry of Natural Resources under the Eastern Ontario Subsidiary Agreement (SOGS).

Under the Kirkland Lake Incentives Program (KLIP), the Precambrian Section continued a three-year detailed stratigraphic mapping project (No. 25) started in 1979. Preliminary findings of the project have been reported by Downes (1979, 1980). In addition to major structural features and carbonate alteration characteristics, this work also detected a potassic alteration associated with the Kerr Addison Mines Limited gold mineralization. Due to staff changes, only limited work was done on this project in 1980.

Under the Northern Ontario Geological Survey (NOGS) program, detailed mapping was completed in the Wawa area (No. 17), the Sudbury area (Nos. 19, 21), and the Englehart area (No. 23), and special studies of the Sudbury Irruptive footwall (No. 23) and alteration in the central Abitibi Belt (No. 18), started in 1979, were continued.

As a result of work on the North Range of the Sudbury Irruptive, it is proposed that the width of the contact metamorphic aureole of the Irruptive may indicate the depth of crustal section now observed at surface. Known mines occur in the widest part of this aureole as delineated to date, suggesting that deeper orebodies may occur in areas where the aureole is narrower. In the Abitibi alteration study, analogies between the Ben Nevis area and the Noranda area suggest the possible existence of flat, deep mineral deposits in the Ontario segment of the Blake River Group.

Under the Southern Ontario Geological Survey (SOGS) program, two detailed mapping projects were completed in the Marmora (No. 23) and north Frontenac (no. 24) regions, directed at clarifying the gold, base metal and uranium potentials of these areas.

The summaries contained in this volume represent a first appraisal of raw geological field data, as do the preliminary maps which are in preparation for publication during the 1980-1981 winter period. These summaries and maps were designed as a means of rapidly disseminating highlights and general outlines of new information. Extended analysis of field data in conjunction with detailed office and laboratory research for final report and map publication can be expected to result in changes to the field terminology, interpretations, and concepts expressed.

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No. 1 Lithophile Mineralization in Northwestern Ontario: Rare-Element Granitoid Pegmatites

F.W. Breaks[1]

Introduction

This is the second year of a continuing project (Breaks 1979) designed to develop exploration concepts for granitoid areas. Efforts this year concentrated upon evaluation of granitoid pegmatites in northwestern Ontario for tantalum-niobium potential and on ascertaining whether any relationship exists between these pegmatites and the regional metamorphic regime, and the derivation of S-type granitoids (White and Chappell 1977). The project has particular importance in view of a 15 to 20 percent shortage of tantalum (Emerson 1980).

Dryden Area

Mineral Exploration

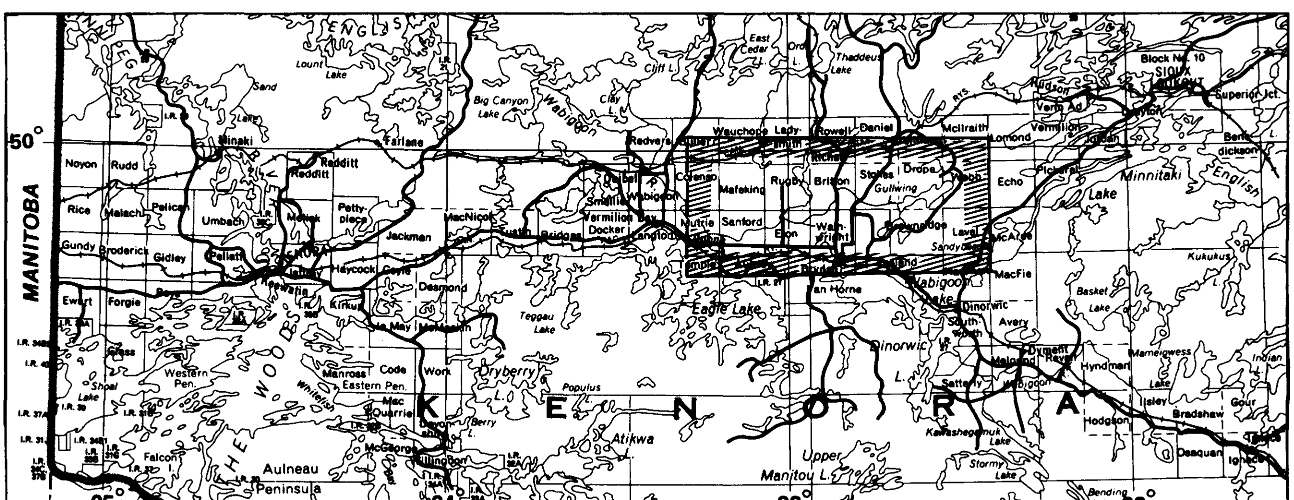
Early work in this district has been reported by Satterly (1941) and Moorhouse (1939). Work in the 1950s and 1960s is reported in the Assessment Files[2]. The Mavis Lake spodumene pegmatite was optioned to Selco Exploration Limited in 1979 and diamond-drilling and lithogeochemical surveys have been carried out. The Tot Lake spodumene pollucite dike was examined in 1979 by Tantalum Mining Corporation of Canada Limited[2].

General Geology

The Dryden pegmatite area is dominated by the Ghost Lake Batholith, an S-type granite which covers approximately 280 km^2. Samples of K-feldspar, muscovite and biotite were taken from associated pegmatites to ascertain fractionation trends and to provide regional prospecting techniques. Between Eagle River and Ghost Lake is a 40 by 13 km area which consists of inhomogenous to homogenous diatexite (compositionally coarse-grained biotite, biotite>muscovite, and muscovite>biotite quartz monzonite and granodiorite). The western two-thirds is possibly a lower structural level, given the predominance of inhomogenous diatexite, a transitional contact with metasediments displaying assemblages typical of the second sillimanite isograd, and paucity of tourmaline and muscovite in this area. The Ghost Lake Batholith is distinguished from other batholiths by the presence of tourmaline, muscovite, cordierite, sillimanite, almandine and rare dumortierite and beryl. The eastern portion represents a

[1]Geologist, Precambrian Geology Section, Ontario Geological Survey, Toronto.

[2]Assessment Files Research Office, Ontario Geological Survey, Toronto.



LOCATION MAP

Scale: 1: 1 584 000 or 1 inch to 25 miles

higher level, as it has an abrupt contact with metasediments, few metasedimentary inclusions, muscovite and tourmaline (locally 10 to 20 percent) and potassic pegmatites[1] which typify the cupola zone of batholiths parental to rare element pegmatites (Varlamoff 1972). Similar rocks were found in concession VII of Zealand Township (Satterly 1941). The cupola zone described above has abundant potassic pegmatite with tourmaline, garnet, green muscovite and blocky K-feldspar. Thus, it is similar to the pegmatite at the Dryden airport, which is interbanded with fine- to medium-grained muscovite-garnet-tourmaline potassic leucogranite[1]. These pegmatites, which are identical to the Green Lake beryl pegmatites of southeastern Manitoba (P. Cerny, University of Manitoba, personal communication, 1980; Cerny *et al.*, in press) are generally barren of rare-element minerals. Lime-green syngenetic beryls, measuring up to 3.0 by 8.5 cm, occur sporadically in the potassic pegmatite zones; these were discovered in 1979 by A.P. Pryslak of Selco Exploration Limited (A.P. Pryslak, personal communication, 1980).

Regional Zonation of Pegmatites

The regional zonation of rare-element pegmatites developed in the Ghost Lake - Mavis Lake - Dryden airport area is summarized in Table 1.

[1]Terminology after Cerny *et al.* (in press).

The zonal pattern of mineral assemblages in pegmatites of the Ghost Lake area is quite similar to those of the Yellowknife-Beaulieu district (Hutchinson 1955), Preissac-Lacorne District (Mulligan 1965) and the Issia et Touvre area of the Ivory Coast in Africa (Varlamoff 1972).

The Tot Lake spodumene-pollucite-columbite-beryl pegmatite, situated about 11 miles to the northeast of the Ghost Lake Batholith, cannot be confidently linked to the batholith and may be related to another anatectic center situated in the Gullwing Lake area.

Tot Lake Li-Cs-Rb-Nb-Ta Pegmatite, Webb Township

The Tot Lake pegmatite is emplaced discordantly in Wabigoon Subprovince metavolcanics near a metasedimentary portion of the southern plutonic domain of the English River Subprovince (Breaks *et al.* 1976a,b). The dike trends E50S, dips 70-75SE over a length of 48 m and has a maximum width of 6 m. Primary longtitudinal layering at the unaltered southeast end is defined by very coarse to pegmatitic pink spodumene and medium to coarse spodumene-green muscovite-albite layers. Lithium values range from 2.45 percent in the coarse layers to 0.84 percent in the medium-grained layers. Toward the northwest end, primary rhythmic layering of medium- to coarse-grained and fine-grained light green aplite is transverse to dike contacts and acts as a substrate for spodumene crystals measuring up to 38 by 14 cm.

Approximately 70 percent of the exposed pegmatitic dike is variably albitized, as detailed below:
1) characterized by mild to pervasive replacement of preexisting spodumene pegmatite adjacent to a fracture

TABLE 1: Regional Zonation of Rare-Element Pegmatites in the Dryden Area.

INCREASING DISTANCE FROM PARENTAL SOURCE AND INCREASING DEGREE OF FRACTIONATION ↓

Area	Pegmatite Structure	Characteristic Pegmatite Mineral Assemblage[1]	Degree of Replacement Stage Albitization
Dryden Airport	Unzoned, internal, usually barren potassic pegmatites. Lime-green syngenetic beryl sporadic.	Garnet + Muscovite + Tourmaline + Blocky K-feldspar (+ beryl)	Absent
Concession VII, Zealand Township (Taylor occurrence)	Unzoned, marginal potassic pegmatites.	Beryl + Muscovite + Tourmaline	Absent
Mavis Lake (Fairservice property)	Unzoned external pegmatites. Randomly oriented, primary Fe-rich spodumene phenocrysts present from wall to wall.	Spodumene-Beryl-Green Muscovite-Blocky K-feldspar (+ apatite + tourmaline + garnet + tantalite)	Incipient to moderate albitization with deposition of secondary alkali-rich white beryl
Tot Lake (Tantalum Mining Corporation of Canada Limited property)	Zoned external pegmatite. Pink spodumene phenocrysts either oriented sub-horizontally and normal to dike contacts or in random stockwork.	Spodumene-Pollucite-Green Muscovite-Blocky K-feldspar-Columbite (+ white beryl + Mn-garnet + apatite + tourmaline)	Most of pegmatite affected by moderate to pervasive albitization; minor secondary alkali-beryl.

[1]Accessory minerals placed in brackets.

system which sub-parallels the strike of the dike; spodumene may be partially to completely replaced by lepidolite, green mica, cookeite, or possibly albite + eucryptite; K-feldspar is replaced by albite + green muscovite;
2) characterized by irregular pods of saccaroidal, fine-grained apatite-tourmaline sodic aplite; this aplite is not connected to fracture systems, but does transect pre-existing primary layering.

The contact zones are marked by local tourmalinization and development of veins of purple, fibrous, fine- to medium-grained holmquistite, which cuts massive metagabbro at distances up to 1 m from the dike contact.

This dike is the most strongly fractionated in the Dryden area and is distinguished by internal zonation, moderate to intense albitization, local development of sub-horizontal spodumene phenocrysts normal to dike contacts, and the presence of minor pollucite.

Economic Geology

Mavis Lake Li-Be-Ta Pegmatites

Assays of 17 grab samples from dike 1 and an *en echelon* dike to the south ranged from 2 to 260 ppm Ta and averaged 150 ppm (Robert Fairservice, prospector, personal communication, 1980). The second most easterly dike in the Main Zone averaged 125 ppm Ta from six grab samples. Assays of eight grab samples, taken by the author across 5.5 m of the dike, ranged from 33 to 200 ppm Ta and averaged 110 ppm.

Tot Lake Li-Cs-Rb-Nb-Ta Pegmatite

Samples taken at 0.6 m intervals across the least altered southeast end and the moderately to highly albitized northeast end of this dike yielded the average values listed in Table 2.

Albitization in trench 3 has produced higher Ta values and disordered columbite crystals (determined by X-ray diffraction, P. Cerny, University of Manitoba), measuring up to 2 by 1 cm, which locally comprise 2 to 3 percent of the dike. These crystals are usually associated with coarse, completely albitized K-feldspar crystals and variably altered spodumene and quartz.

TABLE 2: AVERAGE CONCENTRATIONS OF LITHIUM, CESIUM, RUBIDIUM AND TANTALUM IN TOT LAKE PEGMATITE

	Average Concentration (ppm) Li	Cs	Rb	Ta	Number of Samples
Trench 2 (least altered)	6309	2717	2444	103	11
Trench 3 (moderately to highly altered)	1786	498	3419	218	10

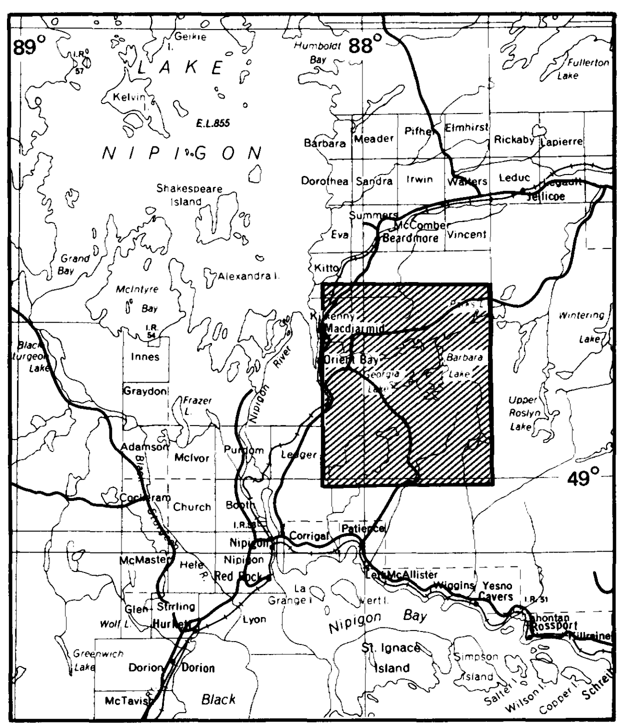
Gullwing Lake Pyrochlore-Microlite Occurrence

Several crystals belonging to the pyrochlore-microlite series[1] were discovered during the present survey in an area 200 m southwest of the Coates molybdenite occurrence near the northeast end of Gullwing Lake. These crystals occur in two 3 to 4 m wide muscovite granitic pegmatite dikes which intersect at 75 degrees on a high hill in this area. The largest crystal, which measured 2 by 3 cm, occurs in a K-feldspar-rich patch in the north-trending pegmatite. Research is currently in progress to establish whether these minerals are strictly microlite, $(Na, Ca)_2 Ta_2O_6(O, OH, F)$.

Georgia Lake Area

This area of the Quetico Subprovince, previously described by Milne (1962) and Pye (1965), contains the most profuse development of rare-element pegmatites in Ontario.

[1]X-ray diffraction by Geoscience Laboratories, Ontario Geological Survey, Toronto.



LOCATION MAP

Scale: 1:1,584,000 or 1 inch to 25 miles

Mineral Exploration

The Georgia Lake area was extensively explored for spodumene deposits during the mid-1950s (Pye 1965). Recent activity has, however, been minimal. J.A. Donner acquired five claims covering most of the 425 m length of the MNW property in 1974, for the purpose of developing a ceramic-grade spodumene deposit.

Regional Zonation of Pegmatites

The area south of the metasedimentary contact (Pye 1965) near Cosgrave Lake has extensive development of cordierite-biotite, biotite, and muscovite-biotite inhomogeneous and homogeneous diatexites, i.e. S-type granitoids. These rocks are well-exposed along the Lil Bear Quarry Road, although more reconnaissance mapping is needed to fully delineate the extent of the unit.

The anatectic center is a possible source for the marginal and external beryl- and spodumene-bearing pegmatites in the Georgia-Blay Lakes area to the north. Such a progression from barren to rare-element pegmatites is similar to that in the Dryden area, except for the lack of black tourmaline in the interior pegmatites of the supposed parental source area. The Georgia Lake pegmatites display a regional zonation similar to those in the Dryden area, except for the zoned MNW Li-Be pegmatite described by Pye (1965, p.103) and the Cosgrave Lake beryl occurrence discovered during this survey. The MNW pegmatite may have evolved at a higher crustal level than the others in the area as it contains petalite ($LiAlSi_4O_{10}$) now pseudomorphed by white spodumene-quartz symplectites, minor cassiterite, fluorite and moderate albitization, and is within its presumed parental biotite-muscovite-albite granite, herein named the MNW stock.

MNW Pegmatite

This unique zoned pegmatite was examined in detail because of the presence of petalite and columbite (Milne 1962). This pegmatite contains the only occurrence of petalite in Ontario known to date (Cerny and Trueman 1978, p.375). Wedge- and tabular-shaped euhedral to subhedral petalite crystals range in length from 11 cm to 1.3 m and form most of the core zone, as indicated by the modal analysis in Table 3.

TABLE 3: MODAL ANALYSIS OF SAMPLE FROM CORE ZONE OF MNW PEGMATITE

Mineral	Percent Abundance
Petalite	71.1
Quartz	24.3
Blocky K-feldspar	4.5
Amblygonite	<0.1
Muscovite	trace
Columbite	trace
Beryl	trace

Quartz, amblygonite, blocky K-feldspar, columbite and beryl occupy the interstitial spaces between petalite masses. The lamellar spodumene-quartz intergrowths are identical to "squi" ore observed by the writer at the Bernic Lake Ta-Li-Cs deposit and have ceramic potential (Heinrich 1975) because of low Fe content inherited from the parental petalite. Eleven grab samples of spodumene-quartz intergrowth material selected and analyzed by B.V. International Handel-en Scheepvaartmaatschappij Jan de Poorter of Holland averaged 0.10 percent Fe_2O_3 and 4.26 percent Li_2O[1].

Columbite-tantalite minerals are relatively rare in the petalite zone but, where present, can measure 3 cm to 13 cm.

An important feature of the pegmatite is the presence of a continuous multi-cuspate albitization "front", dominated by light blue to pink radiating cleavelandite fans symmetrically disposed along the flanks of the petalite-quartz zone. Textural details indicate that this cleavelandite zone was in the process of inward advancement before crystallization was arrested. Partial replacement of petalite by cleavelandite, serration and penetration of quartz-rich areas, and amyblygonite in the core zone were established by plagioclase staining tests. This albitization is also marked by deposition of secondary columbite (masses up to 3 by 4 cm), phosphates (purpurite + huhnerkobelite), and white alkali-rich beryl behind the metasomatic front, forming complex symplectites with cleavelandite.

Economic Geology

The previously unknown albitization associated with impressive local deposition of columbite suggests a relatively high economic potential for this dike and the surrounding MNW Stock. In the zonal classification of beryl-bearing granitic pegmatites of Beus (1962, p.54-55) this deposit compares closely with the cleavelandite zone of an albite replacement complex. Characteristic typomorphic minerals of this replacement complex (greenish muscovite, green tourmaline and secondary Fe-Mn phosphates) are present at the MNW deposit, in addition to the rare-element minerals columbite, cassiterite and alkali beryl. Beus (1962, p.55) considers that "wide development of albitization is a very favorable feature in exploration and evaluation of pegmatites for the content of rare metals".

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PRECAMBRIAN — SUPERIOR PROVINCE

No. 2 Red Lake Synoptic Project, District of Kenora

Henry Wallace[1]

Introduction

In 1978 preliminary work was initiated with the objective of producing 1:50 000 scale geological maps and a synoptic report summarizing stratigraphy, structure and economic geology of the Red Lake belt. The project involves integration of all previous geological data, mapping only to fill data-gaps, reconciling discrepancies in interpretation, and updating older surveys to current scientific levels where reconnaissance spot-checks showed them to be inadequate. This work was started by James Pirie (1978, 1979) and is being continued by the author.

The 1980 field work began in the western half of the Red Lake belt where rocks were less altered, in terms of silicification and carbonatization, and structurally simpler (Riley 1975, 1978a, b) than those around the gold-producing areas located in the eastern part of the belt. The work involved examination of shoreline outcrops on Red Lake, and had a three-fold purpose. First, it was necessary to ascertain the accuracy and consistency of previous mapping and to establish stratigraphic and structural relationships in this area of relatively good exposure. Second, sampling for petrochemical analysis was carried out on all rock types. Recent studies by Pirie (1980) and MacGeehan and Hodgson (1980) have shown correlations between the type and intensity of hydrothermal alteration and the occurrence of economic gold mineralization in the eastern part of the belt. Comparison of the petrochemistry of these rocks with those from the western half of the belt, particularly around known gold occurrences in the western part, is a major objective of the study. This will also permit a critical evaluation of the volcano-stratigraphic environment proposed by Pirie (1980). The third aspect of the 1980 field work was examination of known mineral occurrences in the western part of the belt.

General Geology

The author's 1980 field work included examination of parts of Ball, Todd and Fairlie Townships which were previously mapped by Riley (1975, 1978a, b).

Ultramafic flow rocks have been identified in the Golden Arm, Middle Narrows and Fisher Islands areas. Pillow structures are present in serpentinized peridotite around Golden Arm and east of Middle Narrows. Similar serpentinized ultramafic rocks, exhibiting spinifex textures and autoclastic breccias indicative of extrusive ori-

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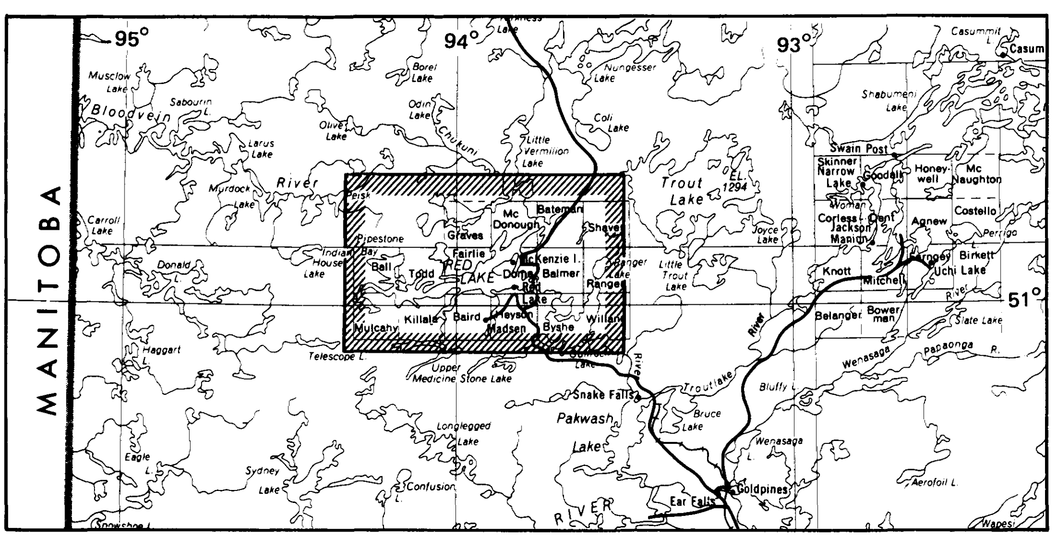

LOCATION MAP

Scale: 1:1,584,000
or 1 inch to 25 miles

gin, were encountered in several areas along both sides of Golden Arm; spinifex-textured rocks were seen interlayered with quartz-magnetite ironstone in the Fisher Islands. Less definite evidence for ultramafic extrusive rocks was found around West Narrows and the islands to the west, and north of the entrance to Sadler Bay, where poorly developed spinifex texture and polysutured jointing were observed (Pyke 1970).

Pyroclastic rocks are present along the south side of Martin Bay and in places between Para Lake and Red Lake. The pyroclastic rocks in Martin Bay, which extend eastward at least as far as the Fisher Islands, are predominantly thinly bedded, crystal-rich, monolithic tuff to lapillistone units. The fine bedding, monolithic character, absence of pumiceous fragments, and the equant nature of fragments in these units suggest that they are air fall in origin. However, at least part of that sequence consists of thin units which have been tentatively identified as distal ash-flow deposits. Evidence for this interpretation is based on the presence of abundant partially collapsed pumice fragments, and obvious partial to complete welding near the base of the cooling units to form vitrophyric layers.

Preliminary field work has shown that the pyroclastic rocks north of Red Lake in Fairlie Township are monolithic and heterolithic units ranging in tephra size from tuff to tuff-breccia. These are distinguishable from the clastic metasediments in the area by their much lower sand-size quartz content, the preponderance of metavolcanic fragments, and the common occurrence of euhedral plagioclase grains. Felsic to intermediate flows are also believed to occur in this sequence, but these massive flows can be difficult to distinguish in the field from monolithic pyroclastic units, which are recognizable in places only where accidental fragments are discernible.

The presence of welded ash-flow deposits in Martin Bay, coupled with the occurrence of extensive clast-supported conglomeratic units, roughly at the same stratigraphic level along the southern side of Wolf Bay, indicates that the stratigraphy developed in a shallow marine to subaerial environment. Domal stromatolites, which are found in the chert-carbonate beds on the west side of Golden Arm and north of Galena Island (west of West Narrows) are also evidence for an extensive shallow marine to littoral environment (Playford and Cockbain 1976).

From the distribution of lithologic units around Pipestone Bay, the volcanic rocks in that area can be interpreted as a primary volcanic dome. Rhyolitic to dacitic flows and pyroclastic units are intercalated with basaltic flows. On the flanks of this paleodome, quartz-magnetite ironstone sequences are common interflow sediments. Pyroclastic rocks near the apparent apex of the dome in Middle and Sadler Bays are particularly siliceous, most units consisting of quartz-phyric monolithic lapillistone and lapilli-tuff. Overlying the felsic metavolcanics is a thick sequence of chemical metasediments, namely chert, ironstone and marble (including the stromatolitic exposures) which extends at least from Trout Bay to Hahn Lake.

The large mass of serpentinized and commonly carbonatized peridotite, centred in Pipestone Bay, is probably entirely intrusive, since the rocks appear to cross-cut the volcanic stratigraphy and evidence for extrusive origin such as polysuturing, pillows and spinifex texture are lacking. It is probably a composite body, but extensive pervasive alteration makes it very difficult to distinguish between original intrusive phases.

Structural Geology

Along the north side of Red Lake, between Middle and Wolf Narrows, the metavolcanic and metasedimentary sequences face north. However, there is evidence, from aeromagnetic data (Ontario Geological Survey 1978) and a limited number of top determinations, of tight isoclinal folding between Sadler and Wolf Bays. There are at least two and possibly more northeast-trending fold axes. An anticlinal axis extends eastward along Golden Arm, probably as far as north of Martin Bay. Subparallel to this is a synclinal axis which passes through the southeastern corner of Sadler Bay, continuing north of Hahn Lake and south of Abate Lake. This fold may extend westward into the Trout Bay Syncline proposed by Riley (1975).

Preliminary assessment of the area between Para and Red Lakes suggests considerable structural complexity in terms of isoclinal east- to northeast-trending folds.

There is little evidence in the field for major faulting in the supracrustal rocks in the western part of the belt.

Economic Geology

Intense exploration activity for gold went on throughout the Red Lake belt in the 1980 field season. Because of sustained high prices for gold, several properties which have been inactive for many years are currently undergoing serious review. Some of these, such as the Mount Jamie Mine, are in the western part of the belt where there has never been appreciable gold production.

Alteration of supracrustal rocks in the western part of the belt does not appear to be nearly as pervasive as that described by Pirie (1980) for the rocks in the Red Lake-Balmertown-Cochenour area. However, carbonatization, commonly intense in places, does occur in the mafic metavolcanics north of the central part of Red Lake, in the ultramafic intrusive rocks around Pipestone Bay, and in the felsic metavolcanics around Middle and Sadler Bays where the alteration effects are less obvious in hand specimen. Several of the gold showings visited during the field work were located within carbonatized felsic to intermediate rocks. Fuchsite is a common accessory in some of these occurrences; the mica typically occupies shear planes adjacent and subparallel to sulphide-bearing quartz or quartz-carbonate veins. Further observations regarding the association of gold with metasomatic processes, and comparisons with hydrothermal alteration effects from the gold-producing areas in the eastern part of the Red Lake belt must await analytical work.

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No. 3 Slate Lake Area, District of Kenora (Patricia Portion)

R.P. Bowen[1]

Introduction

The Slate Lake area, which was mapped at a scale of 1:15 840, covers roughly 310 km^2, is bounded by Latitudes 50°52.5′ and 51°1.1′N and Longitudes 92°22.5′ and 92°37.64′ W,.and is located approximately 100 km east of Red Lake. Access to the area is by float- or ski-equipped aircraft from Red Lake or Ear Falls. Transportation within most of the area can be accomplished by canoe on the Papaonga and Wenasaga River systems. Access to the smaller lakes is by airplane or helicopter. The adjoining area to the west was mapped by Ontario Department of Mines personnel in 1965 and 1966 (Fenwick 1965, 1967). The adjoining area to the north was mapped by Ontario Division of Mines personnel in 1973 and 1974 (Thurston *et al.* 1974; Thurston *et al.* 1975). All of the map-area south of Latitude 51°N was included in the helicopter reconnaissance mapping program carried out by the Ontario Division of Mines in 1975 (Breaks *et al.* 1976).

Information on early mineral exploration is taken from Assessment Files, Ontario Ministry of Natural Resources, Red Lake. Mineral exploration probably began shortly after the Red Lake gold rush of 1925. Most of the activity centered around Uchi Lake and the Woman, Confederation and Narrow Lakes areas to the north and northwest of the map-area until the financial crash of 1929. More active work began in 1936 and continued until World War II. Further prospecting for gold was undertaken in 1945 by J. Pemicam and J. Hager, who staked eight claims north of Panama Lake. These claims were transferred in 1946 to Pemmican Mines Limited, who did some surface work and some 1,500 feet of diamond-drilling. The claims were transferred to Colin A. Campbell in 1951 and allowed to lapse. In 1958 J. Kolak & K. Koezur staked 12 claims in the area but allowed them to lapse; Kolak restaked the area in 1960 and again allowed the claims to lapse. Some work was also done by H. Polkum in the 1940s. All information up to 1960 is sketchy and not well documented; recorded assays run from *nil* to 0.26 ounce of Au per ton.

Well-documented assessment work dating from 1957 to the present is available at the Resident Geologist's Office in Red Lake. Recent exploration has centred on both base and precious metals as well as iron ore.

Newkirk Mining Corporation Limited had a strip of ground in the southern part of the map-area, measuring approximately 172 km long and 1.6 km wide and with it's long axis oriented in an easterly direction, surveyed by airborne magnetometer in 1956 by Aeromagnetic Surveys Limited. This predated the government-sponsored

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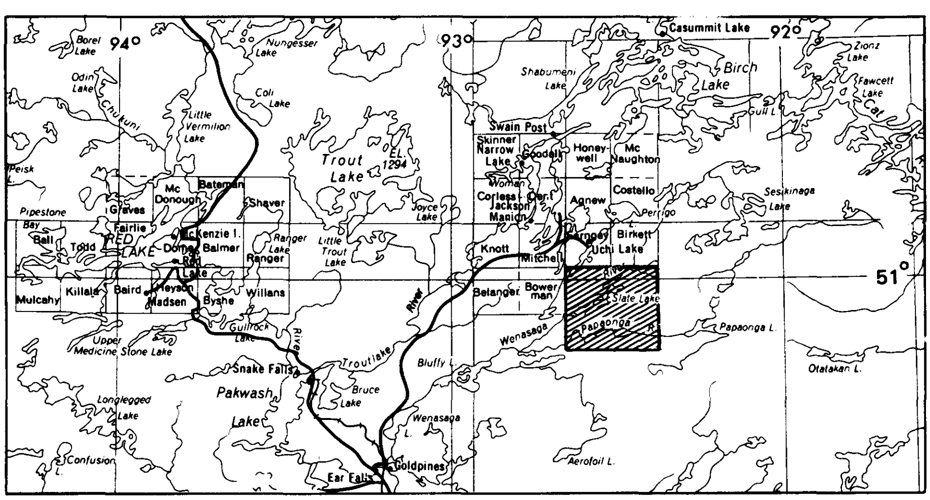

LOCATION MAP

Scale: 1:1 584 000 or 1 inch to 25 miles

aeromagnetic survey (Ontario Department of Mines-Geological Survey of Canada 1960a,b,c,d) by three years.

Quebec Labrador Development Company Limited and El-Sol Gold Mines Limited staked a large amount of ground in the southern and eastern parts of the map-area; considerable diamond-drilling of magnetic anomalies on these claims revealed magnetic ironstone deposits. El-Sol Gold Mines Limited became Tex-Sol Explorations Limited in 1964 and took 124 claims, centred around Kesaka Lake, to lease on the basis of work done by El-Sol Gold Mines Limited. A ground magnetometer survey was followed by 33,998 feet of diamond-drilling in 53 holes, which delineated two ore zones, consisting of 312.5 million tons to a depth of 1,000 feet and averaging 31.1 percent Fe; this was later revised to 115 million tons to a depth of 440 feet averaging 31.2 percent Fe. Aumague Gold Mines Limited conducted magnetometer and ground electromagnetic work over a portion of the Papaonga Lake Pluton for precious and base metals, and drilled seven shallow holes with negative results in 1956-57. These claims were dropped in 1961. In 1957 Quebec Labrador Development Company Limited diamond-drilled 13 holes totalling 6,725 feet to test magnetic anomalies in the southwest part of the map-area. The ironstone proved to be less than 3 m wide and of low grade, less than 30 percent Fe. These claims were dropped in 1962. Exploration activity was low until 1969 when Dome Exploration (Canada) Limited contracted Canadian Aero Mineral Surveys Limited to fly an airborne magnetic, electromagnetic and gamma-ray spectrometer survey over some 66 claims in the northwestern portion of the map-area. This was followed up by 2,137 feet of diamond-drilling in seven holes in 1970 to test conductors delineated by the airborne survey. Results were not encouraging and the claims were dropped.

In 1969 the Keevil Mining Group Limited staked 20 claims between Anape Lake and Lower Slate Lake and conducted a magnetic and electromagnetic survey over the area, delineating two strong conductors. These were not tested by diamond-drilling. That same year Halren Mines Limited staked 65 claims between Lower Slate Lake and Wassa Bay and conducted magnetic and electromagnetic surveys over the property. Diamond-drilling was reported in the Canadian Mines Handbook but was not filed for assessment credit. Also in the same year Noranda Exploration Company Limited staked two claim groups in the northeastern portion of the map-area between Kesaka and Jubilee Lakes. Magnetic and electromagnetic surveys were conducted, after which the claims were allowed to lapse. In 1971 the Ernest Prieston property in the southwestern portion of the map-area was drilled and trenched in the vicinity of the Newkirk magnetic anomaly. Results were not encouraging and the property was dropped.

Between 1977 and 1980 St. Joseph Explorations Limited staked 12 claim groups, mostly in the northern half of the map-area, and conducted geological, geochemical, magnetic and horizontal loop electromagnetic surveys over most of the claims. To date eight holes totalling 2,455 feet have been diamond-drilled to test electromagnetic conductors and more drilling has been recommended.

General Geology

The area is underlain by Early Precambrian (Archean) rocks. Bateman (1939, 1940) divided the area roughly into northern and southern halves and assigned them to the Uchi Lake volcanic series and the Slate Lake sedimentary series, respectively. Since then the area has been redefined by chemical and petrographic methods (Thurston 1978; Breaks *et al.* 1978), with the northern portion being assigned to the Uchi Subprovince and the southern portion to the English River Subprovince.

Mafic metavolcanics comprise roughly 10 to 15 percent of the map-area and can be classified as Thurston's cycle I volcanics of the Uchi Lake volcanic series, except for a small portion in the northwestern corner which are upper cycle II metavolcanics (Thurston 1978). Most of these cycle I metavolcanics are mafic to intermediate in composition and range from flows and pillow lavas to pyroclastic rocks. Some coarse-grained phases were noted, but not all were intrusive. Pillow selvages as well as flow banding were in evidence.

Interbedded with the mafic metavolcanics are intermediate (10-15 percent) and felsic (15-20 percent) metavolcanics and clastic metasediments (30 percent). The intermediate and felsic metavolcanics are mostly pyroclastic in origin, consisting of ash to lapilli size fragments; a few dense flows were noted. A cherty rhyolite breccia outcrops on Lower Slate Lake. The clastic metasediments vary from arkose to wacke in composition and many of the units consist of felsic to intermediate volcanic debris. In some areas, pronounced graded-bedding and cross-bedding are in evidence, indicating deposition from high velocity currents.

A band of polymictic pebble and cobble conglomerate in an arkose to wacke matrix stretches from Lower Slate Lake to Maskooch Lake, a distance of some 12 km, and is 300 to 450 m thick. The band is actually a series of conglomerate and wacke horizons which vary from a few centimeters to 6 m in thickness. Weathering of the clasts took place prior to deposition and lithification, as the volcanic and sedimentary clasts are smooth and oval in shape, much like the weathered fragments of these same rock types found elsewhere in the area. These rock types make up some 80 percent of the clasts. Granitic or intrusive rock clasts, which constitute about 20 percent of the clasts, are well-rounded and relatively undeformed. The plutonic clasts have not been correlated with plutonic bodies outcropping in the surrounding area. The conglomerate has been described as a fan type of sedimentary deposit (Bateman 1939, 1940); this interpretation seems reasonable in light of evidence discovered in the field to date.

Chemical metasediments consist of magnetitic chert and/or jasper interlayered with magnetite ironstone. Specular hematite is associated with the jasper-rich unit. These units appear to be associated with the contact between felsic metavolcanics and the metasediments. Sulphide facies ironstones and zones of carbonatization are also associated with the metavolcanic-metasedimentary interfaces. The chemical metasediments comprise 1 to 5 percent of the rock types in the map-area.

In the southernmost part of the map-area migmatitic rocks derived from wackes outcrop. Sillimanite, andalusite, muscovite, tourmaline and garnet were found in these rocks, which range from metasedimentary muscovite mica schist to a homogeneous diatexite or 95 percent medium- to coarse-grained leucocratic granite pegmatite (Breaks *et al.* 1978; Breaks *et al.* 1976).

Mafic intrusive rocks comprise 5 to 10 percent of the map-area. The most significant pegmatite, at the western tip of the Papaonga Lake Pluton, is dioritic to monzonitic in composition with biotitic inclusions, 3 to 7 cm long and 2 to 3 cm wide, aligned parallel to the foliation in the pluton. Medium- to coarse-grained gabbroic to dioritic sills and dikes intrude the metavolcanics and metasediments throughout the map-area, but are most common in the northern portion. Four silicic plutons of deep seated to shallow intrusive origin, and several feldspar porphyry dikes or smaller intrusive bodies, make up approximately 15 percent of the map-area. The four plutons range in size from 1 to 3 km wide by 2 to 6 km long, with the long axes paralleling the general foliation trend, and are composed of biotite tonalite, granodiorite, monzonite, syenite, hornblende-biotite tonalite, and feldspar and quartz-feldspar porphyry.

The entire area has been glaciated. The most obvious glacial trend was from northeast to southwest, but in places two sets of striations were observed, the second trending roughly 20 degrees more to the south.

Structural Geology

The majority of the rock formations trend easterly and dip vertically or steeply southward. The various plutons produce some doming in their immediate vicinity. It is also possible that the dome centered around Maskooch Lake is a thick portion of the surrounding felsic sequence. Top determinations from pillows and grading in clastic metasediments indicate tops are generally to the south. The few northward top determinations suggest some folding. Chemical metasediments, notably silica-rich ironstones, exhibit intense deformation in places, indicating rapid deposition of overlying material before lithification. Very little evidence exists for north-trending faults, and little movement is indicated by stratigraphic dislocation along possible east-trending faults. The most notable of these would be parallel to the long axis of Slate Lake. Strike and foliation are generally conformable, although, in a few instances, schistosity is markedly different.

Economic Geology

To date the most significant occurrance of any economic potential has been the Tex-Sol iron deposit around Kesaka Lake. The gold showings north of Panama Lake and sulphide mineralization in quartz veins in felsic metavolcanics and in the carbonate and sulphide zones on Slate Lake have provided drill targets, but reported assays for both precious and base metals have been low and over narrow widths. The conductors drilled by St. Joseph Explorations Limited were found to consist of pyrite and pyrrhotite interbanded with felsic to intermediate metavolcanics, usually tuffaceous in nature and often associated with thin argillaceous beds.

The carbonatized mafic metavolcanics along the south shore of Slate Lake, especially where sulphides are present, and the north shore of Sawan Bay are of particular interest for gold and base-metal potential. The felsic units do not appear to have been explored over their entire extent, nor have all geophysical anomalies been tested. This is especially true where the felsic units are in contact with mafic units and where sulphide and oxide ironstones are present. The magnetitic jasper interlayered with magnetite and specular hematite ironstone north of Tepeka Lake has not been extensively prospected, as far as can be determined from the assessment file records. A number of electromagnetic conductors, delineated in previous work but never drilled, should be re-examined and possibly tested. The mafic metavolcanics have the best overall potential for both precious and base-metal mineralization.

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No. 4 Gibi Lake Area, District of Kenora

N.F. Trowell[1], J. Logothetis[2] and G.F. Caldwell[3]

Location

The map-area, bounded by Latitudes 49°35′ and 49°40′N and Longitudes 94°00′ and 94°14′W, comprises portions of the four contiguous townships of Code, Work, McMeekin and le May. The town of Sioux Narrows is approximately 25 km to the south, and Kenora 30 km to the northwest. Highway 71 passes through the central part of the map-area. Logging and camp access gravel roads from the main highway provide access to the entire area.

Mineral Exploration

Exploration, concentrating on gold, was initiated within the map-area during the late 1890s and continued into the early 1900s. Underground development and considerable trenching was undertaken during this period at the Triggs and Stella prospects situated in the northwest corner of Code Township (Beard and Garratt 1976). Sporadic activity continued at and in the vicinity of the Stella prospect, with additional trenching occurring during the periods 1935-1937 and 1946-1948 (Beard and Garratt 1976) and diamond-drilling by E.J. Stone in 1960[4]. A bulk sample was taken from the Triggs prospect in 1950 (Beard and Garratt 1976). In 1953 Rexora Mining Corporation Limited carried out geological mapping and diamond-drilling in the vicinity[5]. In the same year they also conducted diamond-drilling north of Hook Lake[4]. Further drilling near the Triggs prospect was conducted by Macassa Gold Mines Limited in 1960[5]. D. Schack and A. Jensen (Olympia Gold Mines Limited) carried out diamond-drilling west of Hook Lake in 1970. Dome Exploration (Canada) Limited carried out airborne and ground magnetic and electromagnetic surveys and follow-up diamond-drilling on several claim groups north, west and south of Gibi Lake in the period 1972-1976. Currently, exploration work is reportedly (R.C. Beard, Regional Geologist, Kenora, personal communication) being done or is being planned for the Triggs and Stella prospects.

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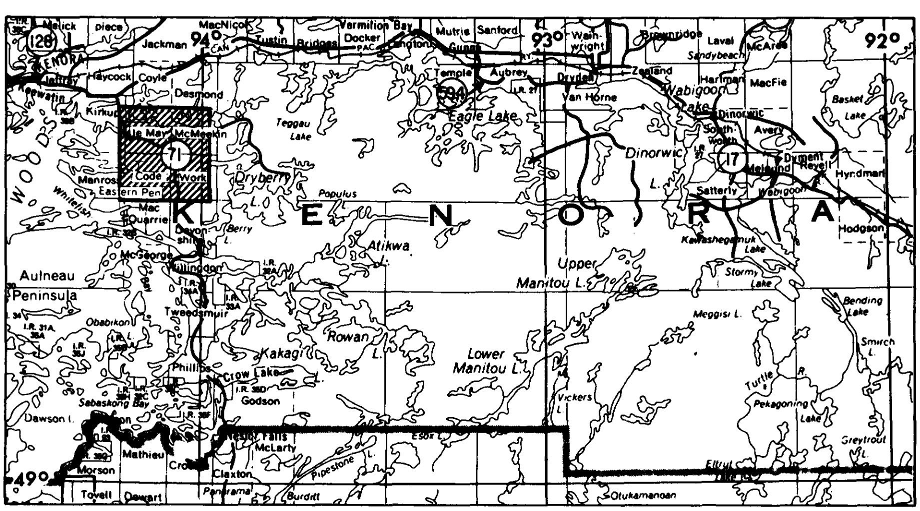
[2]Graduate Student, Dalhousie University, Halifax.
[3]Student, University of Windsor, Windsor.

[4]Regional Geologist's files, Ontario Ministry of Natural Resources, Kenora.
[5]Assessment Files Research Office, Ontario Geological Survey, Toronto.



LOCATION MAP

Scale: 1: 1 584 000 or 1 inch to 25 miles

General Geology

The Gibi Lake area has not previously been mapped as a whole. In 1885 Lawson published his report covering the Lake of the Woods region to the west. Suffel (1931) and Fraser (1943), mapped the northeastern and southwestern parts of the area, respectively. The area is covered by a geological compilation map by Davies and Pryslak (1967). The author did a brief reconnaissance of the area in 1979 (Trowell 1979).

All consolidated rocks, except for Late Precambrian diabase dikes (Mackenzie dike swarm of Fahrig and Wanless (1963)) are of Early Precambrian (Archean) age. They consist of a metavolcanic-metasedimentary assemblage, intruded by mafic to ultramafic bodies and granitoid plutons and bounded and intruded to the north and south by the Dryberry Batholith (Figure 1).

Two major sequences of metavolcanics are exposed in the Gibi Lake area: the Dogtooth Lake and the Gibi Lake Sequences.

The Dogtooth Lake Sequence consists of mafic, predominantly massive, locally plagioclase-phyric and pillowed amphibolitized flows in the northeast to predominantly pillowed, locally plagioclase-phyric flows with minor autoclastic breccia zones in the southwest. Large gabbro-diorite intrusions are present near the exposed base of this sequence. Thin beds of wacke-siltstone occupy interflow positions in the predominantly pillowed upper portion of this sequence.

The Gibi Lake Sequence, consisting of both mafic and intermediate pyroclastic material, overlies the metasediments exposed in the southern part of the map-area.

A fold-repeated sequence of minor mafic flows and fragmentals comprises the base of the Gibi Lake Sequence in the central and eastern part of the area. To the west, intermediate fragmentals overlie the metasediments. The distribution and intermixing of lithologies in the Gibi Lake Sequence is indicative of concomitant mafic and intermediate volcanism, with their sources in the east and west of the map-area, respectively.

Intermediate volcanic material increases in abundance upwards, and shallow water reworking of the pyroclastic material is indicated by large-scale trough cross-stratification

Both the mafic fragmentals and minor mafic flows are characterized by the presence of large, abundant, euhedral clinopyroxene (now hornblende) crystals. The flows are both plagioclase- and hornblende-phyric, and are layered, grading from an ultramafic cumulate base to a pillowed plagioclase-phyric and amygdaloidal top. The fragmentals vary from tuff to tuff-breccia and were deposited by ash flows, proximal debris flows and settling of air-fall ash material.

Intermediate fragmentals increase in abundance upwards and to the west. They also have been deposited predominantly by subaqueous settling of air-fall ash and redeposition by debris flow. Possible ash flows, consisting of coarse fragmentals showing reverse grading and preservation of pumiceous clasts, and thinly bedded air-fall ash occur at the top of the Gibi Lake Sequence.

Two metasedimentary sequences are present within the map-area. Feldspathic arenites, which are exposed

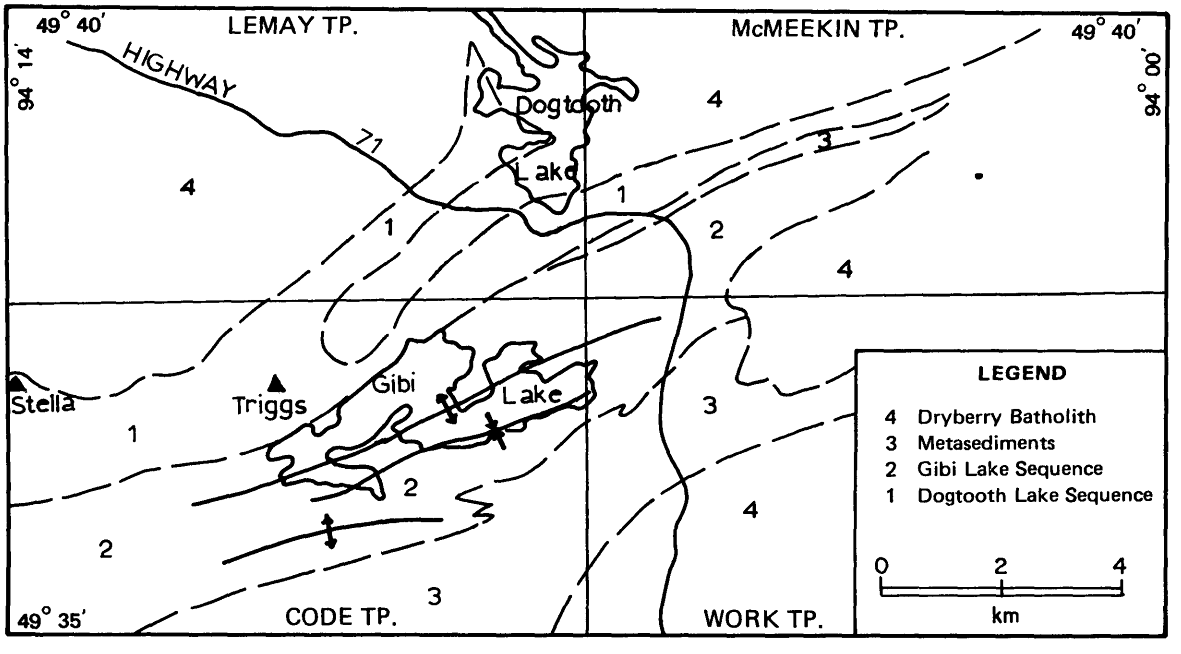


Figure 1 — Generalized geology of the Gibi Lake area.

on Andy Lake, become more pelitic eastwards into McMeekin Township. They appear to be intercalated with and perhaps derived from the intermediate to felsic fragmental sequence. A second sequence of feldspathic wackes and siltstones, with minor mudstones, extends from Hump Lake southwest to the southern margin of the map-area. A zone of intercalated garnet-amphibole-magnetite ironstone and chert can be similarly traced near the southern margin of this metasedimentary sequence. Along Highway 71, thickly bedded wackes and mudstones, metamorphosed to the andalusite-sillimanite (± garnet ± diopside) grade, have apparently been deformed by a plastic soft-sediment style of deformation.

West of the southern end of Dogtooth Lake, massive pods of pyroxenite and a layered ultramafic to mafic body intrude the exposed base of the mafic metavolcanic Dogtooth Lake Sequence. Similar pyroxenite pods intrude the metasediments exposed along Highway 71.

The part of the Dryberry Batholith mapped during the present survey can be subdivided into three broad zones. West of Dogtooth Lake, biotite-hornblende (pyroxene cores) monzodiorites intrude mafic metavolcanics and pyroxenites. To the north, a uniform biotite granodiorite phase, cut by sills of biotite trondhjemite and minor pegmatite, covers the mapped part of le May Township. The biotite granodiorite phase intrudes the monzodiorite phase at Dogtooth Lake.

The part of the Dryberry Batholith exposed along Highway 71, in Work Township, consists of a "gneiss dome" of several complexly interlayed plutonic phases. These were intruded by later phases ranging from predominantly trondhjemite to syenite and diorite in composition. Only the border phases were mapped.

Structural Geology

Supracrustal rocks in the map-area strike east to northeast and are steeply to vertically dipping.

The axial plane trace of a major antiformal structure lies along the approximate centre of Gibi Lake. Subsidiary parallel antiformal and synformal structures are also present. Top indicators in the form of graded bedding, flame structures and vesicular pillowed flows are often inconsistent with one another due to small scale isoclinal folding that could not be traced out at the present map scale.

Locally the metasediments appear to have suffered both soft-sedimentary deformation and later tectonic folding. Late brittle fracturing is indicated by pseudotachylite developed in the metasediments.

Brown (1976) has completed a structural study of the west half of the present map-area and an adjacent area to the west.

The author has tentatively interpreted the stratigraphy as being comprised of a lower mafic metavolcanic sequence (Dogtooth Lake Sequence) overlain by metasediments and an upper sequence of mixed fragmentals and minor flows (Gibi Lake Sequence).

Economic Geology

Gold prospects (Triggs and Stella prospects) occur in quartz veins along shear zones within the mafic metavolcanic Dogtooth Lake Sequence. Diamond-drilling of this sequence was carried out by Rexora Mining Corporation Limited in 1953[1], E.J. Stone in 1960[1], Macassa Mines Limited in 1961[2], D. Schack and A. Jensen (Olympia Gold Mines Limited) in 1970[2] and Dome Exploration (Canada) Limited in 1973-1974[2]. The work indicated trace amounts of Au, Ag, Cu, Ni and Zn in several conductors consisting of siliceous shear zones and cherty, locally graphitic, pyrite- and pyrrhotite-bearing tuffaceous and sedimentary interflow units. The distribution of the mineralization suggests that, originally, it may have been stratigraphically controlled, with subsequent mobilization and emplacement along late fractures. Detailed mapping was done by the field party in the vicinity of the Triggs and Stella prospects and near Kite Lake on the former Rexora Mining Corporation Limited property.

Extensive tourmalinization is present within the northern part of the metavolcanic-metasedimentary assemblage. The tourmaline occurs as massive pods and as joint and fracture fillings in the pyroxenites and mafic metavolcanics. Quartz-tourmaline veins containing minor sulphide minerals occur in both the mafic metavolcanics and metasediments. The tourmaline may have originated as detrital tourmaline in the metasediments, subsequently being driven off in solution and redeposited during metamorphism. The tourmalinization, the intense deformation and the indication of extensive solution movement through the mafic metavolcanics and pyroxenites, which locally transformed them into biotite schists, suggests that this area should be prospected for areas of potential gold mineralization.

Drilling of conductors by Dome Exploration (Canada) Limited[1] in 1973 and 1974, within the intermediate to felsic fragmental sequence, picked up traces of Cu, Zn and Pb in intercalated intermediate to felsic tuffs and pelitic graphite-bearing sediments.

Several pegmatites, similar to those described by Breaks *et al.* (1978) and postulated to be of diatexitic origin, were observed within metasediments at the margin of the Dryberry Batholith south of Gibi Lake. In addition to potassium feldspar, plagioclase and quartz, these pegmatites contain yellow-green muscovite, magnetite, garnet, apatite, tourmaline and yellow and green beryl. Exploration should be directed toward the zone containing these pegmatites as a potential source of lithium, beryllium, and such associated elements as cesium, tantalum and, possibly, tin.

Titano-magnetite and apatite cumulate segregations were observed in the layered ultramafic to mafic intrusion west of Dogtooth Lake. The occurrence of cumulate mineralogies indicates that this body should be checked for

[1]Regional Geologist's files, Ontario Ministry of Natural Resources, Kenora.

[2]Assessment Files Research Office, Ontario Geological Survey, Toronto.

nickel, copper and platinum. Gold mineralization is also of potential interest since the body has been intensely deformed and altered.

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No. 5 Kawashegamuk Lake Area, District of Kenora

C.E. Blackburn[1]

Location

Kawashegamuk Lake lies about 30 km southeast of Dryden. The map-area is bounded by Latitudes 49°22'30" and 49°33'N and Longitudes 92°15' and 92°30'W, and covers approximately 300 km². Approximately two-thirds of this area has been mapped during the 1979 and 1980 field seasons.

Access to the map-area is facilitated by two gravel roads. A lumber road, currently in use by Reed Paper Company of Dryden, leaves Highway 17 at Jackfish Lake, approximately 10 km east of Dinorwic. This road gives access to the western part of the map-area and to Stormy Lake. A township road that leaves Highway 17 at Borups Corner gives access to the eastern part of the map-area and to Kawashegamuk Lake.

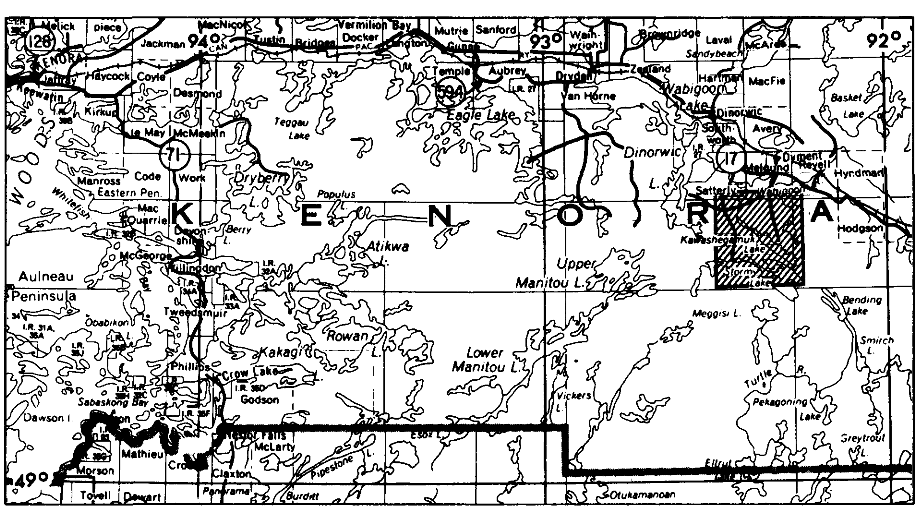
Mineral Exploration

The Manitou-Stormy Lakes area, of which Kawashegamuk Lake is a part, was the scene of considerable gold prospecting and mining activity during the period 1895 to 1912, and again in the 1930s (Thomson 1933). Most of the activity centred around the Manitou Lakes in the west and north of Kawashegamuk Lake in the east. The only deposit to attain significant production in the eastern area was the Sakoose Mine, from which, during the period 1890 to 1947, 3,669 ounces of gold and 145 ounces of silver were produced (Beard and Garratt 1976). The Tabor Lake prospect reportedly produced 36 ounces of gold and 4 ounces of silver in 1935 (Beard and Garratt 1976). Patents on both of these former properties have been cancelled.

In the 1950s, as part of exploration programs following discovery and development of copper and nickel deposits elsewhere in the Kenora District, the Canadian Nickel Company Limited and Falconbridge Nickel Mines Limited conducted geophysical surveys and drilling programs in the map-area. In 1952, the former company examined a gabbro body (Thomson 1933) on the northeast shore of Kawashegamuk Lake that reportedly hosted chalcopyrite and nickeliferous pyrrhotite. In 1957, Falconbridge carried out investigations at Church Lake and near the gabbro body previously investigated by the Canadian Nickel Company Limited (Assessment Files Research Office, Ontario Geological Survey, Toronto).

In 1965 and 1966, Dome Exploration (Canada) Limited carried out geochemical soil sampling, trenching and 1,710 feet of diamond-drilling on a molybdenite prospect between Mennin and Oldberg Lakes (Assessment

[1]Central Archean Subsection Leader, Precambrian Geology Section, Ontario Geological Survey, Toronto.



LOCATION MAP

Scale: 1:1 584 000 or 1 inch to 25 miles

Files Research Office, Ontario Geological Survey, Toronto).

Discovery of the copper-zinc-lead deposits at Sturgeon Lake in 1969 heightened interest in this part of northwestern Ontario. As a result, a number of companies have carried out airborne geophysical surveys over the Manitou-Stormy Lakes area. Two general parts of the Kawashegamuk Lake map-area received considerable ground follow-up. The first is located northeast of the east end of Boyer Lake in the northwestern part of the area; Asarco Exploration Company of Canada Limited (in 1970-71), Newmont Mining Corporation of Canada Limited (in 1975) and Selco Mining Corporation Limited (in 1976) reported having diamond-drilled a total of four holes (Assessment Files Research Office, Ontario Geological Survey, Toronto). The second is located between Church Lake and the southern boundary of Melgund Township in the north-central part of the map-area; Lynx Canada Exploration Limited–Dejour Mines Limited (in 1970), Newmont Mining Corporation of Canada Limited (in 1974), Hudson Bay Exploration and Development Company Limited (about 1974) and Selco Mining Corporation Limited (in 1977-78) are known to have drilled a total of nine holes (Assessment Files Research Office, Ontario Geological Survey, Toronto).

During the winter of 1979-80, St. Joseph Exploration Limited conducted ground geophysical surveys and diamond-drilled four holes on its newly acquired gold property at Tabor Lake. The company carried out geological mapping and geochemical sampling for gold mineralization during the 1980 field season.

As follow-up to a regional exploration program in the general Kawashegamuk Lake area commenced in 1979, Falconbridge Copper Limited carried out a detailed geochemical sampling program for gold mineralization on newly acquired property adjoining that of St. Joseph Exploration Limited west of Tabor Lake.

General Geology

The Kawashegamuk Lake area was previously mapped by Thomson (1933) as part of a reconnaissance survey extending from Lower Manitou Lake to Stormy Lake. The geology, as delineated by Thomson's survey, is incorporated in the current Kenora-Fort Frances compilation map (Davies and Pryslak 1967). The present map-area was also investigated (see Blackburn *in* Trowell *et al.* 1977) as part of a regional study (Trowell *et al.* 1980), and resulting modifications to Thomson's interpretation are included in the revised Kenora-Fort Frances compilation map (Blackburn *et al.*, in preparation). The present survey is part of a continuing program of 1:15 840 (1 inch to 1/4 mile) scale mapping (Blackburn 1976, 1979a, b) and also adjoins, on its north side, detailed mapping by Satterly (1960).

The present map-area is situated on the northeastern side of the Manitou-Stormy Lakes metavolcanic-metasedimentary belt and straddles the major east- to southeast-trending Kamanatogama Syncline.

The following discussion incorporates the mapping results from the 1979 (Blackburn 1979c) and 1980 field seasons.

Synoptic mapping (Blackburn 1980a) west of the current map-area has led to the establishment of three stratigraphic groups of supracrustal rocks, namely the Wapageisi Lake Group, the Stormy Lake Group and the Boyer Lake Group, that have been traced into this area.

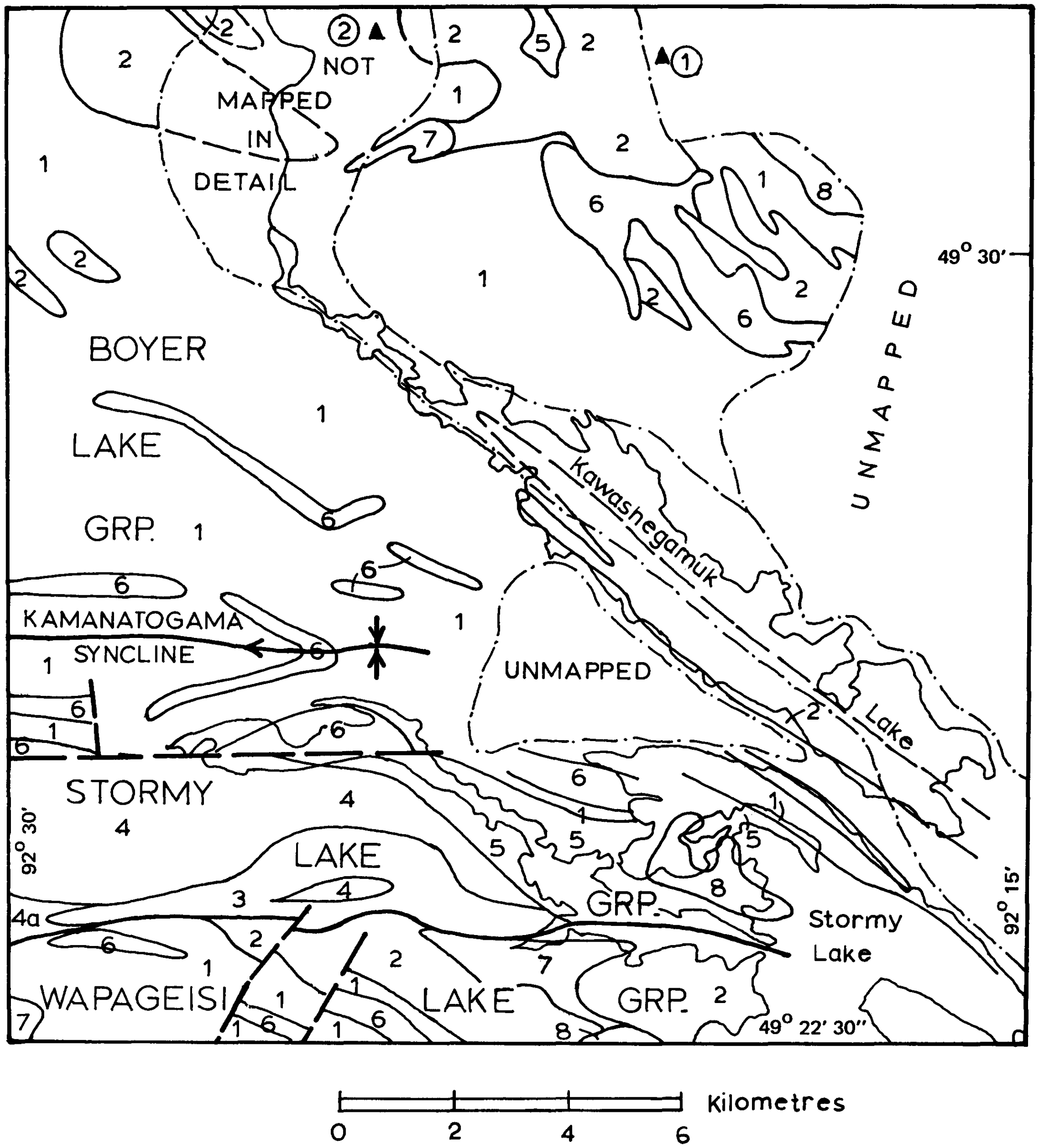
The Wapageisi Lake Group stratigraphically underlies the Stormy Lake Group and faces homoclinally north-northeast. Within the map-area (Figure 1), it is comprised of pillowed mafic flows that are intruded by gabbroic sills and an overlying sequence of intermediate and felsic pyroclastics. A subvolcanic felsic porphyry intrusion into this latter sequence appears to be the root of felsic flows at Gawiewiagwa Lake.

The unconformably overlying Stormy Lake Group also faces north to north-northeast. In the west its basal portion is characteristically polymictic conglomerate with clasts of felsic to mafic volcanic rocks, granitoid rocks, magnetite and hematite ironstone, and chert. Overlying volcanic-clast conglomerates are mostly devoid of granitoid and chemical sedimentary clasts. They represent shallow subaqueous slumping of partially lithified pyroclastic material, as indicated by minor, intercalated, highly amygdaloidal, pillowed flows.

In the east, at Stormy Lake, the Stormy Lake Group is composed of sandstones and siltstones of turbidite facies, probably transitional from the conglomeratic facies in the west, and transitional eastward into more distal turbidites, located at Bending Lake, that contain abundant intercalated magnetite ironstone beds (Trowell *et al.* 1980).

The Boyer Lake Group, which is folded about the Kamanatogama Syncline, is composed of a thick sequence of pillowed mafic volcanics intruded by gabbroic sills. Its relationship to underlying sequences, both the Stormy Lake Group and those northeast of Kawashegamuk Lake, is problematical. The author (Blackburn 1979b, 1980a, 1980b; Blackburn *in* Trowell *et al.* 1980) has interpreted the Boyer Lake Group as being in fault contact with the Stormy Lake group. However, the contact may be an unconformity.

An as yet unnamed sequence of metavolcanics northeast of Kawashegamuk Lake faces homoclinally southwest. Its contact with the overlying Boyer Lake Group, from the limited number of places where it has been observed, appears to be conformable. Basal mafic metavolcanics in the northeast are intruded, at their base, by granitic rocks of the Revell Batholith (Satterly 1960). Overlying felsic pyroclastics vary from coarse monolithic breccias in the north to tuffs in the southeast, where minor clastic and chemical sedimentary rocks are interbedded. Their relationship to felsic porphyry in the west is presently uncertain. The felsic pyroclastic unit is not delineated on Thomson's (1933) map, which shows basic volcanic rocks as does the currently available compilation map (Davies and Pryslak 1967). The felsic pyroclastics are intruded by irregular felsic porphyry dikes in the southeast. Preliminary chemical analyses indicate that overlying mafic metavolcanics are andesitic. An irregular



LEGEND

1	Mafic metavolcanics	6	Gabbros
2	Intermediate and felsic metavolcanics	7	Felsic hypabysal rocks
3	Polymictic conglomerate	8	Granitoid rocks
4	Volcanic clast conglomerate-intermediate composition		
4a	Felsic composition		
5	Sandstones and mudstones		

PROPERTIES

1 Sakoose Mine, Au

2 Tabor Lake prospect, Au

Figure 1 — Generalized geology of the Kawashegamuk Lake area.

gabbroic body intrudes the metavolcanic sequence at Church and Lowery Lakes.

Structural Geology

The Kawashegamuk Lake area straddles a major east- to southeast-trending syncline, previously shown on compilation maps (Davies and Pryslak, 1967) and confirmed, but relocated, during regional studies by the present author (see Blackburn *in* Trowell *et al.* 1977). This has been named the Kamanatogama Syncline (Blackburn 1980a).

A previously recognized fault, the Mosher Bay-Washeibemaga Lake Fault (Blackburn 1979b, 1980a, 1980b) extends from the west into the map-area and defines the contact between the Stormy Lake and Boyer Lake Groups. However, further east this contact may not be fault-defined.

No other major faults or folds have been recognized.

Economic Geology

Discussion of deposits of and potential for gold, copper-zinc, copper-nickel, and molybdenum mineralization in the map-area has been given previously (Blackburn 1979c). Additional observations on potential for gold mineralization are given below.

Gold

Geological reports, mostly dating from the 1930s and 1940s, by government and company geologists on the Sakoose and Tabor Lake properties, suggest that gold-bearing solutions originated from quartz porphyries in close spatial association with the deposits. Quartz veins reportedly filled fractures that pre-dated or were opened up contemporaneously with intrusion of the porphyries. The assumption was also made that the porphyries were contemporaneous with batholithic invasion. The present mapping has shown that, in addition to the presence of numerous quartz-feldspar porphyry bodies in the vicinity and west of the Tabor Lake prospect, mafic and felsic volcanics have been pervasively carbonatized and silicified. Exploration attention is currently being directed toward this environment and locality by St. Joseph Exploration Limited and Falconbridge Copper Limited.

The author has previously (Blackburn 1979a, 1980a) suggested that the vicinity of the Thundercloud Lake Porphyry, a portion of which outcrops in the extreme southwestern part of the map-area, may be a good area of exploration for gold. Present mapping has revealed fuchsite, a common associate of gold mineralization, to be widely disseminated within metasediments near the base of the Stormy Lake Group in this part of the map-area, and to occur in felsic pyroclastics and flows at the top of the Wapageisi Lake Group, immediately below these metasediments. It is therefore suggested that gold exploration might be concentrated near this unconformity.

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No. 6 Parnes Lake Area, District of Kenora

A.A. Speed[1]

Location and Access

The Parnes Lake map-area is bounded by Latitudes 49°50′ and 49°58′30′′N and Longitudes 91°45′ and 92°00′W. It includes most of NTS sheet 52 G/13 and covers an area of approximately 280 km^2. Sioux Lookout is 16 km north of the centre of the map-area.

The northern part of the map-area is accessible mainly by boat. At the present time, the southern portions of the area can be reached only by float-plane or canoe portaging. A gravel logging road (Basket Lake Road) provides access to Amik Lake from Highway 17. A proposed extension of the Great Lakes Forest Products Camp 328 road system (Bark Lake Road) will provide limited access to the central portion of the map-area.

History of Mineral Exploration

Earliest accounts of mineral exploration date back to the late 1890s and early 1900s, principally in connection with the search for gold. A number of old gold prospects are located within the map-area, but most work was done on the Sykes Mine mining location SV105 (patented claim), located at the southeastern corner of Twin Bay between Twinflower Lake and Parnes Lake. A 110-foot shaft was sunk on a shear-zone, with crosscuts driven at two levels; a mill and other machinery was set up on the property. Operations were suspended in the year 1900.

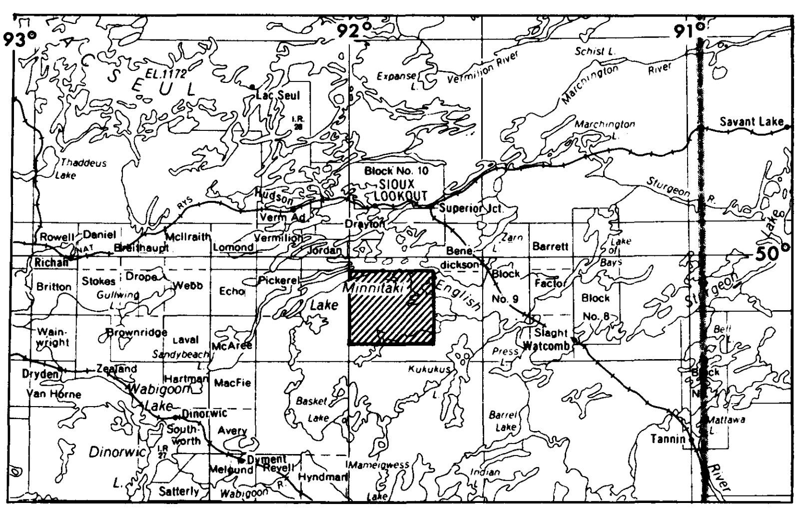
In 1951 Kelore Mines Limited carried out geological and magnetometer surveys on two groups of claims in a search for gold mineralization[2]. The first group covered the area between Twinflower Lake and Parnes Lake, including the old Sykes Mine (SV105), and the other was located north and west of Twin Bay.

A number of iron prospects have been known since the early 1900s. One deposit, located between Twin Bay and the northwestern shore of Minnitaki Lake, is highly siliceous, relatively low in iron, ranges in width from a few feet to 250 feet, and consists of highly contorted bands of grey chert, magnetite, jasper and slate. Magnetite bands vary from a fraction of an inch up to 6 inches in width. No grades or tonnages have been reported for this deposit[2].

A second iron property covered the iron formation south of Minnitaki Lake that extends from Redpine Bay to Twin Bay and the northwestern part of Southeast Bay. This property originally consisted of 159 contiguous un-

[1]Resource Geologist, Ontario Ministry of Natural Resources, Sioux Lookout.

[2]Resident Geologist's files, Ontario Ministry of Natural Resources, Sioux Lookout.



LOCATION MAP

Scale: 1: 1 584 000 or 1 inch to 25 miles

patented mining claims staked in 1961 by the Minnitaki Iron Range Limited. A magnetometer survey and diamond-drill program was conducted by the company and completed in 1965 between Twill Lake and Little Goose Lake. The magnetic survey indicated that the iron formation was widest in this "Main Zone", about 800 feet wide over a distance of 3,000 feet, the thickening being the result of repetition by folding. As a result of the diamond-drilling, preliminary estimates indicated about 200,000 tons per vertical foot with assays of drill core sections averaging 18 to 19 percent acid-soluble Fe. No sampling or drilling has been done on the iron formation to the west of the main zone, where maximum widths are about 400 feet[1].

Base-metal exploration in the map-area was not conducted to any great extent until the early 1970s, when Denison Mines Limited - Goldray Mines Limited and Selco Exploration Company Limited (1971-73) and Geophysical Engineering Limited (1977) explored the intermediate to felsic pyroclastic rocks in the Southeast Bay area[1].

General Geology

The Parnes Lake area adjoins areas mapped by Johnston (1969, 1972) and constitutes a portion of a metasedimentary-metavolcanic belt of Early Precambrian age bordered on the south by granitoid intrusive rocks. Approximately half the map-area is underlain by mafic and intermediate to felsic metavolcanics, one-quarter by metasediments, and the remainder by granitoid and pegmatitic rocks.

The Central Volcanic Belt (Turner and Walker 1973) consists of equal amounts of mafic flows and autoclastic and pyroclastic fragmental rocks.

The Southern Volcanic Belt (Turner and Walker 1973) consists mainly of mafic metavolcanics, mostly massive flows, pillow lava, amygdaloidal/vesicular flows and rare porphyritic flows. Intermediate to felsic tuffs and tuff-breccias occur in the northeastern part of Southeast Bay and extend eastward out of the map-area along the Tata River.

Clastic metasediments of the Minnitaki Group (Walker and Pettijohn 1971), which overlie the volcanic rocks, consist of sandstone, wacke, siltstone, mudstone, arkose, arenite and volcanogenic conglomerate.

A zone of chemical metasediments, consisting of chert and hematite-quartz-magnetite ironstone interbedded with the above-mentioned clastic metasediments, extends intermittently from the western portion of the map-area through to the eastern shore of Southeast Bay.

The granitoid rocks in the southern portion of the map-area consist of foliated biotite granodiorite cut by late pegmatite dikes.

Structural Geology

Structural interpretation is taken mainly from Trowell *et al.* (1980) and previous interpretations by Pettijohn (1936), Walker and Pettijohn (1971), Johnston (1972), and Page and Clifford (1977).

The contacts between the major lithologic groups (Central Volcanic Belt, Minnitaki Group, and Southern Volcanic Belt) are defined by east- to northeast-trending faults. North- to northeast-trending, presumably later faults transect the east- to northeast-trending faults and the major east-trending folds.

The Twinflower Lake-Twin Bay Fault and the Southeast Bay Fault are newly reported by Trowell *et al.* (1980). The Twinflower Lake - Twin Bay Fault, in part, separates the Minnitaki Group of metasediments and the Southern Volcanic Belt. Rocks exposed along and near this feature are highly sheared and contain carbonate and quartz-carbonate veins and veinlets locally carrying pyrite and possibly gold.

The Southeast Bay Fault is interpreted by Trowell *et al.* (1980) to trend north through the central part of Southeast Bay. Rock units, specifically the intermediate to felsic pyroclastic rocks to the east and the metasediments of the Minnitaki Group to the west, end abruptly in central Southeast Bay. Correlation with aeromagnetic data (Ontario Department of Mines-Geological Survey of Canada 1961) also supports this interpretation.

Economic Geology

As noted by Trowell *et al.* (1980) and corroborated here, gold mineralization within and adjacent to the immediate map-area appears to be controlled by shear zones within mafic volcanic rocks. The only occurrence of visible gold was reported by Kelore Mines Limited (1951)[1] on patented claim SV105, in a shear zone located south of the old Sykes Mine shaft on which a number of trenches had been excavated. No assay values are available from this property.

Base-metal mineralization in the map-area occurs as disseminated to thin, massive zones of pyrite and/or pyrrhotite and/or graphite, with small concentrations of chalcopyrite and sphalerite. The only mineralization of this type tested to date occurs in the Southeast Bay area of Minnitaki Lake where intermediate to felsic metavolcanics occur.

Since mapping during the 1980 field season was confined to the northern half of the map-area, little is known of the potential for lithophile elements in the granite and pegmatite bodies which are situated in the southern part of the area.

Recommendations for Exploration

Copper-Zinc-Lead

To date, diamond-drilling to test sulphide conductors in the Southeast Bay pyroclastic unit has not been encour-

[1]Resident Geologist's files, Ontario Ministry of Natural Resources, Sioux Lookout.

aging. This area is still considered to have potential for massive sulphide (copper-zinc-lead) deposits because of the volcanic environment, but not all known conductors appear to have been tested by diamond-drilling. There are no indications that the mafic volcanic rocks west of Southeast Bay have been extensively explored by geophysical methods or diamond-drilling for possible base-metal mineralization. It is suggested that both the above mentioned areas be explored for possible massive sulphide deposits.

Gold

Because the known gold mineralization appears to be structurally controlled, occurring near or within east- to northeast-trending shear zones and near the contact between the Minnitaki Group of metasediments and the mafic volcanic rocks of the Southern Volcanic Unit, exploration for gold should be concentrated in these areas.

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No. 7 Felsic Centres of Volcanism, Uchi and Gods Lake Subprovinces, Northwestern Ontario

P.C. Thurston[1]

Introduction

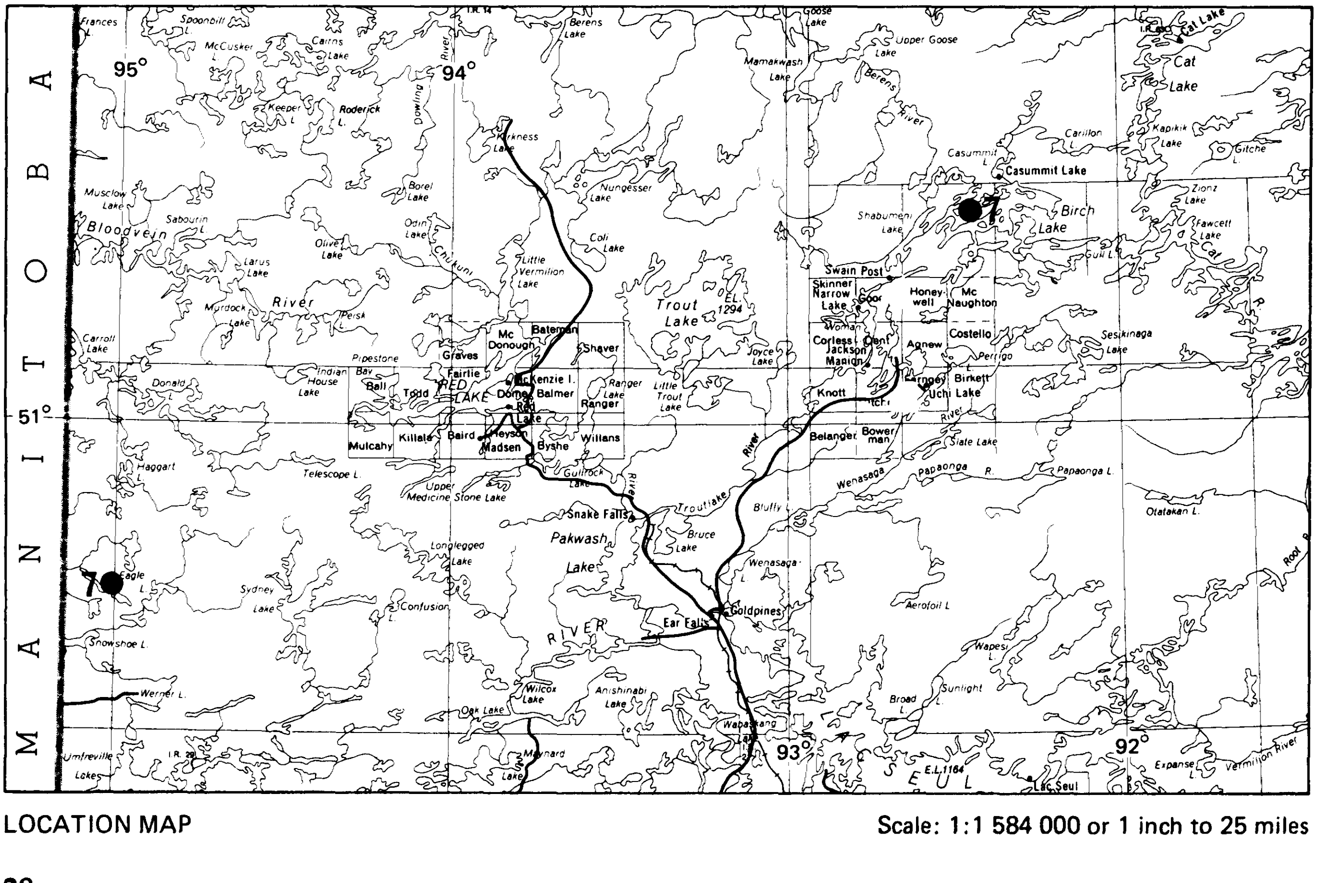
This year's field work is part of a continuing project having as its objective an assessment of the economic potential of centres of felsic volcanism within the Uchi and Gods Lake Subprovinces. Mapping of felsic volcanic rocks is being carried out in order to describe the style of volcanism, the stratigraphy of the resulting accumulation of felsic volcanic rocks and associated rock types, and the probable environment of deposition. Chemical sampling of the felsic volcanic rocks has yielded some preliminary results, previously described by the author (Thurston 1980a), which will be summarized here as they may be of economic significance.

[1]Northern Archean Subsection Leader, Precambrian Geology Section, Ontario Geological Survey, Toronto.

General Geology

1) Birch Lake area

The area lies 106 km northeast of Red Lake. Access is via float-equipped aircraft from Red Lake or Ear Falls. All bedrock in the area is Early Precambrian in age and part of the Birch-Uchi Lakes metavolcanic-metasedimentary belt within the Uchi Subprovince (Ayres *et al.* 1971). Previous mapping has been conducted by Horwood (1937), Harding (1936), Goodwin (1967) and Thurston (1977, 1978, 1980a).



LOCATION MAP

Scale: 1:1 584 000 or 1 inch to 25 miles

The area examined was the sequence of felsic flows and pyroclastic rocks located northeast of the central part of Birch Lake. While the author did not previously attempt to place the stratigraphy of this map-area within the stratigraphic scheme of three mafic to felsic cycles proposed by Pryslak (1971), it is now possible to correlate this occurrence of felsic subvolcanic rocks with cycle II volcanism south of the Swain Lake fault. Mapping was designed solely to provide more details on this occurrence.

Stratigraphically, the sequence consists of felsic lapilli-tuff and tuff-breccia with minor interbedded tuffs underlying felsic flows and flow breccia. The pyroclastic rocks contain abundant pumiceous clasts and lithic clasts in a relict ash matrix. Primary structures in the pyroclastic rocks include the presence of cross-bedding in a 10 to 30 m thick basal lapilli-tuff, which is overlain by lapilli-tuff to tuff with poorly developed reverse grading i.e. pumice-rich upper portion with more abundant lithic fragments at the base of the unit. No deformation or recrystallization of fragments due to welding was observed. The pyroclastic rocks are overlain by massive and brecciated facies of felsic flows ranging in thickness from 3 to 60 m. Each flow is generally capped by a 1 to 6 m thickness of felsic hyaloclastite. The existence of the massive facies of flow rocks and the presence of cross-bedded basal tuff deposited by a base surge eruption mechanism suggest a relatively proximal environment. The lack of welding and the presence of hyaloclastic debris suggests subaqueous deposition.

2) Bee Lake Area

This area lies 95 km southwest of Red Lake and is accessible from Red Lake or Ear Falls via float-equipped aircraft. Previous mapping in the area includes Shklanka (1967), Burwash (1923), Gilbert (1928), Thomson (1946) and in the adjacent area of Manitoba, Stockwell and Lord (1939) and Weber (1971). The area forms the eastern extremity of the Long Lake portion of the Rice Lake Group metavolcanic-metasedimentary belt which lies in the southern portion of the Uchi Subprovince (Ayres *et al.* 1971). Shklanka (1967, p.6) described the sequence from north to south as felsic tuff succeeded by metasediments consisting of "interbedded acid tuffs and biotite feldspar quartzite" with local "phyllite and tuffaceous quartzite"; arkose and arkosic conglomerate followed by felsic flows and pyroclastic rocks and mafic flows.

A preliminary examination of the sequence, involving the shoreline geology of Bee Lake, Anderson Lake, Rickaby Lake and Wingiskus Lake, with some work inland south of the west end of Bee Lake, has suggested several modifications of Shklanka's (1967) work. The "felsic tuffs" at the northwest end of Bee Lake appear to represent hypabyssal intrusive rocks of trondhjemitic composition with zones of brecciation caused by late stage activity. South of the metasediments on Bee Lake, the sequence consists of felsic lapilli-tuff, tuff-breccia and tuff. Organization of individual units 30 to 150 m thick suggests that they represent ash flows, since they contain abundant pumice and display reverse grading, lack of bedding and some evidence of welding in the form of elongation and recrystallization of pumiceous clasts. Rhyolitic ash flows, 240 m thick and immediately above the metasediments, are succeeded by a relatively thin 30 to 60 m andesitic ash flow which contains a mafic pumice-rich upper portion. This is succeeded upward by about 200 m of mafic pillowed flow and mafic hyaloclastite. Overlying these are felsic ash flows without obvious welding, with individual units being 60 to 100 m thick; these have an aggregate thickness of about 600 m, contain minor intercalated pyritic wacke and mudstone, and are overlain by pillowed mafic flows. This sequence is succeeded on the shore of Wingiskus Lake by felsic lapilli-tuff to tuff-breccia with abundant pumice, no bedding, reverse grading, welding and recrystallization of pumice fragments, all of which suggest subaerial deposition. The unit can be traced west to the south shore of Rickaby Lake, where it consists of felsic tuff-breccia of uncertain origin.

Northeast-trending faulting appears to be important in the area, in that units as defined above cannot be traced laterally. For example, the area south of the west end of Bee Lake consists of white-weathering epidote-, tremolite- and carbonate-rich pillowed mafic flows similar to those described by the author in the Confederation Lake area (Thurston 1978).

The structure is apparently a south-facing, slightly overturned homoclinal sequence. Application of the concept of structural facing (Borradaile 1976) suggests that the area may represent the basal portion of a nappe. However further work on both the stratigraphy and structure of this area is required before any conclusions can be drawn.

Economic Geology

Work on the felsic metavolcanics of the Confederation Lakes area (Thurston 1980) suggested that rare earth elements may serve to indicate whether hydrothermal alteration of felsic metavolcanics has occurred. Therefore, samples from known mineralized and unmineralized felsic metavolcanics in the Abitibi Subprovince were sampled for corroboration of this hypothesis. These results, which will appear in more complete form in a forthcoming publication (Thurston 1980b), are summarized below.

Evaluation of the mineral potential of Archean felsic volcanic rocks by lithogeochemical methods has involved trace elenents (Zn, S, Cu) and major elements (Mg, Na, K, Fe). Most methods applied in the Canadian Shield have involved analyses of large numbers of samples, followed by statistical evaluation to separate effects of normal igneous fractionation from chemical changes brought about during formation of volcanogenic massive sulphide bodies. Trace elements such as Nb, Y, Zr, Cr, and Ni and rare earth elements (REE) are generally considered to be less mobile than the major and trace elements previously used in economic evaluation of felsic volcanic rocks. Therefore, data on the abundance of REE would more readily separate effects of igneous fractionation from mineralizing events.

Seventy-five samples from three superimposed basalt to rhyolite volcanic cycles in the Uchi Lake area of northwestern Ontario have been analyzed for Nb, Zr, Y and the REE. The basalts are of tholeiitic affinity and the overlying felsic rocks of each cycle are of calc-alkaline affinity. The Uchi Lake results have been compared to 18 new analyses of samples of unmineralized tholeiitic rhyolites, and mineralized and unmineralized calc-alkaline rhyolites from the Abitibi Belt of northeastern Ontario. The results are listed in Table 1.

Interpretation

The conventional fractionated REE patterns are interpreted in terms of partial melting of amphibolites and/or magma mixing. The puzzling feature of unfractionated REE patterns in rhyolites associated with volcanogenic massive sulphide deposits can be explained by complexing of heavy rare earths in carbonate-rich fluids circulating through the volcanic pile during the mineralizing event. Alternatively, the calc-alkaline rhyolites associated with the mineralization in the Uchi Lake area are underlain by variolitic, highly fractionated basalts with a pronounced andesite gap. Analysis of the variolites reveals a similar unfractionated pattern, suggesting that the lack of fractionation of REE in the felsic rocks may be related to production of felsic magmas by liquid immiscibility. The immiscibility event may have produced a carbonate-rich fluid phase capable of complexing heavy rare earths and producing economic mineral concentrations. Work is continuing in order to establish the general applicability of contrasted REE patterns in characterizing mineral potential.

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TABLE 1: RARE EARTH ELEMENT (REE) CHONDRITE NORMALIZED VALUES[1]

Area	Rock Units	Light	Heavy	Pattern	Comments
Uchi Lake	Cycle I Rhyolites[2]	20-100	2-4	Highly Fractionated	Unmineralized
	Cycle II Rhyolites[2]	50-150	2-40	Fractionated	Unmineralized
	Cycle III Rhyolites[2]	120-240	53-100	Unfractionated	
Kamiskotia	Lower Super-Group[3] Calc. alk. Rhyolites	100-135	30-50	Unfractionated	Mineralized
	Upper Super-Group[3] Tholeiitic Rhyolite	80	25-30	Unfractionated	Unmineralized

[1]Values shown are derived by comparison of sample content with average chondrite content REE and represent Sample/Chondrite.
[2]Thurston (1977, 1980).
[3]Pyke (1978).

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No. 8 Calm Lake Area, District of Rainy River

S.L. Fumerton[1]

Location and Access

The area mapped is bounded by Latitudes 48°42'30" and 48°50'N, and Longitudes 92°00' and 92°17'W. It covers parts of NTS Sheets 52 C/9 and 52 C/16, and includes parts of Bennett, Tanner and Asmussen Townships. Flanders, an abandoned settlement, is located within the map-area and the nearest town, Mine Centre, lies some 25 km west of the western boundary. Atikokan is approximately 30 km east of the eastern boundary. Highway 11, joining Thunder Bay, Atikokan and Fort Francis, passes through the southern part of the area. Most of the map-area is easily accessible by motor vehicle or boat, except the northwest corner which is only accessible via the Little Turtle River from a point 10 km downstream from the map-area.

History of Mineral Exploration

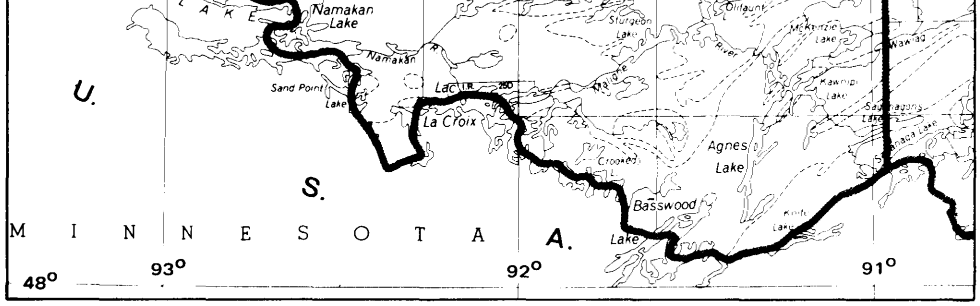
At the end of the last century, gold was discovered in the area and since then has been the principal target of exploration.

[1]Geologist, Precambrian Geology Section, Ontario Geological Survey, Toronto.

The Independence Mine, operated by the Independence Mining and Development Company, was in production for only one year (1898), during which period 125 tons of ore worth $1,906 were milled (Ferguson *et al.* 1971). The mine consisted of three shafts located about 1.6 km north of Bennett Lake and an adit on the lake shore.

Commencing in 1936, when Red Cedar Lake Gold Mines Limited discovered gold, extensive trenching and drilling has been carried out on the Red Cedar prospect adjacent to the Independence Mine. Further work on this prospect has been carried out by Sylvanite Gold Mines Limited in 1940, Jacobus Mining Corporation Limited in 1958, Turbenn Minerals Limited in 1960, E. Corrigan in 1971, E. Rivers in 1973, and International Chemalloy Corporation in 1974.

Periodic work, including trenching, drilling and geological mapping, has been carried out at the Mayflower prospect since gold was discovered there in 1901 by the Rainy River Development Company of London Limited. The work was done by Mayflower Gold Mines Limited in 1928, Animikie Mines Limited in 1936, Andowan Mines Limited in 1945, Freeport Exploration Company in 1946, Kerr Addison Mines Limited in 1976, and Corporation Oil and Gas in 1979.



LOCATION MAP

Scale: 1: 1 584 000 or 1 inch to 25 miles

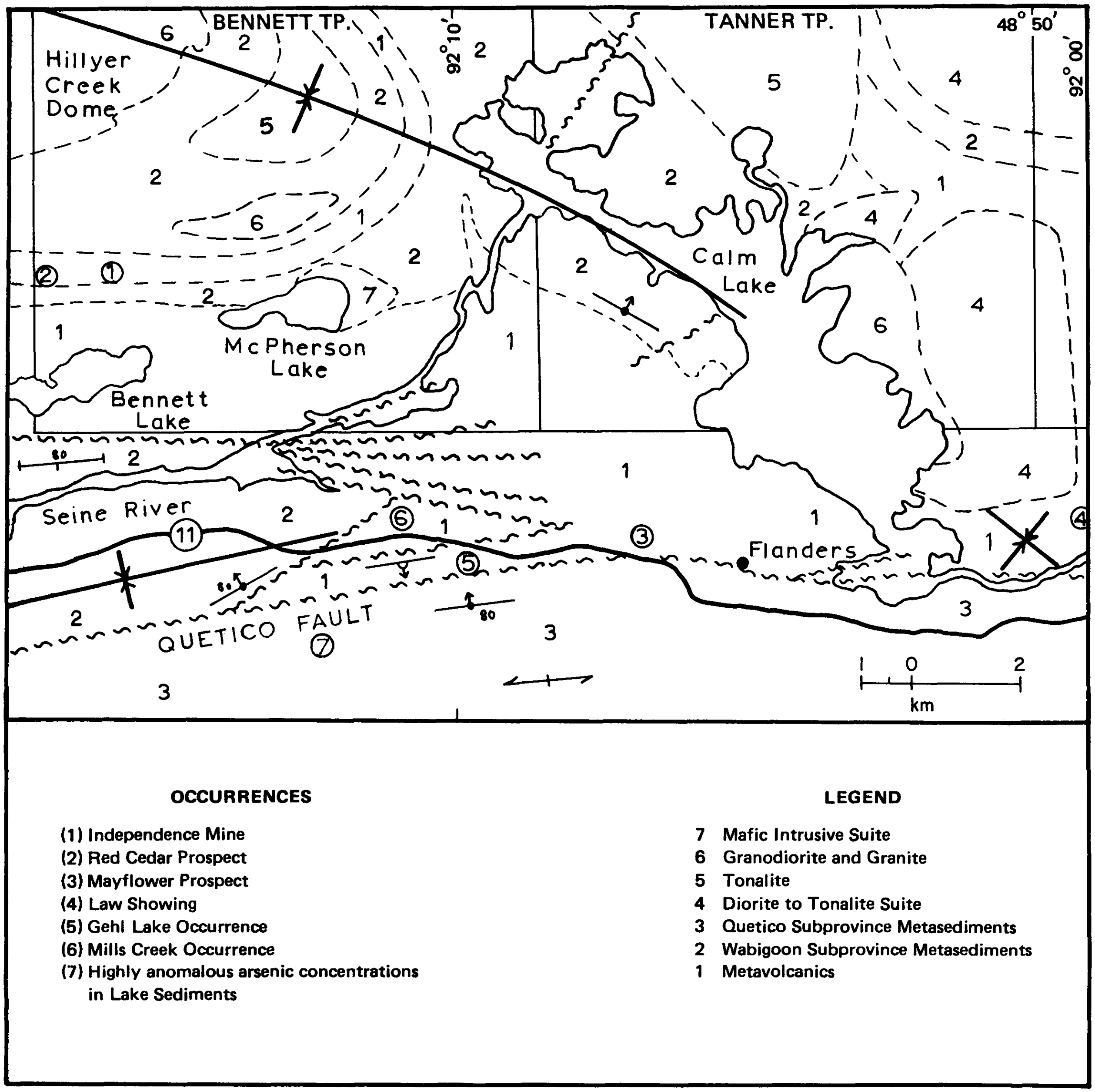


Figure 1 — Generalized geology of the Calm Lake area.

Economic Geology

Four gold occurrences are known in the map-area: 1) Independence Mine, 2) Red Cedar prospect, 3) Mayflower prospect, and 4) Law occurrence.

The principal workings of the Independence Mine exploited narrow and discontinuous quartz veins in a quartz crystal tuff. Variable amounts of pyrite occur in the quartz veins, and short stringers of pyrite with some chalcopyrite occur in the adjacent host rock. Bow (1899) reported alleged Au values of 0.39 ounce per ton in the host rock adjacent to the main quartz vein, which contained erratic Au values of up to 7.76 ounces per ton.The Independence Mining and Development Company also developed a 4 m adit on the north shore of Bennett Lake to exploit a 1 m thick quartz vein within a quartz porphyry. However, Au values were reportedly low and no production was realized (Bow 1899).

During 1956 geological mapping and a ground magnetometer survey were carried out by Moneta Porcupine Mines Limited on the Law Lake copper-gold prospect and in 1976 this property was diamond-drilled by Cominco Limited. In 1976, Canadian Nickel Company Limited drilled a hole near Fin Bay off the Seine River to test a minor sulphide occurrence. Shell Canada Resources Limited carried out reconnaissance exploration in 1979 for base metals over most of the map-area, and conducted a ground magnetometer survey in the vicinity of Banning Narrows on the Seine River.

Exploration for iron, which involved 3120 m of diamond-drilling in eight holes to test magnetite ironstones, was done in 1956 by R.R. Brown and Associates in the centre of Calm Lake. Steep Rock Iron Mines Limited has periodically investigated the banded magnetite ironstones in the area over the last thirty years.

As part of a study of gold mineralization in the Atikokan area, Wilkinson (1979, 1980) inspected the Mayflower prospect.

General Geology

The area is located astride the boundary between the Quetico Subprovince to the south and the Wabigoon Subprovince to the north. All outcrops mapped within the Quetico Subprovince consist of a monotonous sequence of metasediments, whereas the Wabigoon Subprovince within the map-area is composed of metavolcanics and metasediments which have been intruded by a number of granitic bodies. The map-area coincides, in large part, with that mapped by Young (1960).

Metasediments of the Quetico Subprovince consist of wacke and mudstone beds that are interlayered and gradational into one another. Preserved gradational bedding cycles, typically thin to medium bedded (< 0.5 m), suggest that these rocks comprise a turbidite sequence. These primary structures are evident in the north, but are obliterated in the south by metamorphic recrystallization.

The metavolcanics are predominantly intermediate to mafic in composition. These rocks, especially the more mafic varieties, are commonly sheared and carbonatized. Fragmental metavolcanics are typically intermediate in composition and include tuff-breccias, lapilli-tuffs and lithic and crystal tuffs. A metasedimentary sequence including polymictic conglomerates, wackes, arkoses, siltstones and mudstones occurs immediately north of the Wabigoon Subprovince boundary in the western part of the map-area. These rocks correspond to the Seine series of Lawson (1913). The remaining metasediments in the northern part of the map-area stratigraphically overlie the metavolcanics. This relationship is suggested by some graded beds in the metasediments which face away from the metavolcanic-metasedimentary contact, and the existence of metasediments near this contact which are possibly derived from volcanic rocks. However, most primary features are totally obscured by metamorphic recrystallization, *lit par lit* intrusions of tonalite dikes, and the development of migmatites. These high grade metasediments are interpreted to be equivalent to the Seine 'series' to the southwest because of the presence of some conglomerates that are lithologically very similar.

Five different types of granitic rocks have intruded the supracrustal rocks of the Wabigoon Subprovince in the map-area. These consist of 1) a diorite to tonalite suite which is largely restricted to the eastern part of the area, 2) a coarse-grained tonalite in the northeastern part, 3) a fine-grained tonalite with occasional quartz phenocrysts in the northwestern part, 4) granodiorite of the Hillyer Creek Dome (Schwerdtner *et al.* 1978), and 5) granite at Calm Lake. These rock types typically occur in large plutons, but a number of small stocks of the diorite to tonalite suite, and of granite related to that at Calm Lake, occur away from the main plutons.

A single mafic intrusive body consisting of gabbro, diorite and associated tonalite dikes occurs at McPherson Lake. Mafic dikes related to this intrusive body occur up to a few kilometers from the main body but are not common.

Structural Geology

Major regional faults separate areas of differing structural style. The boundary between the Quetico and Wabigoon Subprovinces in the map-area is defined by a narrow but continuous shear zone.

This shear zone is part of a major fault that has been called the Quetico Fault to the east (Kaye 1967; Mackasey *et al.* 1974; Pirie 1978) and the Seine River Fault to the west (Davies 1973; Wood *et al.* 1980). The term 'Quetico Fault' has also been used for another major fault (Davies 1973; Wood *et al.* 1980) which, within the map-area, splays into a series of lesser faults towards the east. The current mapping has shown that there is no direct connection between the two major faults. It was on the assumption that there was a direct link, as shown on the current compilation map of the Kenora-Fort Frances area (Davies and Pryslak 1967), that the term 'Quetico Fault' was applied to the more northerly of the two faults by Davies (1973). It is suggested here that the term 'Quetico Fault' be retained, on the basis of precedence, for the more southerly fault and that the term 'Seine River Fault' be discontinued.

South of the Quetico Fault, the bedding planes in the metasediments have an easterly strike, dip steeply to the north, and have consistent tops to the north. Tectonic foliation is parallel to the bedding. Bedding planes in the Seine 'series', situated between the Quetico Fault and the other major fault, define a syncline with an axis that plunges at a very shallow angle to the west. The axial planar foliation trends roughly east with a near vertical dip. North of both major faults, the axial plane of another major syncline with a subvertical axis extends from the Hillyer Creek Dome in the northwest to Banning Narrows on the Seine River in the southeast.

The Red Cedar prospect, west of the Independence Mine, is underlain by numerous quartz veins associated with minor shear zones within intercalated ironstones, biotite gneisses and hornblende gneisses. These ironstones are composed primarily of hematite, iron silicates and quartz. The Au concentration reportedly varies from trace to 0.4 ounce per ton with a preferential concentration of the gold in shear zones[1].

The Mayflower prospect is located in metavolcanics adjacent to a small granodiorite stock. The gold mineralizaton occurs in silicified and carbonatized zones within the metavolcanics, and in quartz and carbonate veins within the granodiorite. Within the metavolcanics, small aggregates of pyrite are abundant and small veins of galena are also present. Wilkinson (1980) recognized minor arsenopyrite in these rocks and reports some low Au values of 0.019 and 0.020 g per tonne, whereas in the granodiorite he reported values up to 3.0 g per tonne and the occurrence of chalcopyrite, pyrite, arsenopyrite, galena and sphalerite. Gold assays of 0.50 ounce per ton over 0.9 m, 0.10 ounce per ton over 1.5 m, 0.23 ounce per ton over 0.75 m, and 5.96 ounce per ton over 0.39 m were reported from exploratory drilling[1].

Gold, silver and copper occur in small amounts at the Law occurrence. The mineralized areas are either shear zones or small quartz veins containing pyrite and chalcopyrite. In the shear zones, this mineralization is associated with abundant carbonate. Only trace amounts of Au and Ag have been reported from these mineralized zones[1].

Minor occurrences of base metals also occur at the Gehl Lake occurrence and the Mills Creek occurrence (Fenwick *et al.* 1980). At the Gehl Lake occurrence, small amounts of pyrite and erratic concentrations of chalcopyrite occur in a quartz vein within a thin metasedimentary horizon. The maximum values in ten grab samples were 0.01 ounce of Au per ton, 0.24 ounce of Ag per ton and 0.59 percent Cu (Fenwick *et al.* 1980). At the Mills Creek occurrence, pyrite, chalcopyrite and arsenopyrite occur in completely carbonatized mafic metavolcanics adjacent to a fault along which there has been appreciable displacement. Recent assays of six grab samples show maximum values of 0.02 ounce of Au per ton, 0.11 ounce of Ag per ton, 240 ppm Cu, 70 ppm Co, 178 ppm Ni, 38 ppm Pb, and 163 ppm Zn[2].

Rocks exposed in an outcrop on a lumber road immediately west of Gehl Lake are similar to those at the Mayflower occurrence (i.e. a small granodiorite body with some brecciation intrudes extensively carbonatized metavolcanics) and warrant investigation for gold mineralization.

A recent lake sediment survey (OGS-GSC 1980) over the area yielded one highly anomalous As value, together with several weakly anomalous values along the same drainage system southeast of Price Lake. These As values are associated with high but not anomalous Pb concentrations. Because As is commonly associated with gold mineralization, the drainage area containing these anomalous concentrations and the environs should be prospected to ascertain the type of mineralization from which the As values were derived. No explanation for these high As values was found during the course of the present mapping project.

[1]Regional Geologist's Files, Ontario Ministry of Natural Resources, Thunder Bay.

[2]Regional Geologist's Office, Ontario Ministry of Natural Resources, Thunder Bay, personal communication.

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No. 9 Fletcher Lake Area, District of Thunder Bay

R.H. Sutcliffe[1]

Location and Access

The map-area is bounded by Latitudes 50°26′00″ and 50°37′30″ N and Longitudes 88°53′00″ and 89°07′30″W, and is approximately 30 km north of the town of Armstrong. Caribou Lake, which can be reached via a 10 km gravel road from Armstrong, provides access to the central portion of the map-area. Hollingsworth, Campbell, D'Alton and several smaller lakes are accessible by float-equipped aircraft which can be chartered in Armstrong. A system of portages also connects D'Alton Lake to Caribou Lake, and Campbell and Hollingsworth Lakes to Caribou Lake.

History of Mineral Exploration

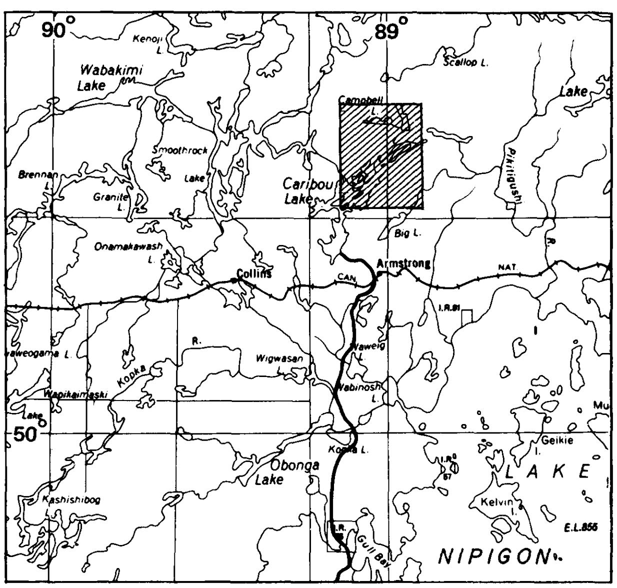
Gussow (1942) reports sporadic prospecting, primarily for gold, near the southwest end of Kellar Island of Caribou Lake. Low-grade gold and copper mineralization is reported (Gussow 1942). From the 1950s onward, the primary interest in the area has been base metals. Information summarized here is available in the Assessment Files Research Office, Ontario Geological Survey, Toronto or at the Regional Geologist's Office, Ontario Ministry of Natural Resources, Thunder Bay.

Argentiferous galena in magnetite ironstone was discovered by J.N. Bovin and A. Gilbert north of Kellar Island during the 1940s. Conwest Exploration Company Limited and Central Patricia Gold Mines Limited diamond-drilled six holes (357 m) in 1949. Kennco Explorations (Canada) Limited examined the area in 1957. In 1959, the Consolidated Mining and Smelting Company of Canada Limited did ground EM and geological surveys over the ironstone. Centusion Mines Limited did magnetic, EM, and geological surveys followed by diamond-drilling (five holes totalling 199 m) in 1962 and 1963.

In 1954, A. Fayolle discovered zones of massive pyrrhotite-pyrite with minor chalcopyrite between Caribou and Campbell Lakes. From 1955 to 1957, Kennco Explorations (Canada) Limited did airborne EM-magnetic (251 km^2), detailed geological, and geochemical surveys and limited diamond-drilling. The Camp, Fletcher Lake, and Fayolle showings were delineated.

From 1954 to 1971, other zones of pyrite and pyrrhotite near Caribou Lake were investigated by Glenora Gold Mines Limited (1954-1955, 988 m of diamond-drilling), J.G. Pollard (1955, 216 m of diamond-drilling), Lun-Echo Gold Mines Limited (1957, trenching and 18 m of diamond-drilling), A.P. Ginn (1957, trenching and 135 m of diamond-drilling), and Gunnex Limited - Tombill Gold Mines Limited - Canpac Minerals Limited (1971, joint venture, geochemical survey, ground magnetic - EM surveys, trenching).

In 1956, Central Manitoba Mines Limited conducted ground magnetic and EM surveys, trenching and diamond-drilling (1287 m) on a chalcopyrite and gold occurrence in quartz-carbonate veins hosted by mafic metavolcanics at the south end of Kellar Island, Caribou Lake. Also in 1956, Noranda Mines Limited did ground EM-magnetic and geological surveys over chalcopyrite, sphalerite, and galena mineralization in a breccia zone in mafic metavolcanics and tonalite on S.M. Lett's claims north of Cumaway Lake. In 1966 and 1967, the Algoma Steel Corporation Limited diamond-drilled five holes (99 m) in this zone. It was again examined by Triton Explorations Limited in 1970, with geological mapping and ground EM-magnetic surveys. In 1970, several other zones of massive pyrite and pyrrhotite mineralization on D'Alton Lake were investigated.



LOCATION MAP — Scale: 1: 1 584 000 or 1 inch to 25 miles

[1]Geologist, Precambrian Geology Section, Ontario Geological Survey, Toronto.

In 1965, Cliffs of Canada Limited examined oxide facies ironstone on C.W. Menifee's property east of Hollingsworth Lake with magnetic surveys, geological mapping and concentration tests. In 1971, Hollingsworth Iron Mines Limited was incorporated to develop the property, and diamond-drilling (five holes totalling 592 m) and beneficiation tests were done. The Northern Miner (August 19, 1971, p.16, 22) reports a tonnage estimate of 217,000 long tons per vertical foot (86 million long tons to 400 feet). The deposit has been restaked several times since, but no further development has been reported.

In 1980, several companies staked claims in the map-area. As of August, approximately 250 claims were held, the majority by New Jersey Zinc Exploration Company (Canada) Limited. The author observed an airborne geophysical survey being flown during the field season.

General Geology

The map-area includes Early Precambrian supracrustal and plutonic rocks of the Wabigoon and English River Subprovinces and Late Precambrian intrusive rocks of the Nipigon Plate. The area has been previously mapped by Gussow (1942) at a scale of 1:63 360 or 1 inch to 1 mile. The present map-area has also been covered by Thurston *et al.* (1969) and Sage *et al.* (1974) as part of regional reconnaissance surveys. The adjacent area to the west has been mapped in detail by Sutcliffe and Fernberg (1980).

Wabigoon Subprovince

The Early Precambrian rocks south of the east-trending fault zone extending through Campbell and Hollingsworth Lakes are within the Wabigoon Subprovince (Figure 1) and comprise part of the Caribou Lake-Pikitigushi River 'greenstone belt' (Gussow 1942).

North of Caribou Lake, the supracrustal rocks comprise a 1 to 3 km thick sequence of pillowed and massive mafic metavolcanics. Local zones of amygdaloidal, variolitic and plagioclase-phyric flows are present. Interflow sedimentary material is rare. Near the base of the mafic sequence, adjacent to the tonalitic granitoids, a 100 m thick unit of interbedded chert, magnetite and grunerite ironstone is present.

Overlying the mafic metavolcanics and extending east through Campbell and Hollingsworth Lakes is a highly deformed metasedimentary sequence named the Linklater Formation (Gussow 1942). The metasediments consist mainly of intercalated polymictic conglomerate with granitoid clasts, and polymictic volcanic conglomerate. The volcanic conglomerate contains predominantly felsite clasts, with lesser amounts of chert and quartz porphyry clasts. East of Hollingsworth Lake, fine argillaceous metasediments and magnetite ironstone occur between the mafic metavolcanics and metaconglomerate.

Mafic metavolcanics lying along the axis of Caribou Lake are generally highly deformed and altered. Carbonatization, silicification, and quartz and/or carbonate veining are common from the southwest end of Kellar Island to the eastern boundary of the map-area. Minor units of talc-carbonate schist and actinolite-rich ultramafic rocks are present in the zone. The alteration and deformation appear to be related to tight folding and faulting parallel to Caribou Lake.

South of Caribou Lake, the metavolcanics range from ultramafic to mafic. Chert, magnetite ironstone and sulphide-rich ironstone occur in several zones within the metavolcanics. Immediately south of Caribou Lake is a 1500 m to 2000 m thick sequence of fine- to medium-grained massive and gabbroic amphibolite which is devoid of primary structures and may be intrusive in part.

A 500 m thick sequence of previously unreported intercalated ultramafic and mafic metavolcanics is present near the north end of Cumaway Lake. The ultramafic flows range from massive serpentinite to talc-carbonate schist, but excellent spinifex textures are locally preserved. Mafic metavolcanics associated with the ultramafics are massive but locally display polysutured flow tops. A second zone of ultramafic rocks ranging from serpentinite to talc-carbonate schist was observed on Mitchell Lake. Here, no primary features indicative of a volcanic origin were observed.

Quartz and/or feldspar porphyry and fine- to medium-grained tonalite units are present at several locations within the mafic metavolcanics. The quartz-feldspar porphyry units on Howie Lake and Campbell Lake locally display a fragmental texture and may be extrusive in part.

An elongate intrusion of hornblende gabbro occurs on the southern shore of Caribou Lake. The pluton contains inclusions of mafic metavolcanics and is intruded by tonalite and granite along its western margin.

Dikes of amphibolite and hornblende gabbro intrude tonalites north of Caribou Lake and are a continuation of the dike swarm mapped east of Funger Lake (Sutcliffe and Fernberg 1980). The gabbro plutons and dikes may be subvolcanic equivalents of the mafic metavolcanics.

The tonalites range from massive to gneissic and biotite tonalite is most common. At least two major phases of tonalite occur in the area. The first, north of Caribou Lake, predates the gabbroic plutonism, while the second, south of Caribou Lake, postdates the gabbro.

West of D'Alton Lake a porphyritic (microcline) biotite granite pluton intrudes the metavolcanics, hornblende gabbro and biotite tonalite.

English River Subprovince

The rocks north of the Hollingsworth and Campbell Lakes fault lie in the English River Subprovince. These rocks range from migmatized metasediments to diatexitic muscovite-biotite granite (derived from anatexis of the sediments). The metasediments are locally well-bedded and consist of metawacke and metapelite components.

The English River-Wabigoon Subprovince boundary is marked by a strongly deformed to locally mylonitized fault zone between diatexitic granites (English River) and conglomeratic metasediments (Wabigoon). Rocks in this zone suggest that the conglomerates were the proximal facies equivalent of the sandstones and pelites of the English River Subprovince. This sequence is similar to that in the Elwood, Never-freeze, and Savant Lakes area to the west (Trowell *et al.* 1977), which also lies at the subprovince boundary.

Nipigon Plate

Shallow-dipping Late Precambrian (Keeweenawan) diabase sheets and diabase and micro-granophyre dikes intrude the Early Precambrian rocks. One outcrop of Sibley Group sandstone occurs beneath the diabase sheet on Kellar Island, Caribou Lake.

The diabase sheets range from fine-grained olivine diabase at the base to medium- and locally coarse-grained quartz diabase near the top. Thicknesses in excess of 500 m were observed. The diabase 'sheet' at D'-Alton Lake appears to be a series of connected funnel-shaped intrusions and contains an internal contact indicating multiple phases of intrusion.

Structure

North of Caribou Lake, an anticlinal axis extends from the western tonalite to the north end of Kellar Island. North of this axis, the mafic metavolcanics generally face north and appear to be stratigraphically overlain by metasediments at the northern margin of the Wabigoon Subprovince.

Along Caribou Lake, more complex folding is suggested by the attitudes of foliations, lineations and minor folds in the supracrustal rocks.

South of Caribou Lake, facing directions are particularly sparse, except near D'Alton Lake. Here the structure comprises an open anticline, extending east from the porphyritic granite stock, and two flanking synclinal folds. On Cumaway Lake, spinifex and polysuturing in the metavolcanics indicate this sequence faces south, but no other facing criterion was obtained in this zone.

The east-trending fault through Campbell and Hollingsworth Lakes is part of a fault system extending west to Pashkokogan Lake. A subhorizontal, dextral movement of unknown displacement is suggested by structures in the fault zone. The fault through Caribou Lake is recognized on the basis of fracturing and alteration along the zone and it appears to have a sinistral offset.

Economic Geology

Gold

Little gold exploration has been done in the area since the 1950s. Because of the possible association of gold with ultramafic and mafic metavolcanics (Pyke 1975), further exploration for gold is warranted in the area. Previously unreported ultramafic rocks on Cumaway Lake, Mitchell Lake and near Kellar Island warrant investigation. These ultramafics are generally carbonatized and locally associated with silicification and quartz and/or carbonate veining.

The Kellar Island occurrence and other mafic volcanic-hosted quartz-carbonate veins may warrant further investigation. Folding, faulting and possibly metamorphism are of significance in the alteration processes. The most abundant veining appears to occur near the amphibolite-greenschist facies boundary.

Copper-Zinc-Lead

Chalcopyrite, sphalerite and minor galena mineralization at the north end of Cumaway Lake is associated with a northeast-trending fault breccia zone. Similar fault zones are present in the vicinity. This association, however, may be more favourable for gold, as previously discussed.

Argentiferous galena veining and disseminated sphalerite occurs in chert and ironstone north of Kellar Island. The mineralization appears to be controlled by fractures in the more competent ironstone in the hinge zone of an anticlinal structure.

Numerous pyrite and pyrrhotite occurrences in the map-area are associated with mafic metavolcanics. Minor chalcopyrite mineralization and local graphite are found with the pyrite and pyrrhotite. Several of these occurrences are associated with chemical metasediments and may be synvolcanic (e.g. Fayolle showing, south of Campbell Lake, and sulphide showings on D'Alton Lake). Other pyrite-pyrrhotite occurrences (e.g. Camp showing, northwest of Howie Lake) appear to be secondary.

Copper-nickel

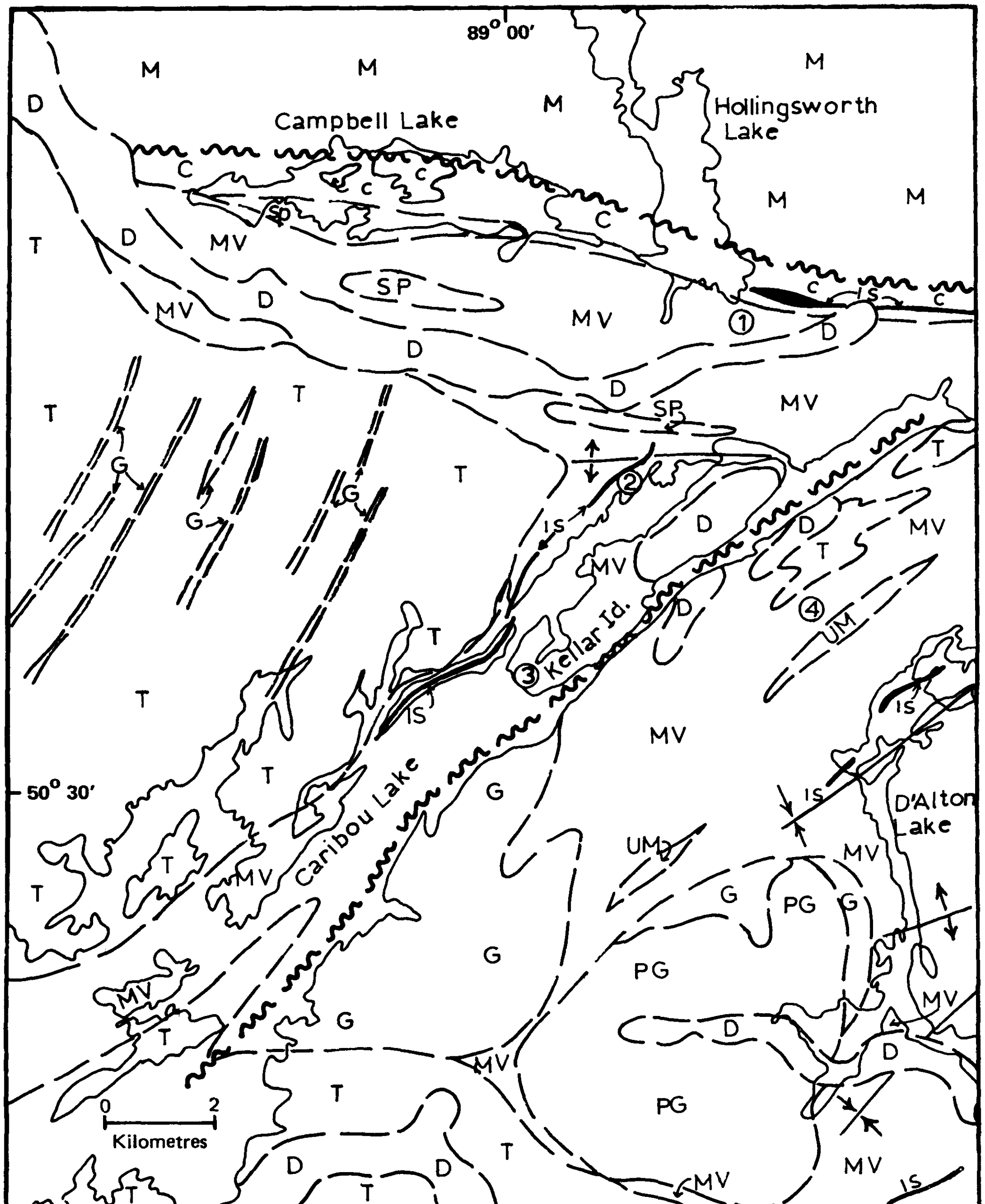
The ultramafic rocks, particularly on Cumaway and Mitchell Lakes, and the hornblende gabbro bodies south of Caribou Lake, may have potential for copper-nickel mineralization.

Lithophile Elements

Beryl and cassiterite mineralization at Linklater Lake, 8 km to the east of the map-area, is associated with pegmatitic muscovite granite. Similar pegmatites are present within the map-area in the vicinity of the English River-Wabigoon Subprovince boundary, although no lithophile element mineralization has been observed in the map-area to date.

Iron

The chert-magnetite ironstone east of Hollingsworth Lake reaches a maximum thickness of approximately 215 m, 1 km east of the southeast shore of Hollingsworth Lake. The ironstone has been tectonically thickened in this zone due to deformation along the Wabigoon-English River Subprovince boundary.



Legend

Late Precambrian
- D Diabase Sheets

Early Precambrian
- M Migmatized Metasediments and Derived Granites
- PG Porphyritic Granite
- T Tonalitic Granitoids
- G Gabbro
- SP Subvolcanic Porphyry
- C Conglomerate and Minor Associated Sediments
- IS Ironstone
- UM Ultramafic Rocks
- MV Mafic Metavolcanics

Selected Mineral Occurrences

1) Hollingsworth Lake - Fe
2) Bovin-Gilbert occurrence - Pb,Ag
3) Kellar Island - Cu, Au
4) Cumaway Lake - Cu, Pb, Zn

Figure 1—Generalized geology of the Fletcher Lake area.

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No. 10 Terrace Bay Area, District of Thunder Bay

M.W. Carter[1]

Location and Access

The map-area, about 274 km², is bounded by Latitude 48°54′00″N and the northern shore of Lake Superior, and Longitudes 87°1′37″W and 87°15′00″W. It includes the Townships of Strey and Priske and the Town of Terrace Bay.

The southern and eastern parts of the area are readily accessible by Highway 17 and a logging road maintained by Kimberly-Clark of Canada Limited, which connects Terrace Bay with Longlac to the northeast. The northwestern and north-central parts of the area are best reached by helicopter and fixed-winged, float-equipped aircraft.

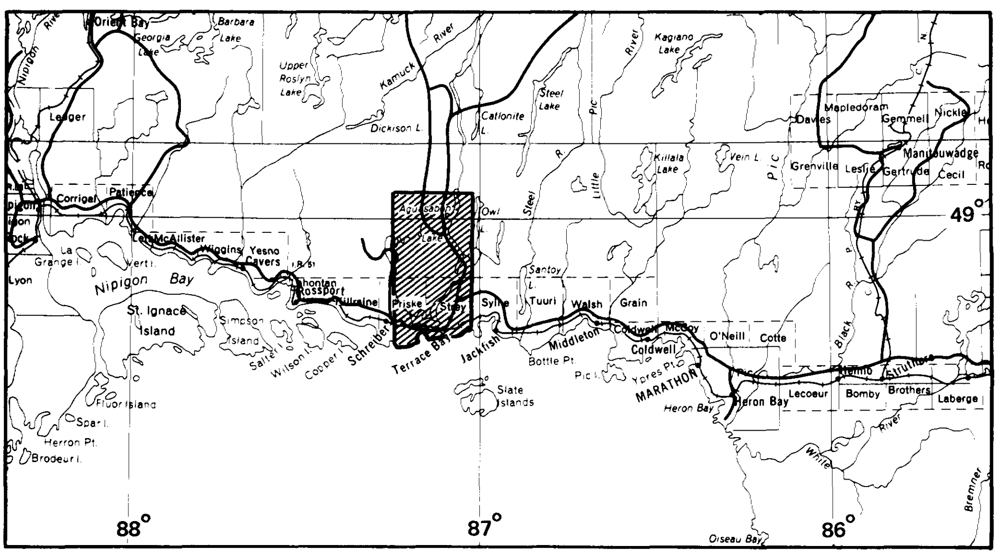
Mineral Exploration

Exploration in the map-area was carried out primarily for gold from 1896 to 1939; later, in the period 1948 to 1977, exploration was extended to the search for copper, copper-molybdenum, copper-lead-zinc, and copper-nickel mineralization.

Gold exploration consisting of surface and underground work was carried out in two areas: within mafic metavolcanics along the northwestern contact of the granitic rocks and the metavolcanics, and in mafic metavolcanics in the west-central part of the map-area. In the former area, work was done on the original properties of the Otisse Mining Company, the Gold Range Mines Limited, and the Harkness-Hays Gold Mining Company Limited, all located west of Hays Lake, and on the original Jedder Gold Mines Limited property, located east of Hays Lake. In areas underlain by mafic metavolcanics away from granitic contact zones, exploration was carried out on the original properties of Schreiber Pyramid Gold Mines Limited, Cook Lake Gold Mines Limited and J.E. Halonen. In most of these areas, recorded exploration work predates 1939.The exceptions are the former Gold Range Mines Limited and Jedder Gold Mines Limited properties. Surface exploration was carried out on the former by R.W. Pitkanen in 1970 and on the latter by W. Acker between 1970 and 1980.

Exploration for copper mineralization was carried out in 1950 by East Sullivan Mines Limited at Ansell Lake in the northwestern part of the area, on showings which had been discovered in 1921. In 1954 Ascot Metals Corpora-

[1]Geologist, Precambrian Geology Section, Ontario Geological Survey, Toronto.



LOCATION MAP   Scale: 1:1,584,000 or 1 inch to 25 miles tion Limited tested this occurrence with three diamond-drill holes totalling 1000 feet.

Exploration for copper-lead-zinc mineralization was done in 1969 by Zenmac Metal Mines Limited. Five diamond-drill holes totalling 790 feet were drilled on the original Schreiber Pyramid Gold Mines Limited property in the west-central part of the map-area. In 1977 HBOG Mining Limited diamond-drilled a 221-foot hole at Lamont Lake and a 347-foot hole at Hollinger Lake, both in the southwestern part of the map-area, in order to test electromagnetic conductors in similar rocks.

In 1965 Nor-Acme Gold Mines Limited examined copper-molybdenum showings in the southwestern part of the map-area. In the same year Noranda Mines Limited diamond-drilled two holes totalling 543 feet in the area. In 1969 OJA Limited carried out a magnetometer survey over these and other similar showings, followed in 1970 by a copper-molybdenum geochemical survey and an airborne electromagnetic survey. Several weak anomalies were obtained. During the period 1969-1970 Thunder Bay Drilling sank five diamond-drill holes totalling 1616 feet on the main showing in the area.

About 1948 Ironlake Exploration Limited carried out a dip-needle survey over an area containing a massive pyrite-pyrrhotite body in the southwestern part of the map-area. Pits had previously been put down on the deposit. In 1965 Tri-J Mineral Surveys Limited carried out a vertical magnetic intensity survey around the showing.

General Geology

The map-area is underlain by Early Precambrian rocks mantled by Pleistocene and Recent deposits.

The Early Precambrian rocks comprise a metavolcanic-metasedimentary sequence, metagabbroic intrusions, granitic-syenitic plutons and diabase and lamprophyre dikes (Figure 1). The metavolcanics consist predominantly of mafic rocks, black to very dark green in colour, that are pillowed, amygdaloidal and variolitic in texture. They are regarded by the author as iron-rich tholeiites. Komatiitic basalts are also believed to be present, and an ultramafic unit occurring at Big Bruin Lake in the west-central part of the map-area may be an ultramafic flow. The occurrence of pillowed structures indicates that the mafic flows are subaqueous and the amygdaloidal texture suggests a shallow-water depositional environment. Intermediate metavolcanics are less voluminous and felsic metavolcanics are rare. Pyroclastic rocks are uncommon, and coarse pyroclastics are absent. The interlayered metasediments comprise narrow units of chert, wacke and magnetite ironstone. These supracrustal rocks have been regionally metamorphosed to greenschist and amphibolite rank, and a general mineral foliation is present. Metagabbroic rocks, varying from coarse- to medium-grained and completely metamorphosed to amphibolites, intrude the supracrustal rocks throughout the map-area. An unmetamorphosed gabbro which occurs in the east-central part of the map-area is probably a very late intrusion. All these rocks have been intruded by porphyritic and non-porphyritic hornblende and hornblende-biotite granite and syenite. Black, rusty-weathering magnetic diabase and olivine diabase dikes, trending northwest and west-northwest, intrude the supracrustal and granitic rocks and are particularly numerous along the shore of Lake Superior. A few west-southwest-trending mauve biotite lamprophyre dikes were observed. These diabase and lamprophyre dikes may be Late Precambrian in age, but in the Schreiber area immediately to the west (Carter, in press), these rocks were not observed to cut Middle Precambrian Animikie rocks.

Cenozoic deposits consist of glaciolacustrine sand at Terrace Bay and glaciofluvial sand, gravel and boulder clay along the highway between Terrace Bay and the western part of the map-area (Gartner 1979).

Structural Geology

The metavolcanics and metasediments are folded about an east-plunging synclinal axis which crosses the central part of the map-area. The lithologic units dip steeply, at about 85°; due to the plunge of the fold axis, they strike northwesterly in the northern part of the map-area and southeasterly in the southern part. Subsidiary folds related to the major folds also occur, e.g. in the southwestern part of the area. Intrusion of the Terrace Bay Batholith has caused local distortion of the regional fold pattern.

The area is crossed by numerous photo-lineaments, many of which are regarded as faults because of associated shearing and the offsetting of lithologic units. The predominant trends of these faults are northwest, northeast and north.

Economic Geology

Gold

Gold occurs characteristically in quartz veins and mineralized shear zones within the metavolcanics.

A grab sample from the Otisse main vein taken by G.A. Harcourt in 1936 (Harcourt 1939, p.26) yielded 0.20 ounce of Au per ton. The best assay obtained by Sylvanite Gold Mines Limited in 1939 was 4.0 ounces of Au per ton over 1.0 foot, apparently by channel sampling[1].

The best assay from the Kay-Hays No. 3 vein, on the former Kay-Hays Mines Limited property, obtained from channel sampling by Harkness-Hays Gold Mines Limited in 1929, was 40.7 ounces of Au per ton over 10 inches[1]. Channel sampling of the vein by Sylvanite Gold Mines Limited in 1939 gave an assay value of 0.66 ounce of Au per ton across 7 inches for 109 feet of vein length[1].

[1]Regional Geologist's Files, Ontario Ministry of Natural Resources, Thunder Bay.

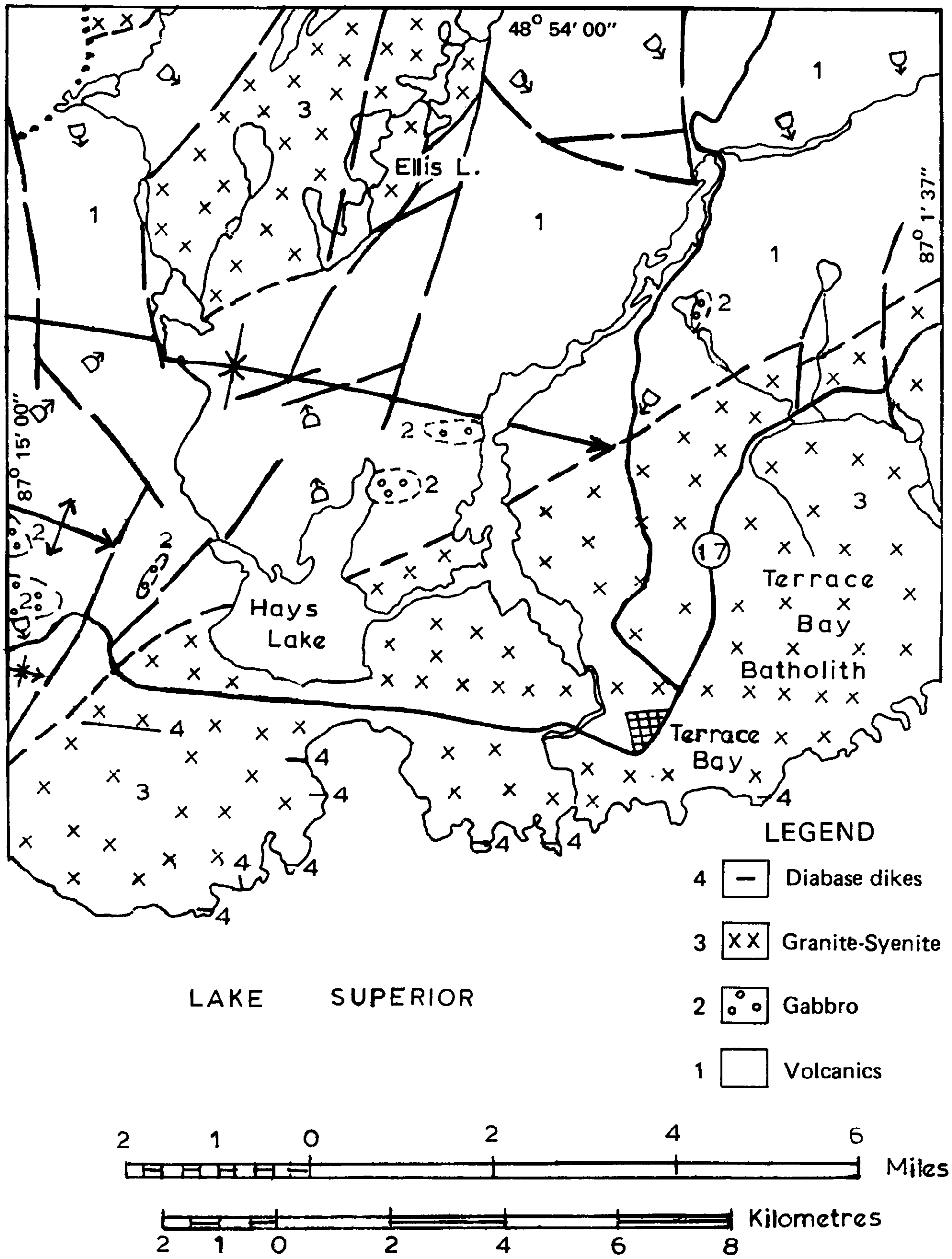


Figure 1 — Geological sketch map, Terrace Bay area.

Two important auriferous quartz veins were explored on the former Schreiber Pyramid Gold Mines Limited property. A grab sample from the No. 1 vein, taken by the senior assistant in the summer of 1980 and assayed by the Geoscience Laboratories, Ontario Geological Survey, Toronto, returned a value of 0.35 ounce of Au per ton. A grab sample from the No. 2 vein, taken by the author in the summer of 1980 and assayed by the Geoscience Laboratories, Ontario Geological Survey, Toronto, returned a value of 0.01 ounce of Au per ton.

An assay of vein material from the No. 2 vein on the original Gold Range Gold Mines Limited property, from an unknown type of sample taken by Allis Chalmers Manufacturing Company Mining Laboratory in 1936, gave 6.99 ounces of Au per ton[1]. The veins on the property were resampled by Sylvanite Gold Mines Limited in 1939. A channel sample taken in the No. 3 tunnel from the No. 2 vein assayed 0.49 ounce of Au per ton across 10.9 inches for a length of 25 feet[1]. A grab sample, taken by the Regional Geologist, Thunder Bay from the same vein at the surface and analyzed by the Geoscience Laboratories, Ontario Geological Survey, Toronto, returned a value of 25.82 ounces of Au per ton. Assay values obtained by Gold Range Gold Mines Limited from placer deposits on ths property gave a best value of 0.07 ounce of Au per ton[1].

A chip sample across 14 inches, and a grab sample taken from the Derraugh Vein on the Walter Acker property by G.A. Harcourt in 1936 (Harcourt 1939, p.23) yielded 2.19 and 1.31 ounces of Au per ton, respectively. A grab sample, taken by the senior assistant during the current survey and analyzed by the Geoscience Laboratories, Ontario Geological Survey, Toronto, gave 0.45 ounce of Au per ton.

The quartz veins comprising the McKenna-McCann showings were assayed by the Cook Lake Gold Mines Limited in the period 1936-1937. The best assay was 0.538 ounce of Au per ton across 1.13 feet for a length of 130 feet from one of the veins[1]; a 5-ton bulk sample from this vein gave 1.13 ounces of Au per ton[1]. During the current mapping program, a grab sample assayed by the Geoscience Laboratories, Ontario Geological Survey, Toronto, gave a value of 0.21 ounce of Au per ton from one of the veins. A 5-ton bulk sample from the Johnston-McKenna vein was reported to assay 0.81 ounce of Au per ton (Harcourt 1939, p.25). Nine character samples taken from the main Mina-Nova vein assayed up to 30 ounces of Au per ton[1].

Copper

A grab sample, taken from a mineralized shear in basalt by Ascot Metals Corporation Limited in 1954, yielded 1.06 percent Cu across 47 feet from the main Ansell Lake showing[1]. Assays for Ni were *nil* from drill core, but 0.6 percent Cu and 0.3 ounce of Ag per ton were obtained over 10 feet[1].

[1]Regional Geologist's Files, Ontario Ministry of Natural Resources, Thunder Bay.

Copper-Lead-Zinc

Drilling for stratiform base-metal sulphide mineralization was carried out in 1977 by Hudson's Bay Oil and Gas Company Limited at Lamont and Hollinger Lakes. Assay values for Cu, Pb, and Zn from the drill core did not exceed 0.1 percent in either area[1].

Drilling by Zenmac Metal Mines Limited in 1969 on the former Schreiber Pyramid Gold Mines Limited property revealed a 1-foot wide zone of massive sulphide mineralization assaying 19.2 percent Zn, and 4.56 percent Cu[1].

Copper-Molybdenum

Mineralization of this type is spatially associated with the Terrace Bay Batholith, the known occurrences being located in the southwestern part of the pluton. Assay results from an unknown type of sample taken in 1965 by Nor-Acme Gold Mines Limited from the Cleaver showing gave 3.26 percent Mo and 0.01 percent Cu[1]. This showing consists of a network of mineralized quartz veins, ½ to 4 inches wide, in a quartz-feldspar porphyry facies of hornblende granite and is located within a quarter mile of the batholith contact. The best assay from drilling on the showing in 1969 by Univex Mining Corporation Limited was 0.2 percent Mo and 0.2 percent Cu over 2 feet in monzonite[1].

Nickel-Copper

No assays for Ni are available.

Recommendations for Future Exploration

Gold Mineralization

The gold deposits of the area occur in two environments: in quartz veins occupying mineralized shears trending northeasterly and northwesterly, and in metavolcanics in the contact zone of the Terrace Bay Batholith. Exploration for gold should thus be concentrated in the northwestern two-thirds of the map-area, which is underlain by metavolcanics and along the northwestern contact zone of the batholith. The map-area is characterized by numerous lineaments, many of which follow these directions and which are clearly visible on aerial photographs. Exploration work should be directed toward determining which of these lineaments are shears. Stream geochemical surveys should be used to isolate favourably mineralized zones, as streams usually follow the lineaments.

[1]Regional Geologist's Files, Ontario Ministry of Natural Resources, Thunder Bay.

Copper-Lead-Zinc Mineralization

Current mapping has shown that narrow horizons of interflow sediments comprising chert, wacke and ironstone occur within the metavolcanic sequence. Drilling by Zenmac Metal Mines Limited has outlined base-metal massive sulphide mineralization associated with such rocks. It is recommended that detailed mapping be carried out in the metavolcanic areas to outline these interflow sediment horizons and base-metal geochemical surveys be used to outline any mineralized horizons.

Copper-Molybdenum Mineralization

Copper-molybdenum mineralization is associated with quartz veins occurring in the granitic rocks underlying the southeastern third of the map-area. The western contact zone of the Terrace Bay Batholith, representing the hood region of the batholith, appears to be especially favourable. However, copper-molybdenum mineralization also occurs well within the batholith, suggesting that the upper part of the hood is also preserved. The entire batholith should therefore be prospected in detail using copper-molybdenum geochemical surveys to outline favourable areas.

References

Carter, M.W.
In press: Schreiber Area, District of Thunder Bay; Ontario Geological Survey Preliminary Map, Geological Series. Scale 1:15 840 or 1 inch to 1/4 mile.Geology 1979.

Gartner, J.F.
1979: Schreiber Area (NTS 42D/NW), District of Thunder Bay; Ontario Geological Survey, Northern Ontario Engineering Geology Terrain Study 59, 15p. Accompanied by Map 5092, scale 1:100 000.

Harcourt, G.A.
1939: The Southwestern Part of the Schreiber Area; Ontario Department of Mines, Vol.47, Pt.9, 1938, p.1-28. Accompanied by Map 47j, scale 1:31 680 or 1 inch to 1/2 mile.

No. 11 Wawa Area, District of Algoma

R.P. Sage[1]

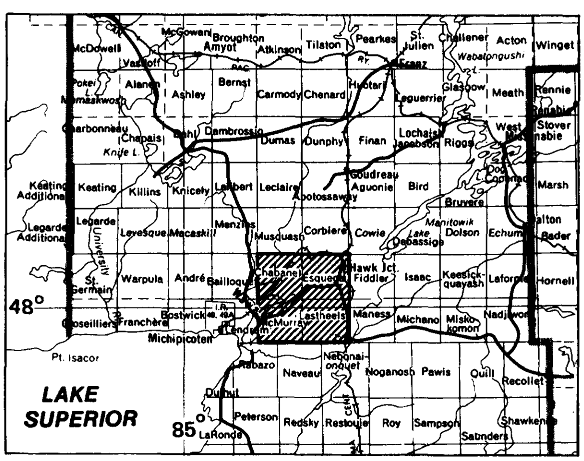
Location

The center of the project area is at approximately Latitude 48°00′N and Longitude 84°30′W. The map-area includes the town site of Wawa. This report summarizes the results of the second year of a two-year program to map Chabanel, Esquega, Lastheels and McMurray Townships. Mapping of the supracrustals in McMurray and Lastheels Townships has been previously discussed (Sage 1979). Except for helicopter-supported reconnaissance in granitic areas of Lastheels Township, the geologic work of this past season was largely restricted to Esquega and Chabanel Townships.

Access to these townships is fair. A four-wheel-drive road leading west from Hawk Junction gives access to the former mine site of Regnery Gold Mines Limited in the centre of Esquega Township. Numerous winter roads, used for logging, branch from this road. Loonskin and Hawk Lakes provide water access to portions of Esquega Township. The Algoma Central Railway spur line to Wawa roughly follows the northern boundary of Esquega Township and then swings southwest across Chabanel Township. A private mine-access road leading north from Highway 17 at the east end of Wawa Lake, 6.4 km west of Wawa, provides access to the west side of Esquega Township and the east side of Chabanel Township. This road terminates before reaching the northern boundary of the map-area. A four-wheel-drive road leads north from the sinter plant of the Algoma Ore Division of The Algoma Steel Corporation Limited to the abandoned power site at Steephill Falls on the Magpie River, in the center of Chabanel Township. Helicopter is the most efficient means of access to that portion of Chabanel Township which lies northwest of the Magpie River.

Outcrop in Esquega and Chabanel Townships is abundant, with 80 to 90 percent exposure in broad areas of southern Chabanel Township. The terrain north of Hawk Lake and in the southern and southwestern portions of Chabanel Township is very rugged, with past logging and bush fires having contributed to jungle-like bush conditions in many areas.

[1]Geologist, Precambrian Geology Section, Ontario Geological Survey, Toronto.



LOCATION MAP

Scale: 1: 1 584 000 or 1 inch to 25 miles

Mineral Exploration

Mineral exploration in Esquega Township has been roughly divided between gold and base metals. During the late 1930s considerable effort was spent looking for gold on the former properties of Soocana Mines Company Limited, Atnel Mines Limited and Murray-Algoma Mines Limited. Production statistics from these properties are unavailable. These showings occur in a broad curvilinear zone where quartz-feldspar porphyry, possibly associated with the Hawk Lake granitic stock, intrudes the supracrustal rocks.

In the southwest corner of Esquega Township, Firespur Exploration Limited, working on the former Lakemount Mines Limited property, is presently testing a number of base-metal showings. Most of these showings are associated with quartz porphyry intrusive rocks, shear zones and quartz veining. The property contains a copper-nickel showing, reportedly yielding platinum group metal values (values not available). This showing has undergone approximately 21 000 m of diamond-drilling which indicated the presence of approximately 2,000,000 tons of ore grading approximately 1 percent combined Cu and Ni (Canadian Mines Handbook 1977-1978, p.177). The mineralization is disseminated in an ultramafic intrusive body.

The former Regnery Gold Mine Limited property is situated within granitic rocks of the Hawk Lake granitic complex. Mineralized specimens from the dump consist of massive chalcopyrite with minor molybdenite in chlorite schist. The mineralization may be associated with xenolithic blocks of supracrustal rocks caught up in the Hawk Lake granitic complex.

The Ruth iron range, located in the northwest corner of Esquega Township, has undergone several periods of diamond- drilling but has not been placed in production.

Chabanel Township contains the George W. Macleod Mine of The Algoma Steel Corporation Limited, currently in production, as well as two abandoned open pit iron mines.

A gold showing at Magpie Junction has been recently examined by Canabec Explorations Limited[1]. North of Wawa Lake, and just south of the Chabanel Township boundary, the former Mammoth Metals Limited tested a quartz vein containing galena, sphalerite and arsenopyrite. Silver values of up to 60 ounces per ton have been reported[2].

General Geology

In Esquega Township, the Hawk Lake granitic complex (Figure 1), centered northwest of Hawk Lake, consists of medium-grained equigranular trondhjemite and granodiorite near the lake and becomes inequigranular porphyritic northwest towards the supracrustal contact. The

[1]Technical Survey File 2.2580, Assessment Files Research Office, Ontario Geological Survey, Toronto.

[2]Regional Geologist's file 982, Ontario Ministry of Natural Resources, Sault Ste. Marie.

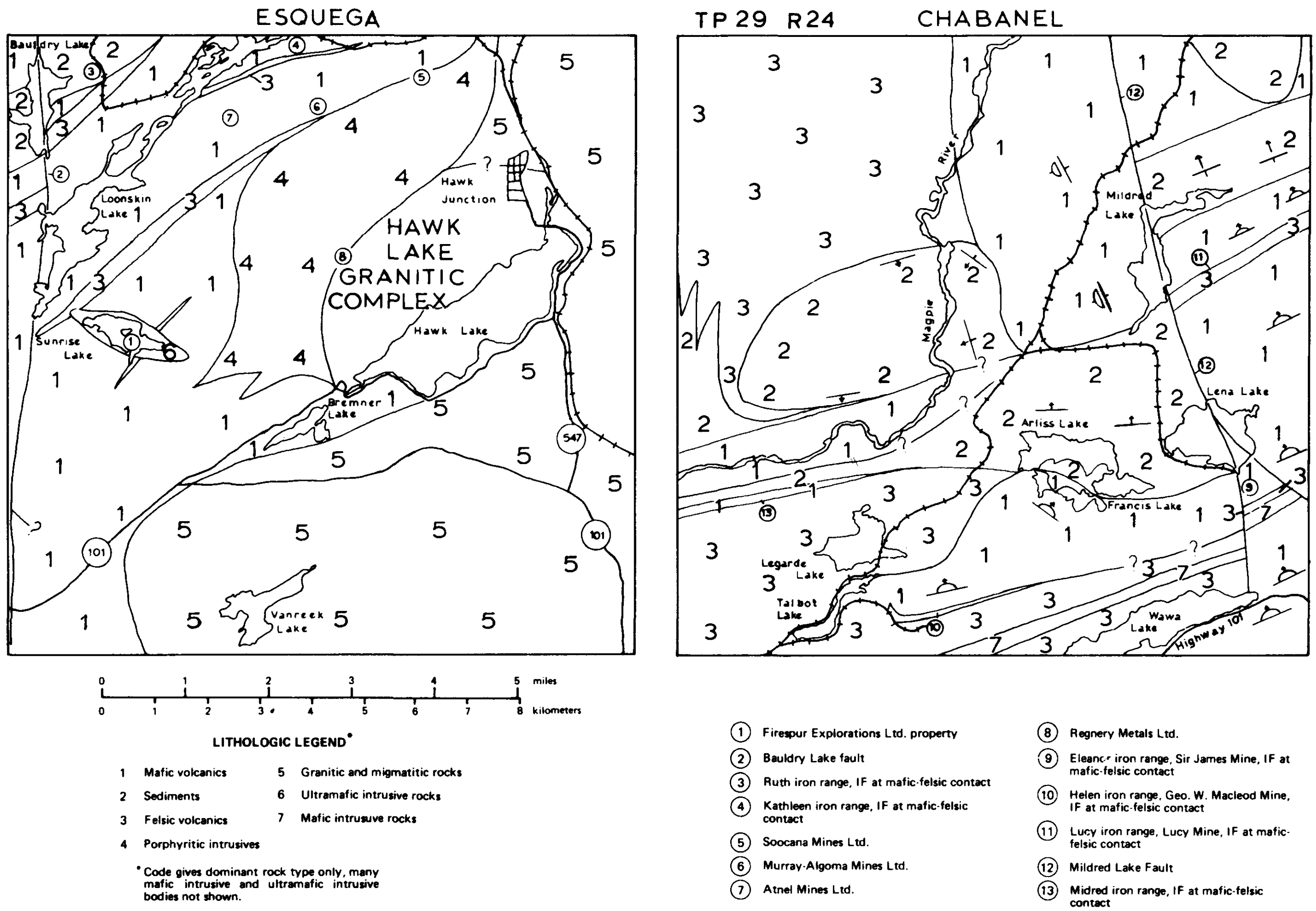


Figure 1 — Schematic diagram of lithologic distribution in Esquega and Chabanel Townships. Lithologic distribution not to scale.

quartz porphyry and quartz-feldspar porphyry intrusive rocks marginal to, and intrusive into, the supracrustals appear gradational into the more plutonic-appearing granitic rocks of the Hawk Lake granitic complex.

Felsic fragmental extrusive rocks occur in a narrow band south of the Firespur Exploration Limited copper-nickel showing. This band may be approximately 150 m in maximum width and 1.6 km in length.

Felsic rocks, consisting of crystal tuff, tuff, lapilli-tuff and massive flows, occur in a poorly defined band striking northeastward from the southwestern corner of Loonskin Lake. Felsic tuffs and lapilli-tuffs occur beneath the Kathleen iron range east of the north end of Loonskin Lake.

In the northwestern corner of Esquega Township, felsic tuffs, lapilli-tuffs and spherulitic flows occur beneath the Ruth iron range.

The mafic rocks in Esquega Township consist of crystal tuffs, tuffs and breccias, and pillowed, amygdaloidal, talc-actinolite and massive types.

Massive medium-grained intrusive rocks of gabbroic to dioritic composition are common. They occur most abundantly on the Firespur Exploration Limited property and between the former properties of Atnel Mines Limited and Murray-Algoma Mines Limited.

In Chabanel Township, felsic extrusive rocks associated with sediments are abundant north of the Magpie River (Figure 1). Felsic extrusive rocks, consisting of crystal tuffs, tuffs, lapilli-tuffs, breccias and ash-flows, occur beneath the Helen iron range and continue into the northwestern corner of McMurray Township; they also occur northwest of the Macleod Mine. Felsic breccias, tuffs and spherulitic flows occur stratigraphically beneath the Eleanor iron range and Lucy iron range. In the northwestern corner of Chabanel Township, large areas of felsic tuff become more reworked and sedimentary in appearance towards the south.

Large areas of sediment, consisting of conglomerate, siltstone, wacke and arkose, occur north of the Magpie River, north of Mildred Lake and in the vicinity of Arliss and Bauldry Lakes. These sediments are thinly bedded and commonly display grain gradation and cross-bedding.

Iron formation, consisting of, from top to bottom, siderite, pyrite, chert, and graphite plus pyrite, constitutes the Helen, Eleanor, Lucy and Ruth iron ranges. The Mildred and Kathleen iron ranges are relatively thin and consist predominantly of chert and minor pyrite.

Large mafic intrusives, possibly gabbros and diorites, cut the felsic metavolcanics beneath the Helen, Eleanor and Lucy iron ranges, and are also present in large numbers northwest of the Macleod Mine.

Peridotite and pyroxenite intrusions (not illustrated) are found on Lena, Mildred and Bauldry Lakes.

The supracrustal rocks display prominent chloritoid development beneath the Helen iron range and, to a much more limited extent, beneath the Lucy iron range. A chloritoid zone (not illustrated) was roughly outlined in the northwestern corner of Chabanel Township, but no mineralization was observed to be associated with it.

Carbonate alteration of the supracrustal rocks is pervasive in large areas throughout Chabanel Township. The origin of the siderite iron formation as part of the carbonatization process appears warranted and future studies are planned to investigate this hypothesis.

The helicopter work in Lastheels Township indicated the granitic rocks to be dominately medium-grained trondhjemite and granodiorite. Migmatites were generally restricted to the contact area between the supracrustals and the granitic terrain.

Structural Geology

The supracrustals in Esquega Township form a northeast-trending series of units which appear to be monoclinally facing north. The Hawk Lake granitic complex displays an intrusive relationship with the supracrustals.

In Chabanel Township, the rocks east of the Mildred Lake fault trend northeast, monoclinally face north and are cut by numerous faults. Immediately west of the Mildred Lake fault, the supracrustals trend north to northwest, dip shallowly to the east, and stratigraphically face west. Felsic metavolcanics trend south to southwest from the northwestern corner of the map-area and then swing abruptly to the east just north of the Magpie River. The overturned northwest-trending rocks immediately west of the Mildred Lake fault are terminated abruptly by the east- to northeast-trending rocks lying south of the Magpie River.

Economic Geology

The Sir James Mine of The Algoma Steel Corporation Limited, located in the Eleanor iron range, has produced 7,790,632 tons of iron ore from pre-production reserves of 80,000,000 tons, while the Lucy Mine produced 1,107,773 tons of ore from unspecified reserves[1].

The Helen iron range has produced in excess of 60 million tons of iron ore. Reserves of 93 million tons were indicated in 1972, while reserves of 7,359,000 tons of low silica and 12,714,000 tons of high silica ore are listed for the Ruth iron range[1]

Approximately two million tons of copper-nickel ore, with an average grade of 1 percent combined Cu and Ni plus values in platinum metals, occurs in the southwestern corner of Esquega Township[2]. Gold production in Esquega and Chabanel Township has been minor but a number of showings are present.

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[1]Statistical Files, Mineral Resources Group, Ontario Ministry of Natural Resources, Toronto.

[2]Lakemount Mines Limited, Canadian Mines Handbook 1977-78, p.177.

Recommendations to the Prospector

The iron ranges have been extensively drilled so as to preclude the location of additional near-surface iron deposits.

The general zone of quartz-feldspar porphyry intrusion and supracrustal contact in Esquega Township appears to be a particularly favourable area to prospect for gold; some of the former gold properties found in this area may warrant re-examination.

The rocks found in both townships are favourable for base-metal mineralization even though base-metal showings are not common. The shallow-dipping attitude of the rocks found in the central portion of Chabanel Township may make geophysical surveying in this area less effective than in an area of subvertically-dipping rocks.

Minor iron-sulphide mineralization was commonly observed near the mafic metavolcanic-metasedimentary and mafic-felsic metavolcanic contacts.

Reference

Sage, R.P.
1979: Wawa Area, District of Algoma; p.48-53 *in* Summary of Field Work, 1979, by the Ontario Geological Survey, edited by V.G. Milne, O.L. White, R.B. Barlow and C.R. Kustra, Ontario Geological Survey, Miscellaneous Paper 90, 245p.

No. 12 Jerome Area, District of Sudbury

G.M. Siragusa[1]

Location and Access

The map-area has a roughly trapezoidal outline. The northwest and southwest corners of the area have Latitudes of 47°37′ and 47°32′30″N, respectively, and lie on Longitude 82°05′20″W; the northeast and southeast corners have Latitudes of 47°35′30″ and 47°30′N, respectively, and lie on Longitude 81°50′30″W. The area includes Chester Township, a large part of Yeo Township, and southern parts of Neville and Potier Townships, for a total of about 200 km^2. Highway 144 crosses the eastern margin of the area and a good gravel road connects Highway 144 with the eastern side of the narrows of Mesomikenda Lake in eastern Chester Township. The distance of this locality from Gogama via Highway 144 is about 27 km. A mining road crosses the narrows of Mesomikenda Lake over a steel bridge and gives access to Three Duck Lakes in central Chester Township, and Clam Lake in western Chester Township. Owing to extensive harvesting of trees currently carried out by Eddy Forest Products Limited, bush roads were being cut or extended in several parts of the map-area during the 1980 field season. One of these roads connects the northern tip of Chester Lake with the Ramsey Road, and thus offers convenient means of access to southwestern Chester Township. Further west, similar roads connect the Yeo-Windy Lakes area with the Ramsey Road. Mesomikenda, Schist, Chester, Three Duck, Bagsverd and Yeo Lakes are good access points by bush plane.

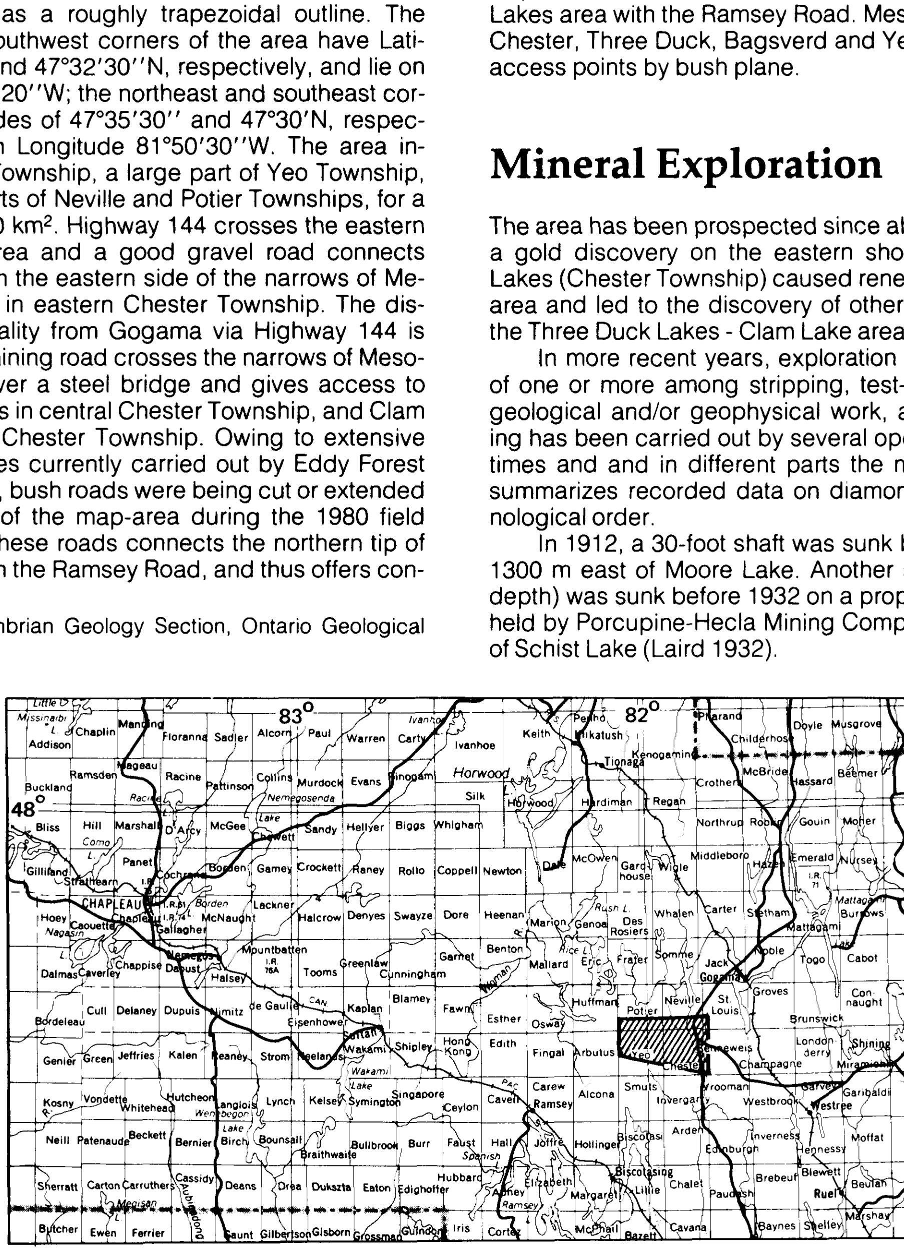
[1]Geologist, Precambrian Geology Section, Ontario Geological Survey, Toronto.

Mineral Exploration

The area has been prospected since about 1900. In 1930 a gold discovery on the eastern shore of Three Duck Lakes (Chester Township) caused renewed interest in the area and led to the discovery of other gold showings in the Three Duck Lakes - Clam Lake area (Laird 1932).

In more recent years, exploration activity consisting of one or more among stripping, test-pitting, trenching, geological and/or geophysical work, and diamond-drilling has been carried out by several operators at different times and and in different parts the map-area. Table 1 summarizes recorded data on diamond-drilling in chronological order.

In 1912, a 30-foot shaft was sunk by P. Moore about 1300 m east of Moore Lake. Another shaft (of unknown depth) was sunk before 1932 on a property that was then held by Porcupine-Hecla Mining Company Limited south of Schist Lake (Laird 1932).



LOCATION MAP

Scale: 1:1 584 000 or 1 inch to 25 miles

Gomak Mines Limited was incorporated in 1933 to take over a property in Chester Township which consisted originally of 17 claims, and was later expanded to 24. Surface work and 5,000 feet of drilling were carried out, and in 1935 sinking of a two-compartment shaft, inclined at 65 degrees, was begun on claim S 20009. A 35-ton mill, erected in 1936, operated intermittently from May to December. When operations ceased in 1937, the workings consisted of an 85-foot shaft, with 215 feet of lateral development and 68 feet of raising on the 65-foot level[1]. In 1937, Strathmore Gold Mines Limited sunk a two-com-

[1]Ontario Geological survey, Geoscience Data Centre, Toronto, Source Mineral Deposit Record Files, Chester Township, "Gomak" and "Strathy Basin"

TABLE 1: SUMMARY OF RECORDED INFORMATION ON DIAMOND-DRILLING IN THE JEROME AREA.[1]

Year	Company	Twp.	Location (Claim number)	Number of D.D. holes	Length[2]	Reference[3]
1938	Clam Lake Gold Mines Ltd.	Chester	S 8995-97	11	1,776	Tim. T-2016
1948/50	Chesgo Gold Mines Ltd.	Chester	S 47769	3	388	Tor. DR.#14
			S 48091	8	2,246	Tor. DR.#14
			S 47771	3	995	Tor. DR.#14
1949	Gauthier Group	Chester	S 50050	2	332	Tim. T-2019
			S 50047	5	774	Tim. T-2019
1957	Martin-Bird Gold Mines Ltd.	Chester	S 63415	5	390	Tor. DR.#16
1958	Three Duck Lakes Syndicate	Chester	S 106533	1	177	Tor. DR.#17
		Yeo	S 105993	1	152	Tor. DR.#13
			S 106544	1	159	Tor. DR.#11
			S 106545	1	205	Tor. DR.#11
			S 105987	1	184	Tor. DR.#12
1961	Jonsmith Mines Ltd.	Chester	S 106451	1	101	Tor. DR.#10
		Yeo	S 107051	3	305	Tim. T-2202
1966	Chester Minerals Ltd.	Chester	S 120306	1	308	Tor. DR.#13
			S 125068	3	404	Tor. DR.#13
			S 125070	1	125	Tor. DR.#12
	Beaverbridge Mines Ltd.	Chester	S 120321	2	208	Tor. DR.#11
			S 120324	1	425	Tor. DR.#11
			S 125063	1	250	Tor. DR.#11
1967	Beaverbridge Mines Ltd.	Chester	S 120324	3	1,802	Tor. DR.#11
			S 125064	1	516	Tor. DR.#11
1968	Three Duck Gold Mines Ltd.	Chester	S 121594	1	41	Tor. DR.#15
			S 118911	1	132	Tor. DR.#15
1969	Three Duck Gold Mines Ltd.	Chester	S 121594	1	79	Tor. DR.#15
1970	Beaverbridge Mines Ltd.	Chester	S 120323	1	307	Tor. DR.#11
	Kingbridge Mines Ltd.	Chester	S 121594	1	514	Tor. DR.#15
1971	Kingbridge Mines Ltd.	Chester	S 118912	1	709	Tor. DR.#15
	Caniston Exploration	Chester	S 269250	2	628	Tor. DR.#20
			S 269255	1	403	Tor. DR.#21
	Darwin Mines Ltd.	Chester	S 220897	1	704	Tor. DR.#18
	Miller, Wm. R.	Chester	S 153151	1	150	Tor. DR.#19
1973	Rockzone Mines Ltd.	Chester	S 120326	4	1,047	Tor. DR.#22
			S 125065	2	401	Tor. DR.#22
1979	Texasgulf Inc.	Chester	P 492360	7	679	Tim. T-1842
			P 451639	2	166	Tim T-1842
1980[4]	Lythe, L.K.	Chester	P 537237	1	101	Tim. T-1969
	Cominco Ltd.	Yeo	P 514677	1	90.9m	Tim. T-1953
			P 472916	1	66.6m	Tim. T-1953
			P 514683	1	91.8m	Tim. T-1953

[1]The table contains data available at the time of writing and may be incomplete.
[2]Except where otherwise specified, the length is given in feet to conform to the referenced data.
[3]The following abbreviations are used in the reference list:
Tim — Assessment File available at the Resident Geologist's Office, Ontario Ministry of Natural Resources, Timmins.
Tor DR — Diamond-Drill Report available at the Assessment Files Research Office, Ontario Geological Survey, Toronto.
[4]As of mid-summer, 1980.

partment shaft, inclined at 65 degrees and 125 feet deep on the incline, on claim S 21613 of Chester Township. A level was established at a depth of 100 feet, and 286 feet of lateral development were carried out at this level[1]. Claims S 20009 and S 21613 are currently held by Murgold Resources Incorporated; as of August 27, 1980 the property of this company consisted of a group of 186 claims in east-central Chester Township. In the summer of 1980, Murgold Resources Incorporated was actively engaged in prospecting on parts of the property, and in preparatory surface work at the sites of the old shafts.

In 1935, a two-compartment 125-foot vertical shaft was sunk, presumably by Young-Shannon Gold Mines Limited, in claim S 16304 on Shannon Island (Clam Lake), Chester Township. Lateral development consisted of 110 feet at the bottom of the shaft[2]. In the summer of 1980, the shaft was filled with water and no evidence of recent activity was apparent in the area. Another water-filled shaft is located on the northeastern shore of Clam Lake, in patented claim S 8995. No information on this shaft was available to the author at the time of writing. Claims S 16304 and S 8995 are part of a property consisting of 12 contiguous claims located in western Chester and eastern Yeo Townships. This property is held by an operator known locally as 'Baxter Mines', but no information under this name could be found by the writer in the assessment files. In May of 1980, milling equipment, which was obviously of recent installation, was noted close to the shore of Clam Lake, but this equipment was removed from the property later on in the summer.

In 1936, an inclined two-compartment shaft was sunk to a depth of 200 feet on claim S 19971 in Chester Township by Young-Shannon Gold Mines Limited. In 1936, 172 feet of lateral development were completed at the 100-foot level. In 1937, 160 feet of drifting were completed at the 200-foot level, and a 20-ton mill was installed. Drilling carried out in 1936 and 1937 totalled 2,696 feet[3]. Claim S 19971 is currently held by Canadian Gold Crest Limited, and as of August 27, 1980 the property of this company consisted of 57 contiguous claims located in the Three Duck Lakes - Bagsverd Lake area of Chester Township. In the summer of 1980, the shaft was not operational, but the mill worked intermittently, processing ore from nearby open pits and other areas.

In the summer of 1980, claim staking, airborne geophysical surveys, and prospecting were carried out by Canadian Gold and Metals Incorporated. As of August 27, 1980, the properties of this company in Chester Township consisted of a group of 56 contiguous claims located in the southeastern part of the township and another group of 32 contiguous claims located in the northeastern part of the township.

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[1]Ontario Geological Survey, Geoscience Data Centre, Toronto, Source Mineral Deposit Record Files, Chester Township, "Strathy Basin".

[2]Ontario Geological Survey, Geoscience Data Centre, Toronto, Source Mineral Deposit Record Files, Chester Township, "Shannon Island".

[3]Ontario Geological Survey, Geoscience Data Centre, Toronto, Source Mineral Deposit Record Files, Chester Township, "Young-Shannon".

General Geology

The map-area is crossed by two broadly parallel Early Precambrian (Archean) belts of locally pillowed tholeiitic basalt trending west-northwest and dipping subvertically. The northern basaltic belt is exposed south of Squawman Lake (Potier Township), and in the Schist Lake (Potier-Yeo Townships) Bagsverd Lake (Neville-Chester Townships) area. The southern basaltic belt is exposed south of Yeo Lake in Yeo Township, and in local areas in the eastern part of this township. Close to the western boundary of Chester Township, this belt merges with hornblende metadiorite, metagabbro, and agmatic migmatite which represent recrystallized derivatives of former basalt, metamorphosed and partially assimilated by the intrusion of trondhjemite. These rocks were previously referred to by Laird (1932) as 'granite-diorite complex' and 'diorite breccia' (i.e. agmatic migmatite).

The area between the two basaltic belts is underlain by pyroclastic metavolcanics which may be broadly classed as intermediate in composition owing to the nature and proportions of clasts and matrix. The former are mostly aphanitic to tuffaceous felsic metavolcanics; rare clasts of chert, ironstone, and granitoid rocks may also be present. The granitoid clasts are interpreted as fragments of former subvolcanic felsic intrusive rocks; these rocks are present also as dikelets of coarse feldspar porphyry which are variably metamorphosed and cut the metavolcanics, particularly in the Schist Lake area. The matrix is aphanitic to tuffaceous and is mafic or intermediate in composition. Good exposures of these rocks are found along the eastern shore of Yeo Lake, western segments of the southern shore of Schist Lake, and in the northern part of the Moore Lake area. These rocks are regarded by the author as the upper, and most likely calc-alkaline, section of a tightly folded synclinal volcanic sequence, the lower section of which is represented by the northern and southern basaltic belts. The pyroclastic metavolcanics are locally interbedded with basaltic layers or lens-like bodies of variable thickness. Minor banded mudstone, chert, and/or ferruginous chert are found in the Canoe Lake area and south of Schist Lake in Yeo Township. The rocks regarded as pyroclastic by the author were mapped as metasediments by Laird (1932). A northwest-trending fault cuts the metavolcanics in southern Potier and northern Yeo Townships, and the segment of the sequence west of the fault is displaced about 800 m south of the segment of the sequence east of the fault.

Regional potassic granitic rocks flank the northern and southern basaltic belts and are exposed in all but a narrow strip of southern Potier and Neville Townships, and in the southwestern half of Yeo Township. Central Chester Township is underlain by granitic rocks which, in the central part of the township, are relatively free from metavolcanic xenoliths and/or inclusions, and are markedly leucocratic in character. These rocks are dominantly trondhjemitic in composition and form a broadly oval, west-trending body which intrudes the core of the synclinally folded metavolcanics, and extends westward into the Ash Lake area of Yeo Township. This body is bordered to the south by hornblende metadiorite, metagabbro, and migmatite (see above) which underlie southern Chester Township and extend beyond the southern margin of the present map-area. To the north, the trondhjemitic body is in contact with the pyroclastic metavolcanics. Syenite and lamprophyre (minette) dikelets were found at one locality cutting the regional granitic rocks, and diabase dikes are commonly found throughout the map-area cutting the supracrustal and granitic rocks.

Economic Geology

Gold mineralization in this area is commonly associated with sulphides (chiefly pyrite), and field evidence indicates that the presence of 1) silicified shear zones and quartz-filled fractures in large metavolcanic xenoliths, and 2) silicified fractures in the neosome of migmatite are favourable conditions for gold mineralization.

In 1936, 1,387 tons of ore were milled by Gomak Mines Limited from which 98.314 ounces of gold and 23 ounces of silver were obtained[1]. The following statement refers to the shaft sunk by Strathmore Gold Mines Limited in claim S 21613 of Chester Township: "Data on underground Back sampling of the drift indicated a calculated average value of nearly 0.86 oz Au per ton over an average width of 26" for the northwest drift, and lower values for the southeast drift"[1].

With reference to the shaft on Shannon Island: "Values reported in the Shannon Island shaft to a depth of 22 feet range from 0.32 to 1.82 oz Au per ton, and 1.61 to 6.66 percent Cu"[2].

With reference to the shaft on claim S 19971: "...a zone, 70 feet long, 3 feet wide, and 250 feet deep, contains 3,680 tons of ore averaging 0.46 ounce of Au per ton. It has been blocked out by underground development on two levels, and by diamond drilling. A two-ton bulk sample assayed 0.3 ounce of Au per ton, 0.09 ounce of Ag per ton, and 0.10 percent Cu"[3].

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1932: Geology of the Three Duck Lakes Area; Ontario Department of Mines, Vol.41, Pt.3, p.1-34. Accompanied by Map 41d, scale 1:47 520 or 1 inch to 3/4 mile.

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[1]Ontario Geological Survey, Geoscience Data Centre, Toronto, Source Mineral Deposit Record Files, Chester Township, "Strathy Basin".

[2]Ontario Geological Survey, Geoscience Data Centre, Toronto, Source Mineral Deposit Record Files, Chester Township, "Shannon Island".

[3]Ontario Geological Survey, Geoscience Data Centre, Toronto, Source Mineral Deposit Record Files, Chester Township, "Young-Shannon".

No. 13 Kirkland Lake-Larder Lake Synoptic Mapping Project, Districts of Cochrane and Timiskaming

L.S. Jensen[1]

Introduction

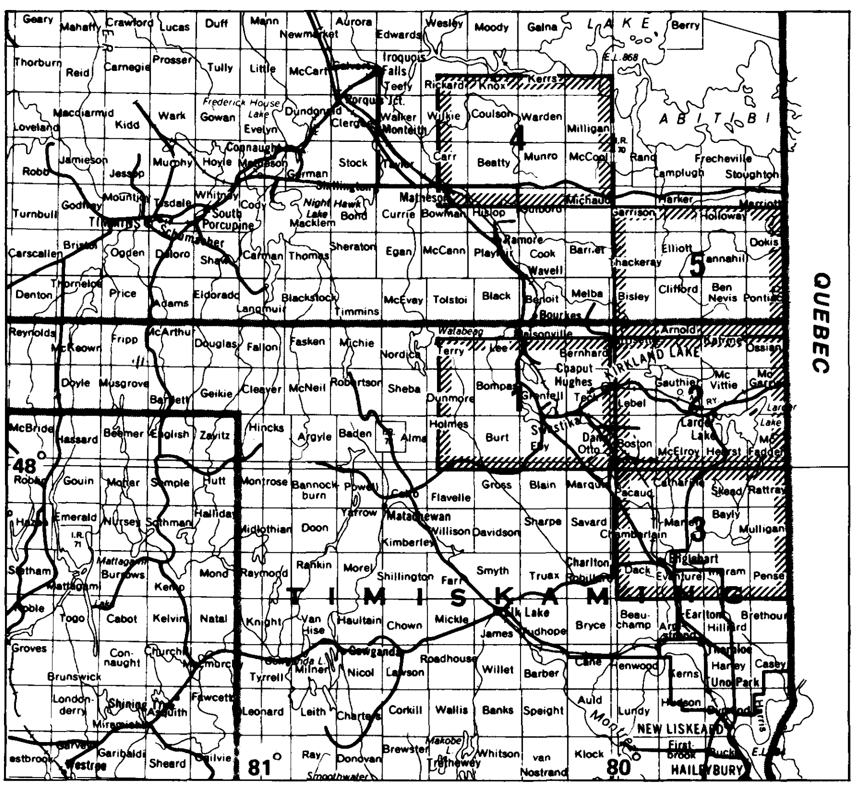
During the 1980 field season, as a continuation of the stratigraphic synthesis of the Timmins-Kirkland Lake sheet, mapping by the author was concentrated in the Kirkland Lake and Larder Lake areas at a scale of 1:63 360. A limited amount of additional mapping was carried out in the Englehart, Lightning River and Magusi River areas.

With the regional mapping, a better understanding of the stratigraphy of the Ontario part of the Abitibi Belt has evolved, so that areas of mineral potential can be better defined and studied with the ongoing detailed mapping (see Jensen 1978a, 1978b, 1979). An emphasis is now being placed on determining the evolution of Abitibi Belt in key areas where mineralization is recognized. The aims are to determine the paleo-environments of deposition of the volcanic and sedimentary rocks, as well as any subsequent alteration and tectonic deformation that may have affected the mineralization (see Grunsky, Trowell, Ploeger, Thomson, this volume).

[1]Geologist, Precambrian Geology Section, Ontario Geological Survey, Toronto.

Mineral Exploration

Gold was initially discovered in the vicinity of Larder Lake in 1906 (Thomson 1943, p.40). Shortly thereafter, several gold mines were brought into production near Kirkland Lake, located 24 km west of Larder Lake, and numerous additional mines were brought into production during the period from 1920 to 1940. Much of this early exploration



LOCATION MAP

Scale: 1: 1 584 000 or 1 inch to 25 miles

activity is described in geological reports on the area by the Ontario Department of Mines.

Between 1950 and 1975, the emphasis has been on the search for base metals, iron and asbestos. Recent fluctuations in the value of gold and silver have spurred new interest in exploring the area for precious metals. For recent mineral exploration in the Kirkland Lake area, see reports by Lovell and Ploeger (1977, 1978, 1979).

The recent release of airborne magnetic and electromagnetic maps by the Ontario Geological Survey and the Ministry of Northern Affairs has spurred a further interest in the Kirkland Lake area (Barlow, this volume).

General Geology

Bedrock in the area consists of Early Precambrian (Archean) metavolcanics, metasediments and plutonic rocks. Middle Precambrian (Huronian) sedimentary rocks unconformably overlie the Early Precambrian rocks in parts of the area. Pleistocene deposits of till, esker deltaic sand and varved clay mantle the bedrock throughout the area (Baker, this volume).

The volcanic succession in the Kirkland Lake area consists of successive volcanic piles, each composed of komatiitic rocks at the base, overlain in turn by tholeiitic and calc-alkalic rocks, and capped by alkalic volcanics. Two such piles, plus the top of an older third pile, are preserved in the Kirkland Lake area. The successive piles together form a stratigraphic section greater than 50 000 m thick, with the uppermost pile being in excess of 35 000 m thick. The volcanic succession is preserved in a large east-plunging synclinorium 80 to 120 km wide (Figure 1).

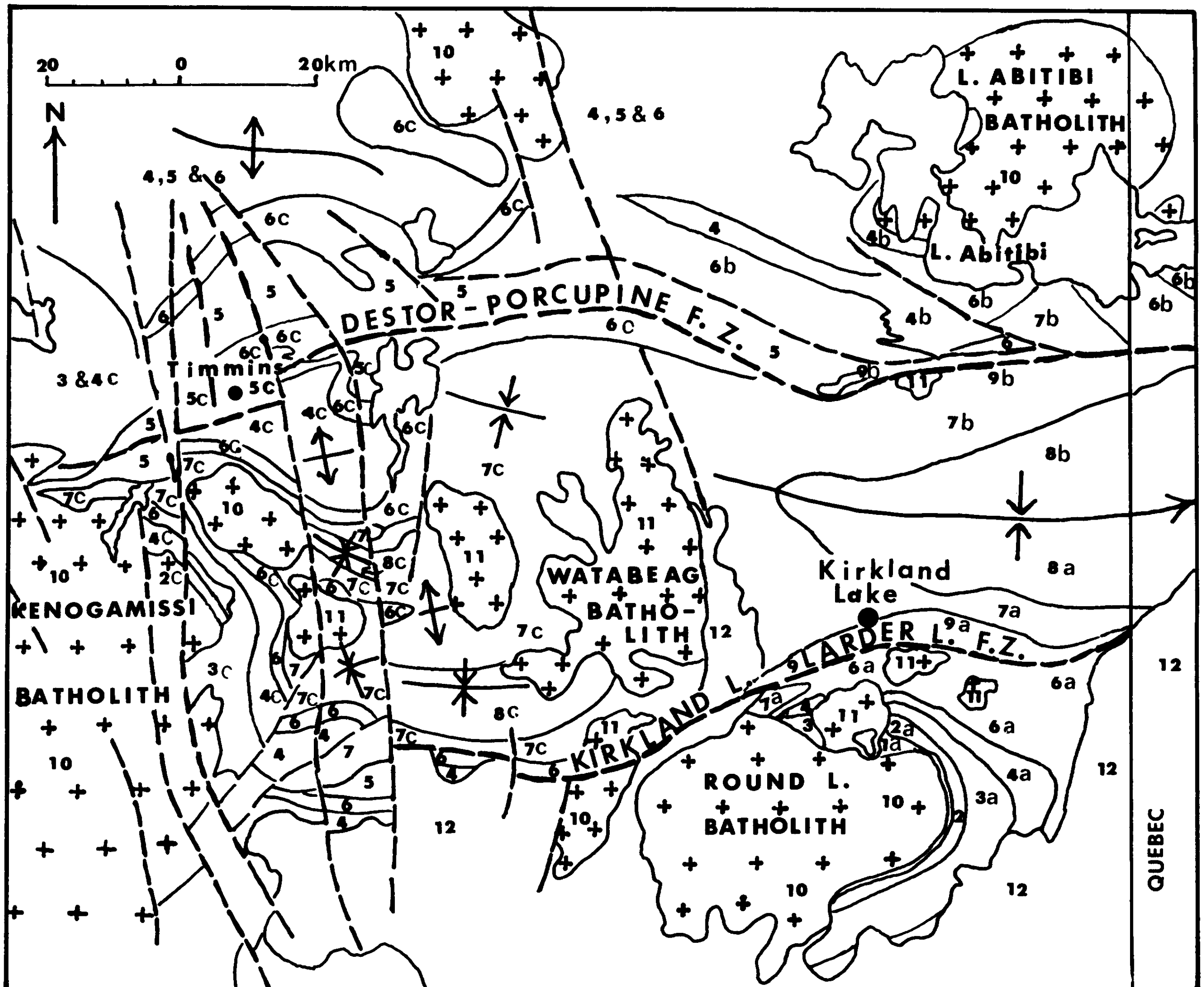
The stratigraphy of the north and south limbs of the synclinorium is shown on Tables 1 and 2 respectively. On the north limb of the synclinorium, the basal komatiitic section of the younger volcanic pile is called the Stoughton-Roquemaure Group. This group is about 10 000 m thick and disconformably overlies calc-alkalic volcanics (Hunter Mine Group) that belong to an older volcanic pile. Except for a few iron-rich tholeiitic basalts at the base and at the top of the Stoughton-Roquemaure Group, it consists of peridotitic komatiite, basaltic komatiite and magnesium-rich tholeiitic basalt, along with a few thin interflow units of cherty tuff and iron formation.

The komatiitic volcanic rocks of Munro Township (Pyke *et al.* 1973; Arndt *et al.* 1977) form part of the Stoughton-Roquemaure Group further west. Many of the komatiitic rocks in the Timmins area farther to the west (Naldrett and Mason 1968; Pyke 1970, 1975, 1978a, 1978b) are probably extensions of the this group.

On the south limb of the synclinorium, the basal komatiitic section of the younger volcanic pile is called the Larder Lake Group (Jensen 1978b). This group disconformably overlies calc-alkalic volcanic rocks (Skead Group) of an older volcanic pile to the south. The thick-

TABLE 1 NORTH LIMB STRATIGRAPHY

Group	Volcanic Rocks	Sediments	Intrusive Rocks	Relationship
Timiskaming Group Destor-Procupine Fault Section 1 000 m	Na-rich mafic to felsic alkali volcanic rocks	Turbidites, conglomerates, wackes, argillite, iron formation	Mafic to felsic syenodiorites, syenites	Faulted contact with SRG and KG
Blake River Group (BRG) 10 000 m	Calc-alkalic basalt, andesite, dacite and rhyolite flows and pyroclastic rocks Minor Mg-rich tholeiitic basalt	Volcaniclastic turbides derived by slumping off volcanic edifices	Gabbro, diorite, quartz diorite and rhyolite domes	Conformably overlies KG
Kinojevis Group (KG) 10 000 m	Mg-rich and Fe-rich tholeiitic basalt with minor tholeiitic andesite, dacite and rhyolite flows	Hyaloclastite and argillite, chert and graphite	Gabbro	Conformably overlies SRG
Stoughton-Roquemaure Group (SGR) 10 000 m	Peridotitic and basaltic komatiite and Mg-rich tholeiitic basalt, Fe-rich tholeiitic basalt at base and top of group	Minor iron formation, chert and tuff	Dunite, peridotite, pyroxenite and gabbro	Disconformably to unconformably overlies HMG or is intruded toward base by Fe-rich tholeiitic basalt
Hunter Mine Group (HMG) 1 500 m	Calc-alkalic basalt, andesite, dacite and rhyolite flows and pyroclastics	Distal tuffs, wackes, argillites, carbonates and iron formation	Rhyolite and dacite, breccia dikes and trondhjemite	Intruded by trondhjemite of Lake Abitibi batholith



LEGEND

Proterozoic
- Keeweenawan diabase (not shown)
- 12 Cobalt Group

Archean
- Matachewan diabase (not shown)

Granitic rocks
- 11 Granodiorite, monzonite, quartz monzonite, syenite
- 10 Massive to gneissic quartz diorite, tonalite, trondhjemite

Upper Supergroup
- 9 9a* Timiskaming Group, 9b** Destor-Porcupine Complex
- 8 8a, 8n, Blake River Group, 8c*** Blake River (Upper Fm., Tisdale Group)
- 7 7a, 7b, Kinojevis Group, 7c Kinojevis Group, (Middle Fm., Tisdale Group)
- 6 6a Larder Lake Group, 6b Stoughton Roquemaure Group, 6c Lower Fm., Tisdale Group
- 5 5c Porcupine Group

Lower Supergroups
- 4 4a Skead Group, 4b Hunter Mine Group, 4c Upper Fm., Deloro Group
- 3 3a Catherine Group, 3c Middle Fm., Deloro Group
- 2 2a Wabewawa Group, 2c Lower Fm. Deloro Group
- 1 1a Pacaud tuffs****

*a refers to Kirkland Lake Area, south limb of synclinorium (Jensen 1978c, 1979).
**b refers to Kirkland Lake Area, north limb of synclinorium (Jensen 1976, 1978b).
***c refers to Timmins Area (Pyke, 1980).
**** (Goodwin, 1965).

Figure 1 — Geological map of the Timmins-Kirkland Lake area showing the distribution of volcanic successions.

ness of the Larker Lake Group is still unknown. It consists of peridotitic komatiites, basaltic komatiites and magnesium-rich tholeiitic basalts interlayered by turbiditic conglomerate, greywacke, argillite, carbonate and iron formation.

Both the Stoughton-Roquemaure and Larder Lake Groups are conformably overlain by tholeiitic rocks belonging to the Kinojevis Group. The Kinojevis Group consists of magnesium-rich and iron-rich tholeiitic basalt with tholeiitic andesite, dacite and rhyolite toward its top. This group is about 10 000 m thick.

Above the Kinojevis Group is a calc-alkalic sequence called the Blake River Group. It consists of magnesium-rich tholeiitic basalt, plus calc-alkalic basalt, andesite, dacite and rhyolite flows and pyroclastic units derived from two or more volcanic centers represented by massive rhyolite domes at the center of the synclinorium. The Blake River Group is about 10 000 m thick.

Unconformably overlying the Kinojevis Group, the Blake River Group and possibly the Larder Lake Group, is the Timiskaming Group. It is about 3000 m thick and consists of alkalic volcanic rocks interlayered with fluviatile sedimentary rocks.

Economic Geology

Kirkland Lake and Larder Lake Areas

The mineralization associated with each group of rocks has been reviewed (Jensen 1979). Recent airborne geophysical surveys carried out by the Ontario Geological Survey for the Ministry of Northern Affairs (OGS 1979) detected numerous electromagnetic anomalies within the Larder Lake Group, many of which are being investigated by mining companies and prospectors. The anomalies are caused largely by graphitic sedimentary rocks which are associated with variable gold, silver, lead, zinc, copper and iron mineralization. The amount and type of mineralization appears to the author to have been controlled mainly by the different environments of deposition for the graphitic sedimentary rocks.

The Larder Lake Group, which is a succession of komatiitic and tholeiitic lavas, appears to have been deposited on a pre-existing sedimentary shelf marginal to a maturing volcanic pile to the south. On the north side, the edge of this shelf sloped steeply northward in the area

TABLE 2 SOUTH LIMB STRATIGRAPHY

Group	Volcanic Rocks	Sediments	Intrusive Rocks	Relationships
Timiskaming Group (Kirkland Lake-Larder Lake Section) 3 000 m	Na- and K-rich mafic to felsic alkalic volcanic rocks and K-rich subalkalic felsic volcanic rocks	Fluviatile conglomerate, wacke and argillite of material derived locally and from LLG	Mafic to felsic syenodiorite and syenites	Unconformably overlies BRG, KG and in places LLG Mainly a fault contact with LLG
Blake River Group (BRG) Kivojevis Group (KG)		See North Limb Stratigraphy		
Larder Lake Group (LLG) Thickness unknown 5000 m	Peridotitic and basaltic komatiite and Mg-rich tholeiitic basalt, minor Fe basalt, calc-alkalic rhyolite tuff toward base of group	Turbiditic conglomerate wacke, argillite of material derived locally from komatiitic flows and distally from SR graphite, carbonate and iron formation	Dunite, peridotite, pyroxenite and gabbro	Disconformably overlies GS
		Pebble conglomerate with syenite clasts.	Syenite intrusion?	
Skead Group (SG)	Calc-alkalic basalt, andesite, dacite and rhyolite flows and pyroclastics	Cherts and iron formation	Rhyolite porphyries	Conformably overlies CG
Catharine Group (CG)	Mg-rich and Fe-rich tholeiitic basalt	Minor argillite	Gabbro	Conformably overlies WG
Wabewawa Group (WG)	Peridotitic and basaltic komatiite and Mg-rich tholeiitic basalt Minor rhyolite-tuff	?	Dunite, peridotite, pyroxenite and gabbro	Overlies calc-alkalic tuffs (Pacaud tuffs)

now occupied by the Kirkland Lake-Larder Lake Fault Zone (see Jensen 1980). The komatiitic and tholeiitic lavas had local sources and were part of the filling of the basin to the north with mafic and ultramafic lava flows. In addition, horizons of calc-alkalic tuff derived from explosive volcanism to the south were deposited among the mafic and ultramafic lavas and clastic sedimentary rocks. These took the form of mass-flow sediments and turbiditic conglomerates, wackes and siltstones, which spread outward onto the floor of the shelf from the higher areas to the south. During periods of low volcanic activity and restricted clastic deposition, chemical sedimentary rocks (carbonates, cherts, iron formtions) were deposited, along with carbonaceous rocks, on various parts of the shelf. Thus, the graphitic horizons are interlayered with mafic and ultramafic lava flows, calc-alkalic tuffs, clastic sedimentary rocks and chemical sedimentary rocks.

Gold is associated with the pyrite in graphitic sedimentary rocks which are interlayered with sedimentary carbonates, and clastic sedimentary rocks on the northern edges of the shelf between Larder Lake and Virginiatown. In many places, the carbonate has been remobilized, as the gold has been, so that it occurs in quartz carbonate veins and carbonatized lava flows.

Sphalerite, galena and argentite occur in pyritic graphitic shales which are interlayered with coarser clastic sedimentary rocks southwest of Larder lake. Elsewhere, chalcopyrite, pyrrhotite and pyrite are mainly associated with graphitic rocks, interlayered with siliceous calc-alkalic tuffs which form interflow horizons 1 to 5 m thick among the mafic volcanic lavas.

In places, these graphitic rocks grade laterally and vertically into cherty iron formation (Jensen 1978b). As yet, the exact relationships between the various graphitic horizons and their mineralization are unknown, but it would appear the mineralization was controlled by the Eh and pH of the sedimentary traps in which carbonaceous material accumulated, the depth of accumulation (Staplin 1969; Radtke and Scheiner 1970) and the location of the traps with respect to the volcanism and erosion to the south. With further work, it should be possible to determine facies of mineralization throughout the Larder Lake Group.

Magusi River Area

The Blake River Group is a calc-alkalic volcanic suite in which gold, copper, zinc and lead mineralization is present in zones of alteration (Grunsky, this volume). Recent airborne geophysical surveys carried out by the Ontario Geological Survey for the Ministry of Northern Affairs detected few electromagnetic anomalies; this supports the conclusion that graphitic and clastic sedimentary rocks are not generally present in the 10 km thick Blake River Group. The absence of sedimentary rocks suggests that the area had a positive relief during the deposition of the Blake River Group. The very low metamorphic grade of the rocks suggests that they were never deeply buried and that only 1 to 2 km of erosion has taken place since their deposition (Jensen 1975; Jolly 1978). Rapid subsidence to accommodate the main mass of the Blake River Group within the core of the regional synclinorium implies that stratabound mineralization will be present as relatively flat deposits capped by significant thicknesses of flat volcanic units. Mineralization would be expected to have occurred near the volcanic vents (Jensen 1975) as the Blake River Group formed. The absence of sedimentary rocks further suggests that, rather than being eroded away or transported, sulphide deposits would have formed proximally and, as they formed, would have been quickly buried by succeeding volcanic units. "Stacking" at depth of flat deposits similar to mineral deposits observed in the Noranda mining camp might be expected.

Lightning River Area

As an interesting historical sidelight, it has been observed that mining was carried out in Frecheville Township during prehistoric times. An examination of lithic material used by the Lake Abitibi area people about 5000 years ago (John Pollock, personal communication) led to the discovery this field season of prehistoric mine workings in Frecheville Township. Large pieces of siliceous interflow tuffs were quarried and carried to the shore of Lake Abitibi where they were used to manufacture stone implements for use throughout northeastern Ontario and northwestern Quebec (Pollock 1976).

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No. 14 Regional Geology of the Cobalt Embayment, Districts of Sudbury, Nipissing and Timiskaming

John Wood[1]

Introduction

Field work carried out during the summer of 1980 is the second phase of a program initiated in 1979 (see Wood 1979). Projects this year involved:

1) completion of a detailed examination of the Gordon Lake and Bar River Formations in the vicinity of McGiffin Lake;

2) continuation of the reconnaissance examination of the component parts of the Gowganda Formation in the northern part of the Embayment; and

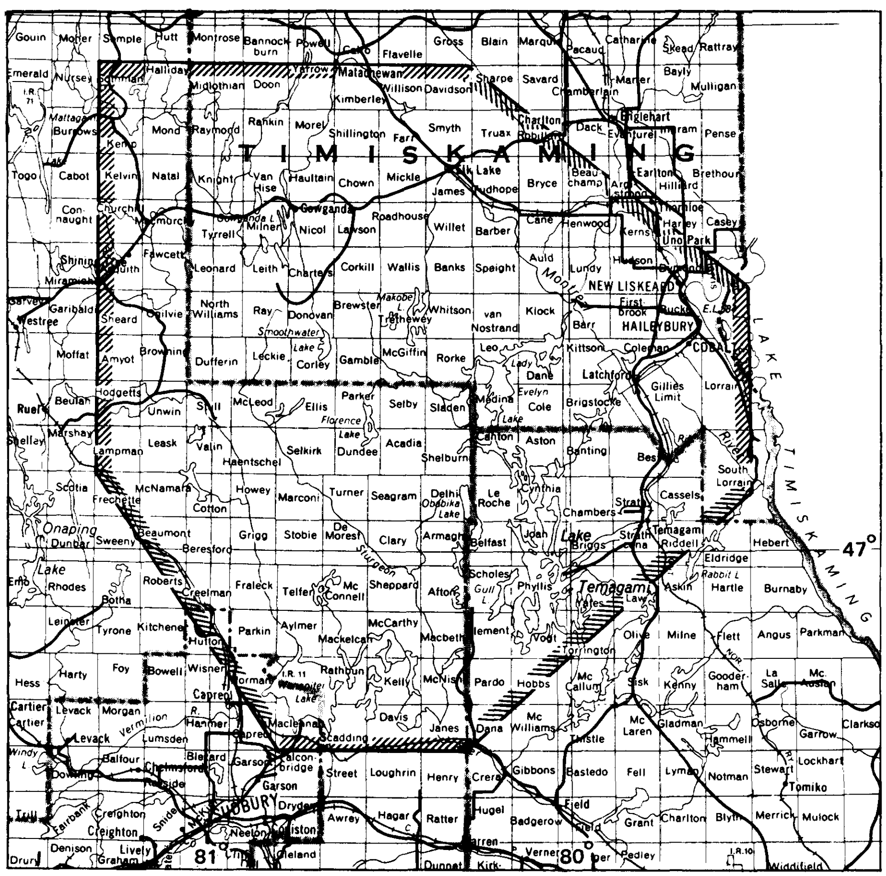
3) examination of the Mississagi Formation near Bull Lake and east of Sudbury.

[1]Proterozoic Subsection Leader, Precambrian Geology Section, Ontario Geological Survey, Toronto.

General Geology

Gordon Lake and Bar River Formations

The descriptions of the Gordon Lake and Bar River Formations given previously (Wood 1979) hold for the area covered this year. The only significant addition is that, in



LOCATION MAP

Scale: 1: 1 584 000 or 1 inch to 25 miles

some localities (e.g. the southern end of Smoothwater Lake), there are large scale (>71 m) crossbeds. These are probably aeolian in origin and fit the concept that the Gordon Lake Formation is principally a tidal flat deposit, the aeolian units having originated as dunes landward of the flat.

Gowganda Formation

Examination of the Gowganda Formation within the Cobalt Embayment was restricted to the Bayly Township, Cobalt and Latchford areas; also, a section near Elliot Lake was examined briefly. It was pointed out last year (Wood 1979) that red beds are absent from the Gowganda Formation south of the northern end of Lake Temegami, are present only in the upper part of the formation near Cobalt and occur throughout the formation to the south of Larder Lake. A precise interpretation of this change has not yet been made. However, the red coloration crosses facies boundaries and some consideration must be given to the possibility that it represents a time line. This would imply that, for the Gowganda Formation, the rocks in the northernmost parts of the embayment are younger than most of the rocks to the south. This could be important from an economic viewpoint, since different ages of Gowganda rocks may have different potentials for detrital mineralization, depending on what was available for erosion at any specific time during deposition of the formation.

Although there can be little doubt, due to the ubiquity of dropstones, that there was a glacial influence on the sedimentation of Gowganda rocks, considerable discussion has centred on the origin of mixtite in the formation. The presence of debris flow deposits north of Elliot Lake attests to the existence of debris flow, and the presence of conglomerate with large clasts (2 m) near a shear zone close to the Turner-Demorest Township boundary indicates a tectonic environment favourable to the formation of debris flows. Emphasis was therefore placed, during fieldwork around Cobalt, on delineating debris flow deposits from glacial deposits. This met with little success, but did show that some of the conglomerate generally considered to be glacial is probably fluvial. A statistically uncorroborated method of identifying the "fluvial" deposits is their local clast population; those currently considered by the author to be glacial have an abundance of exotic fragments not commonly found in basement rocks around Cobalt. Another apparent relationship is that stratabound economic mineralization is found primarily in the fluvial rocks (sandstones and conglomerate) and the lacustrine rocks (mudstones). Further detailed work will be required to substantiate these general observations.

The Archean valleys in which sediments of the Gowganda Formation were deposited have a general northerly trend in the vicinity of Cobalt. The preservation of paleotalus overlain by conglomerate on the west sides of ridges of Archean rocks indicates that at least one of the glacial advances which occurred during deposition of the formation had a strong east to west directional component. Ripple marks in the mudstones at the Little Silver Vein strike N70W and most are assymetric to the north. Rippled mustones in the Silverfields Mine also indicate a northerly current (H. Moore, Teck Corporation Limited, personal communication). However, crossbedded and mineralized sandstone at the Little Silver Vein was derived predominantly from the east. Within the northern part of the Cobalt Embayment, caution should be exercised in extrapolating paleocurrent trends from the trends in preserved areas of Gowganda rocks.

Mississagi Formation

The Mississagi Formation was examined at a number of localities within the Embayment. The bulk of the formation appears to be composed of a multitude of fining upwards cycles. A typical cycle has a sharp base and goes from white to grey quartz arenite or subarkose at the base, through green-grey arkose and grey-green arkose, to green fine sand or mud at the top. The basal parts of beds are extensively crossbedded. East of Sudbury, trough crossbedded sandstone units indicate a paleocurrent direction from the northeast. This part of the formation is fluvial in origin.

The lowermost part of the formation to the northwest, north and northeast of Lake Wanapitei (Meyn 1979) is distinctly different from the upper parts of the formation. Typically, this lower part is composed of conglomerate, pebbly sandstone, immature sandstone and mudstone. Near Bull Lake the conglomerate is composed almost exclusively of felsic volcanic detritus; however, conglomerate composed mostly of chert, vein quartz and quartz arenite clasts is also present and carries the radioactive minerals. This radioactive conglomerate may represent a transitional rock type between the conglomerate with felsic clasts, formed close to source, and the more mature, distal, typically cyclical sandstones. This lower part of the sequence is probably the most complex part of the formation; it is poorly exposed, extensively deformed, and the least understood part; and it is undoubtedly of the greatest economic interest.

Economic Geology

During the examination of the Gordon Lake and Bar River Formations, the rocks were routinely sampled. Several of these samples were submitted for trace element analysis (Geoscience Laboratories, Ontario Geological Survey, Toronto) since the very fine grain size and siliceous character of rocks of the Gordon Lake Formation make the discovery and identification of sulphide minerals difficult. Eight samples had between 20 and 100 ppb Au. Since background Au values in this area are in the 2-6 ppb range, these samples are anomalous in Au. Two samples contained 0.013 and 0.024 percent Cu, compared with background values of less than 10 ppm Cu. Three samples contained greater than 0.01 percent Pb compared with background values of less than 20 ppm Pb. However, none of the high values were common to one sample. If the Gordon Lake rocks were deposited in a sabkha environment (Wood 1973), enrichment in metals near the base of the formation might be expected. This part of the formation in the Cobalt Embayment is seldom exposed and therefore, despite its potential, has not been sampled.

The Mississagi Formation offers potential for economic mineralization (Meyn 1979; Wood 1979). This is illustrated by a sample of dark siltstone, collected by the author from a uranium showing in Grigg Township, which was found to contain 70 ppb Au, 0.014 percent Co, 0.17 percent Cr, 0.03 percent Cu, 0.02 percent Ni, 0.02 percent Pb and 2 pounds per ton U (analysis by the Geoscience Laboratories, Ontario Geological Survey, Toronto). Another sample, from MacLennan Township, contains comparable mineralization and a higher Au concentration (280 ppb). This wide spectrum of mineralization is a result of the concentration of a variety of heavy minerals.

A sample from an offset dike in Parkin Township contained 380 ppb Au, 1.76 percent Cu and 0.2 percent Ni (analysis by the Geoscience Laboratories, Ontario Geological Survey, Toronto). The mineralization is presumed to be of igneous origin.

The abundance of felsic volcanic clasts in the basal Mississagi Formation southwest of Bull Lake prompted the author to look at the Archean basement rocks in that locality. Based on the presence of quartz phyric lapillistone and tuff-breccia and the aerial extent of similar rock types shown on OGS Map 2260 (Card *et al.* 1973), this area of Archean rocks might be worth examining for volcanogenic base-metal deposits.

Discovery of economic deposits in Huronian rocks of the Cobalt Embayment will depend upon detailed sedimentological and structural analyses.

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No. 15 Drag Lake Area, Haliburton County

N.G. Culshaw[1]

Location and Access

The Drag Lake area extends eastward from the town of Haliburton to within 2 km of the village of Wilberforce. It is bounded by Longitudes 78°15′ and 78°30′W and Latitudes 45°00′ and 45°07′N and covers an area of approximately 280 km^2.

Access to the southern and western parts of the area is by Highways 121 and 503 and numerous secondary and cottage roads. In contrast, the northeast quarter of the map-area has few access routes.

Outcrop in the southern half of the area is often obscured by second growth in recently cut hardwood bush.

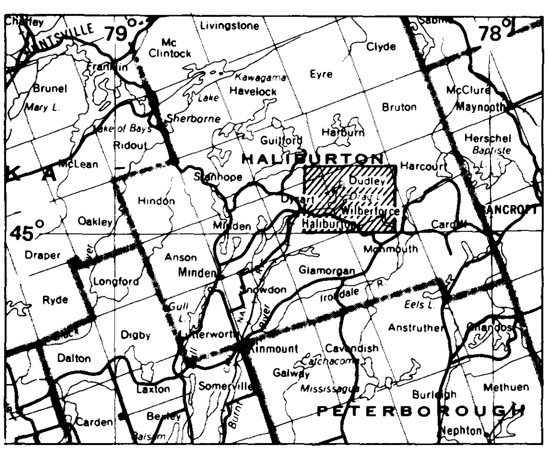
Mineral Exploration

Recorded exploration within the area (Assessment Files Research Office, Ontario Geological Survey, Toronto) has been very limited, with the exception of the extreme southeast corner which overlaps with a zone of considerable exploration for uranium and molybdenum in Monmouth Township. Activity in this area peaked in the mid-1950s. More recently, New Insco Mines Limited conducted a scintillometer survey (1976) on the Cordell Gold Mines Limited showing. In the extreme southwest corner of the map-area, there are similar uraniferous pyroxenite-pegmatite rocks on which Silver Acorn Developments Limited undertook some stripping and drilling in 1979.

Also in the southeast corner, there are two small molybdenite deposits which were worked on a very small scale in the early years of this century. These are now represented by small and partly infilled depressions.

Local residents recall several minor "geiger" surveys carried out in the uranium boom of the 1950s. These are not recorded in the Assessment Files Research Office, Ontario Geological Survey, Toronto.

[1]Geologist, Precambrian Geology Section, Ontario Geological Survey, Toronto.



LOCATION MAP

Scale: 1: 584 000 or 1 inch to 25 miles

General Geology

The rocks may be divided into three main groups; in order of interpreted decreasing age, these are: (1) the Dysart Gneiss (the Dysart Granite Gneiss of Hewitt (1957)) which underlies the northwestern third of the area; (2) supracrustal rocks of the Grenville Supergroup; and (3) younger foliated and unfoliated plutonic rocks which intrude the supracrustals.

Dysart Gneiss

Seventy-five to ninety percent of the Dysart Gneiss consists of a grey, medium- to fine-grained, plagioclase-quartz-biotite (± hornblende and potassium feldspar) tonalitic or quartz dioritic gneiss, with local dioritic and granodioritic variants. The remainder consists of crosscutting foliated pink granitic and pegmatitic sills and dikes. At most localities, the gneiss contains pods or layers of dark amphibolite of unknown origin. All components exhibit a regional southeast-plunging LS tectonic fabric. The relatively homogeneous nature of the gneiss on all scales suggests a derivation from a plutonic ancestor. A sheet of similar amphibolite-bearing gneiss occurs within the supracrustals on the eastern boundary of the map-area and extends into Harcourt Township.

The small part of the northern contact between the Dysart Gneiss and the Eagle Lake Marble Belt which lies within the map-area indicates that the gneiss overlies the supracrustals, in contrast to the southern contact. The gneiss-supracrustal contact may represent an unconformity for the following reasons: (1) the gneiss neither intrudes nor contains xenoliths of the Grenville Supergroup, unlike other orthogneisses of the map-area; (2) it appears to be continuous out of the map-area with rocks of the Ontario Gneiss Segment (Wynne-Edwards 1972), which is considered by Wynne-Edwards to be basement to the Grenville Supergroup, and which also contains the characteristic amphibolite pods and layers (Adams and Bar low 1910; Wynne-Edwards 1972); and (3) a foliation in the gneiss is deformed by the regional lineation and is therefore probably pre-Grenville in age.

Supracrustal Rocks of the Grenville Supergroup

The supracrustal rocks of the Grenville Supergroup include marbles, quartzites, amphibolites, a variety of hornblende-, biotite- and pyroxene-bearing quartzo-feldspathic gneisses and massive pyroxenite. The marbles are uniformly calcitic and always contain one or more silicate minerals, including diopside, phlogopite, chondrodite, tremolite, serpentine, biotite, hornblende and quartz (very rarely). These commonly increase in amount close to syenitic and granitic intrusions and inclusions. Pyroxene scapolite skarns are common.

The supracrustals are always accompanied by some proportion of granitic, syenitic and pegmatitic rocks which form conformable sheets in silicate rocks and are characteristically fragmented in the marbles.

Plutonic Rocks

The plutonic rocks may be subdivided into two groups: (1) an older mafic group and (2) a younger syenitic, monzonitic and granitic group.

Mafic Group

Rocks of the mafic group are found at Dudmon Lake and extending from there southward out of the map-area, and in the Kennibik-Yankton-Allen Lakes area, from where they extend eastward out of the map-area. The Dudmon Lake body is a relatively homogenous and, in part, foliated gabbro. In the second area, mafic rocks form several conformable sheetlike and linguoid masses, each of which has one dominant composition. Primary and metamorphic textures are represented. Gabbro, gabbroic-anorthosite and pyroxenite are the chief rock types. The gabbroic-anorthosites are possible cumulates, since an example of orthocumulate texture, in which mafic material is interstitial to coarse-grained plagioclase laths, is preserved south of Yankton Lake. A similar interpretation is favored for the pyroxenite, which occurs also as blocks within the gabbro south of Allen Lake. These rocks are clearly part of a more extensive mafic complex which extends east of the map-area into the Allen and Farquhar Lakes area.

Syenitic, Monzonitic and Granitic Group

The foliated, conformable monzonites, syenites and granites are found throughout the supracrustals, but are mainly concentrated in a 3 km wide northeast-trending belt extending from the southeast corner of the map-area near Haliburton to Kennibik Lake. This belt is cored by a buff magnetite-rich monzonite with pink syenitic and pegmatitic variants. Corundum is found at several localities. The southerly margin of this body is a wide zone where supracrustals and orthogneiss are interlayered on all scales. This zone has a greater proportion of syenites and pegmatites.

Unfoliated pegmatites occur sporadically throughout the supracrustals near the southern margin of the Dysart Gneiss.

Metamorphic grade (Winkler 1976) is tentatively set at the boundary of medium and high grades at medium pressure.

The compilation map of Hewitt (1957) may be revised in the following ways:

(1) Supracrustal rocks of the Grenville Supergroup are more extensive than shown on this map. They form a continuous band joining the marble belts of Monmouth and Glamorgan Townships to those of Dysart and Minden Townships.

(2) The belt of monzonites and syenites which were not shown on this map are clearly members of the well-known suite of alkalic rocks which extends from Monmouth Township for many kilometres to the northeast (Appleyard 1974).

Structural Geology

In general, the units strike northeastward and dip moderately to the southeast. Most units, except the marbles, have an LS fabric with a southeast-plunging lineation, as is characteristic of gneisses at the northern boundary of the Grenville Supergroup (Hewitt 1962).

Zones of northwest strikes are locally developed. In the Winona Lake-Esson Lake area, such a zone is the result of coaxial, cylindrical refolding of the older northeast trends, such that the new axial surface is nearly parallel to this old northeast trend and the new fold axis is parallel to the old lineation. Granitic and syenitic dikes emplaced during this refolding bear the regional LS fabric, indicating that this refolding is essentially continuous with the main fabric-producing event.

The possibility that the LS fabric was produced during thrust displacements would be strengthened if the identification of the Dysart Gneiss as basement, and the correlation of the gneiss sheet to the east of the area with the Dysart Gneiss, were to be confirmed.

Economic Geology

Bright (1977) states that all economically important concentrations of uranium mineraliation in the Eel's Lake area, which adjoins the Drag Lake area to the southeast, occur in the Tory Hill, Eel's Lake and Cavendish Formations of the Hermon Group of the Grenville Supergroup. The season's mapping has shown that rocks which are continuous with Bright's Tory Hill Formation (Bright 1977, Figure 1) and lithologically identical extend south and east of Drag Lake and underlie approximately one-third of the map-area. All radioactive mineralization identified during the mapping occurs in these rocks, as do all of the uranium properties. The association of the pegmatite in which the mineralization occurs with pyroxenite-marble is fairly common. This formation is therefore a possible target for exploration.

Molybdenite mineralization occurs in an environment similar to that of the uranium mineralization. Several showings were identified by the field party, mostly in skarns and pegmatites associated with marbles, but also, in one exceptional instance, as a fracture coating in a foliated granite of the Dysart Gneiss.

Disseminated magnetite occurs in many of the syenite and monzonite gneisses which intrude the Grenville Supergroup. Two kilometers northeast of Hurst Lake a 1.5 km long lens of the gneiss has concentrations of magnetite in excess of 40 percent.

Iron-sulphide mineralization (pyrite, pyrrhotite) occurs in several environments: within coarse salmon-pink and grey marbles which mantle and fill fractures in the syenitic and monzonitic gneisses where they intrude the marbles; disseminated in discrete horizons in the marbles and metamorphic pyroxenite; in narrow layers of rusty syenite lying within the marbles; and within some foliated granitic pegmatites within the Dysart Gneiss.

Minor quantities of corundum occur within isolated horizons in the syenitic and monzonitic gneisses.

A tongue of Pleistocene fluvioglacial sand and gravel extends in a 1 to 2 km wide north-northeast-trending belt from the north and south ends of Drag Lake. It is now exploited as a source of crushed stone.

Of interest to mineralogists is the occurrence of deep blue scapolite near Holland Lake on the property of the Haliburton Scout Reserve.

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No. 16 Regional Structure and Stratigraphy of the Burleigh Falls Area, Peterborough County

E.G. Bright[1]

Introduction

During the 1980 field season, as an extension of the structural and stratigraphic synthesis of the Bancroft uranium belt of the Grenville Province by the writer (Bright 1977, 1979), a synoptic reconnaissance mapping project of the Burleigh Falls area was carried out at a scale of 1:63 360. The Burleigh Falls area, which forms the southern part of the Bancroft uranium belt, covers about 1000 km^2 and is bounded by Latitudes 44°30′ and 44°45′N and Longitudes 78°00′ and 78°30′W.

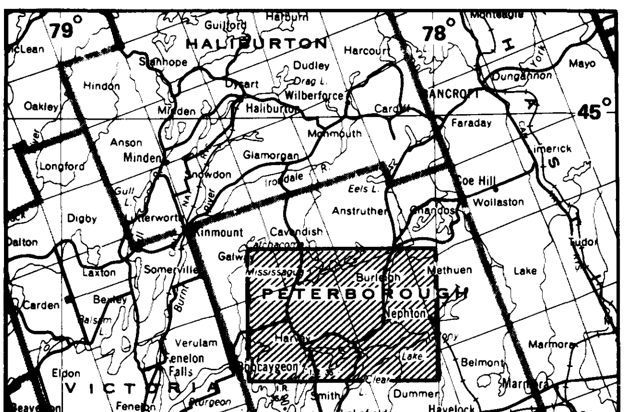
Mineral Exploration

Exploration in the area was originally sparked by the discovery of corundum in the nepheline and alkaline syenites at the turn of the century. Commercial development of nepheline syenite at Blue Mountain in Methuen Township commenced in 1936 and has continued since that time. Output in 1980 was from two major producers: Indusmin Limited and Sobin Chemicals (Canada) Limited.

Since the 1950s most of the exploration has been concentrated in and near the more than 15 known uranium prospects in the northwestern part of the map-area. Periods of peak activity occurred during the mid-1950s, the late 1960s and the 1970s. Production feasibility studies were carried out in the late 1970s by Amalgamated Rare Earth Mines Limited and Esso Resources Canada Limited on their Cavendish uranium deposit in Cavendish Township, and by Camindex Mines Limited on their Loon Call Lake uranium deposit in southeastern Anstruther Township.

To date, there has been little recorded exploration effort directed towards the base-metal potential of the area. In 1975-1976, Imperial Oil Limited examined a copper occurrence associated with minor uranium mineralization on their property holdings in central Harvey Township.

[1]Geologist, Precambrian Geology Section, Ontario Geological Survey, Toronto.



LOCATION MAP

Scale: 1: 1 584 000
or 1 inch to 25 miles

General and Structural Geology

The Burleigh Falls area lies along the southwestern exposed margin of the Grenville Supergroup. Late Precambrian metasediments and metavolcanics, together with a variety of syntectonic to late tectonic, mafic to felsic and alkalic intrusive rocks, underlie the entire map-area. Approximately 60 km to the north of the map-area, this supracrustal sequence rests unconformably upon the southeastern flank of the Algonquin batholith, a regional Middle Precambrian plutonic-gneiss complex which underlies the central part of the Grenville Province of Ontario (Lumbers 1980). Within and beyond the Burleigh Falls area, the entire supracrustal sequence was subjected to a Late Precambrian orogeny consisting of polyphase deformation accompanied by regional metamorphism under conditions ranging from middle to upper almandine-amphibolite facies. Felsic plutons of several ages were emplaced at successive stages during and after culmination of this high-rank metamorphism. During this late metamorphism, which is commonly referred to as the "Grenville Orogeny", the older Middle Precambrian Algonquin batholith was reactivated and became diapiric into the supracrustal rocks of the Grenville Supergroup. Within the map-area, the Burleigh dome, which forms the southern segment of the Harvey-Cardiff basement arch, developed during this period of diapirism. The Precambrian-Paleozoic unconformity passes through the southern part of the area.

The Burleigh Dome

The geology of the map-area is dominated by the Burleigh dome, a 16 km wide oval-shaped center of unexposed basement uplift and granitic intrusion in eastern Harvey and western Burleigh Townships. A thick sequence of Anstruther Lake Group arenaceous metasediments, the lowest sequence of the Grenville Supergroup, completely mantles the inferred basement gneiss complex in the core of the Burleigh dome. Subhorizontal gneissic foliation and recumbent folding are dominant here. Stratigraphically overlying the Anstruther Lake Group arenites, along the flanks of the Burleigh dome, are the intercalated mafic to felsic metavolcanics and clastic to calcareous metasediments of the Hermon Group. The Hermon Group is repeated several times along the flanks of the Burleigh dome by a series of southwesterly-plunging folds which are overturned to the west-northwest. The basal sequence of the Hermon Group on the flanks of the dome is predominately impure marble with subordinate calc-silicate gneiss, metawacke and pelite. However, this basal calcareous sequence undergoes a facies change southeastward through Stoney Lake into a thick basal sequence of thinly-bedded, fine-grained meta-arkose containing several intercalated units of polymictic quartzite-pebble conglomerate. This basal arkosic-conglomeratic sequence can be traced along strike into Methuen and Belmont Townships where it has been stratigraphically defined as the Oak Lake Formation by Hewitt (1961).

Stratigraphically overlying the Hermon Group metavolcanics is the Mayo Group, a sequence of predominantly impure marble containing subordinate calc-silicate gneiss units. The Mayo Group carbonates, which underlie eastern Burleigh Township and northwestern Methuen Township, are structurally confined to the Jack Lake carbonate basin, a cross-folded southwest-plunging synclinorium. North of Jack Lake, along the northern margin of this basin, the carbonates of the Dunganon Formation are stratigraphically overlain by the wackes and ferruginous arenites of the Apsley Formation. In the northwest corner of the map-area, Mayo Group marbles form a southwest-plunging syncline along Nogies Creek in Galway Township.

Metavolcanics West of the Burleigh Dome

A relatively thick sequence of mafic to felsic metavolcanics forms the Squaw River syncline on the west flank of the Burleigh dome in southwestern Cavendish and central Harvey Townships. The lower mafic to intermediate metavolcanic sequence of flows, flow breccias, subordinate tuff and minor interflow metasediments is exposed along Pigeon, Little Bald, Big Bald and Mississagua Lakes. Towards the top of this lower sequence, the mafic to intermediate metavolcanics are interlayered with felsic metavolcanics and, more locally, with epiclastic metasediments. The felsic metavolcanics increase in abundance towards the core of the Squaw River syncline; a fine- to medium-grained foliated synvolcanic quartz monzonite intrusion occupies the core of the syncline. The upper felsic volcanic sequence consists predominately of tuff, lapilli tuff with minor flows, and subvolcanic sills. Near the top of the succession, the felsic metavolcanics are interlayered with chemical metasediments composed mainly of muscovite-quartz-pyrite schist, pyrite-calcite-quartz schist and pyrite-quartz-rich metatuff or metachert; interlayered locally are biotite- and sillimanite-rich gneiss and schist units. The Squaw River mafic to felsic metavolcanic sequence is repeated in the southeastern part of Galway Township.

Metavolcanics East of the Burleigh Dome

A previously unreported narrow belt of mafic to felsic metavolcanics is well exposed along the shores and islands of Stoney Lake in southern Burleigh Township. This tightly folded volcanic sequence structurally underlies the Mayo Group carbonates of the Jack Lake basin in eastern Burleigh and northwestern Methuen Townships. The belt is exposed along the eastern flank of the Burleigh dome from Loon Call Lake southward through Big Cedar Lake; near Burleigh Falls the belt swings eastward through Stoney Lake to Jack Creek, where the trend changes to a northeasterly direction and follows the eastern margin of the Jack Lake basin. The Stoney Lake volcanics are similar to the previously described Squaw River volcanics, except in the eastern part of the Stoney Lake belt where the top of the fine-grained felsic pyroclastic sequence contains intercalated units of mafic to felsic alkalic tuffaceous rocks. These alkalic metavolcanics structurally overlie the Blue Mountain gneissic syenite-nepheline syenite intrusive complex; locally, the alkalic metavolcanics are cut by alkaline syenite sills and dikes. The Blue Mountain alkaline intrusive complex appears to be the synvolcanic equivalent of the alkalic volcanism in Methuen and Burleigh Townships.

Economic Geology and Exploration Recommendations

Base-Metal Mineralization

The Cavendish-Harvey volcanic belt on the west flank of the Burleigh dome has the highest potential for base-metal and precious metal mineralization in the map-area. The present study indicates that the volcanic rocks in the area are more extensive than previously indicated. The presence of a substantial volume of coarse pyroclastics in southwestern Cavendish Township suggests that the area is close to a former volcanic center.

Sulphide gossans and zones of disseminated to stringer pyrite mineralization containing minor chalcopyrite, sphalerite, arsenopyrite and pyrrhotite (Morton 1978) are widespread in the interlayered felsic pyroclastics and chemical metasediments in Harvey Township 1) south of Highway 36 on lots 17 and 18, concessions XII and XIII, and on lots 14, 15 and 19, concession XII; 2) north of Highway 36 on lots 20, 27 and 30, concession XI; and 3) south of Little Bald Lake on lot 15, concession XI and lot 14, concession XII. Small showings of chalcopyrite and molybdenite with pyrite and traces of bornite occur in breccia zones within and along the contacts of the synvolcanic quartz monzonite stock in central Harvey Township on lot 22, concession XI, lot 20, concession IX and lot 19, concession XII. The breccia zones consist of numerous mineralized stringers, veins and open space fillings which surround and seal small fragments to large blocks of quartz monzonite (Morton 1978).

In Cavendish Township, minor blebs of chalcopyrite associated with disseminated pyrite and pyrrhotite are present in the metavolcanics on the south halves of lots 12 and 13, concession VI. Rusty zones and pyrite-quartz-rich metasediments within the metavolcanics are present in lot 28, concession VI, Galway Township and in lot 5, concession XI, Burleigh Township.

Uranium Mineralization

Late Precambrian Rocks of the Grenville Supergroup

Within the Burleigh Falls area, uranium-bearing granite pegmatites are stratigraphically concentrated in the tightly folded, high-rank metavolcanics and metasediments of the Hermon Group along the flanks of the Burleigh dome. These same late tectonic potassic pegmatite sills and dikes are equally as abundant in the Anstruther Group arenites and the Mayo Group carbonates, but to date no important concentrations of uranium mineralization have been found in either group anywhere in the Bancroft uranium belt (Bright 1977). Exploration is warranted in the new areas of metavolcanics outlined above that previously were considered to be entirely underlain by Mayo Group carbonates.

Paleozoic Rocks of the St. Lawrence Platform

The flat-lying Paleozoic strata which unconformably overlie the southern part of the Bancroft uranium belt in Harvey Township should be considered as a potential target for uranium concentrations analogous to the Ordovician South March uranium deposit in March Township near Ottawa (see Grasty 1973).

The basal unit of the Paleozoic strata in Harvey Township is conglomeratic feldspathic sandstone of the Ordovician Shadow Lake Formation (Liberty 1955). A reconnaissance scintillometer survey of this permeable clastic unit by the writer indicated no anomalous radioactivity.

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No. S1 Molybdenite Lake Area, District of Algoma

Z.L. Mandziuk[1]

THIS PROJECT WAS FUNDED BY THE ONTARIO MINISTRY OF NORTHERN AFFAIRS THROUGH THE NORTHERN ONTARIO GEOLOGICAL SURVEY (NOGS) PROGRAM.

Introduction

Geological mapping of André and Bailloquet Townships at a scale of 1:15 840 was conducted during the 1980 field season as one of the special projects of the NOGS program. The center of the map-area is accessible by road and is located 11.5 km northwest of the Town of Wawa. Latitudes 48°01'5" and 48°06'26"N and Longitudes 84°47'34" and 85°00'00"W delimit the boundaries of the map-area, which includes all of Bailloquet Township and the eastern two-thirds of André Township, an area of 146 km^2. Trans-Canada Highway 17 runs north through the eastern part of Bailloquet Township, providing access to the two largest lakes in the area, Black Trout and Catfish. A private logging road from Highway 17 in the southwestern part of the area provides access northwards and westwards as far as the Doré River. At the south end of Catfish Lake, another network of logging roads penetrates 2 km west to Black Trout Creek and, in the southeastern part of the area, a private road follows the east side of the Magpie River. A hydro power line cuts across the southwest corner of the area and a microwave communication tower and access road are located in the northeast corner. Molybdenite Lake is accessible by float-equipped aircraft, while helicopter support was used in the extreme northern and western parts of the area.

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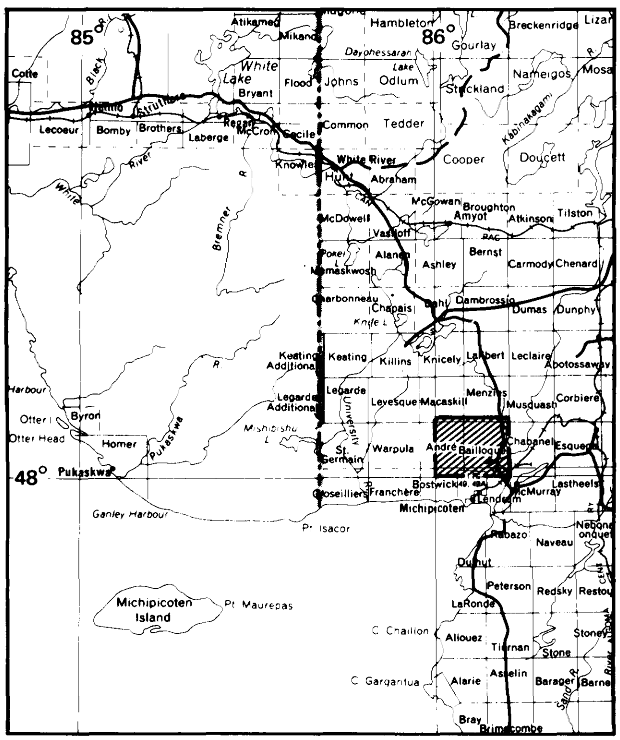


LOCATION MAP **Scale: 1: 1 584 000 or 1 inch to 25 miles**

Mineral Exploration

Situated close to the Michipicoten iron ranges, the area has undergone a long history of intermittent exploration for iron ore, gold, and base metals. Exploration work has mainly concentrated on two properties: the Mildred iron range, discovered in 1906, and the Molybdenite Lake molybdenum prospect, first explored prior to 1905.

The Mildred property consists of 10 patented claims belonging to the Algoma Steel Corporation; seven of the claims occur in the southeast corner of Bailloquet Township. Rupert's (1979, p.65-68) report on McMurray Township summarizes the history of exploration and geology of this property. Additional unpublished reports, maps, drill logs, and magnetic and gravity survey plans covering the period 1909 to 1951 are available from files of the Resident Geologist's Office, Ontario Ministry of Natural Resources, Sault Ste. Marie.

The main showings of the Molybdenite Lake prospect are located on currently unclaimed land at the end of the southeast arm of Molybdenite Lake. Available records indicate that in 1939 Superior Molybdenum Company Limited established a cut-line grid over the showings and put in 12 trenches (570 m total) and four diamond-drill holes (averaging 46 m in length). Magnetometer and geological surveys were also conducted, and in 1940 a selected bulk sample of 98 tons sent to the Mines Branch in Ottawa yielded an average assay of 0.5 percent MoS_2. International Ranwick Limited examined the property in 1958 but did no additional work. During 1963-64 additional trenching, line cutting, and magnetometer and geological surveys were conducted by the Algoma Central and Hudson Bay Railway Company. The International Nickel Company of Canada Limited examined the property during 1964-65 under option from the Algoma Central Railway. Soil and bedrock samples were tested for molybdenum and some stripping and blasting were carried out over the showings prior to diamond-drilling of five holes totalling 468 m. As a result of unfavourable drilling results International Nickel terminated the option and no further development work has since been done on this property.

Other older records received from the Algoma Central Railway and filed at the Resident Geologist's Office, Ontario Ministry of Natural Resources, Sault Ste. Marie refer briefly to a quartz vein, containing chalcopyrite and other sulphide mineralization in two trenches on the defunct Surluga claims north of Black Trout Lake. Little information is available on this occurrence and the current survey was unable to locate the described trenches which are thought to be several decades old. During 1980, two claims were staked at the south end of Bailloquet Township, but no exploration work was recorded.

General Geology

The Wawa area is currently being mapped by Sage (1979 and this volume) to the east and south of Bailloquet Township. Approximately two-thirds of the map-area are underlain by granitic rocks, with the remaining eastern parts underlain by the Wawa supracrustals (Figure 1). The supracrustals include Early Precambrian mafic metavolcanics, felsic metavolcanics and metasediments.

Progressively metamorphosed mafic metavolcanics are well-foliated to occasionally massive or pillowed; they are frequently intercalated with metasediments (argillites and reworked tuff) and felsic metavolcanics. Rock types include tuff, breccia, flows and subvolcanic intrusions. Metamorphic effects within these rocks have resulted in hornfelsic chlorite + amphibole lithologies which, toward the granite contact, give way to schists and gneisses containing biotite + amphibole $\pm$ garnet.

Felsic metavolcanics consist of tuff, lapilli-tuff, tuff-breccia, flows and shallow intrusive porphyries. The rocks are strongly foliated to occasionally massive with a predominance of crudely banded pyroclastic units of uniformly silica-rich composition.

Metasediments display close spatial and genetic relationships with the metavolcanics. Finer grained facies consist of laminated to sub-fissile argillaceous wacke, tuffaceous wacke, and mottled biotite amphibole paragneiss which becomes migmatitic in proximity to granitic rocks. The Doré sedimentary rocks, first described by Logan (1863), occur in the southeastern part of the map-area. They form an east-trending band of dominantly polymicitc, matrix-supported and poorly sorted conglomerates, and of finer grained turbidites. Relict bedding structures, textures and stratigraphic relations suggest that a high energy fluviatile deposition of coarse intraformational detritus within a rapidly accumulated volcanic terrain is a model which accounts well for the nature of the Doré series in the map-area.

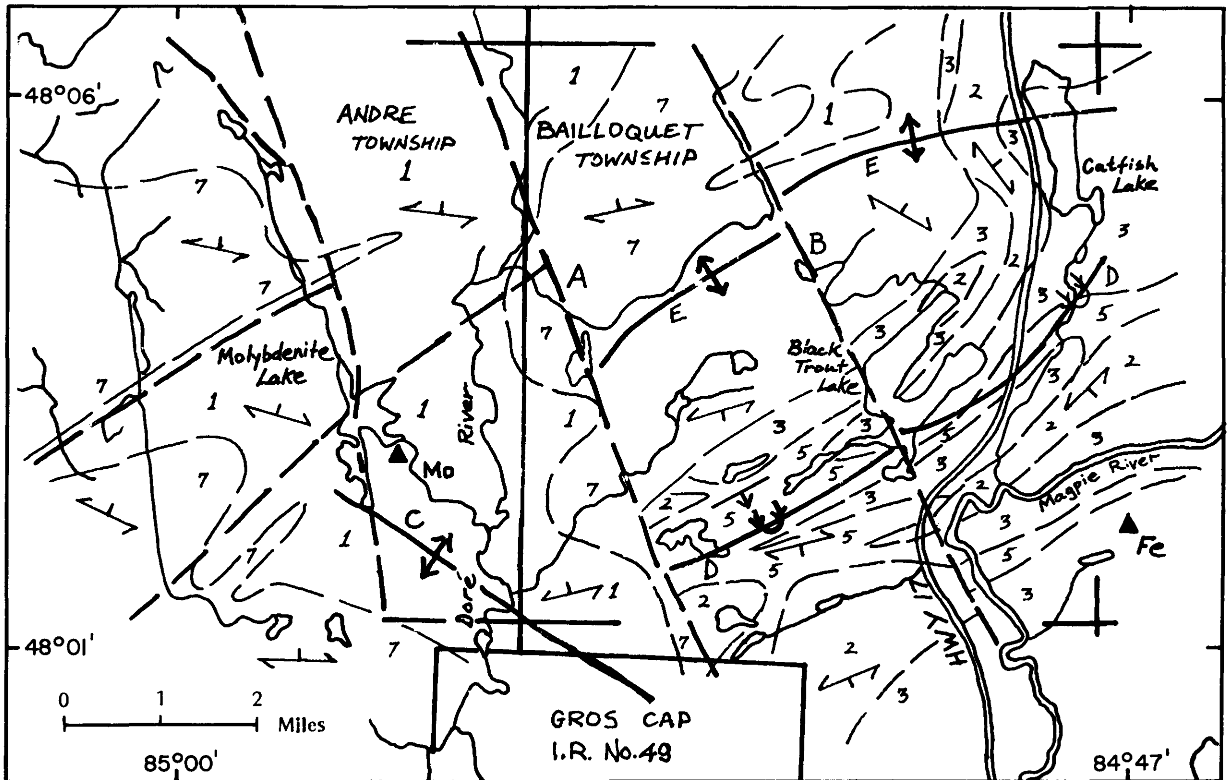
Granitic rocks are composed of several phases. The oldest phases are well exposed around the shores of Molybdenite Lake and consist of gneissic biotite $\pm$ hornblende trondhjemite, granodiorite, diorite and migmatite. Later more massive phases consist of quartz monzonite, granodiorite, granite, quartz diorite, aplite, migmatite and hybridized granitic rocks. These intrude both the supracrustals and the early granitic gneisses, though contact with the latter is usually poorly defined and gradational. The latest phases of this felsic intrusive activity were responsible for widespread potash metasomatism and the emplacement of fault-controlled quartz veins following separation of hydrous fluids at mesozonal levels. Within the early-phase gneisses, remnant zones of melanocratic schists (mafic paleosomes) display progressive stages of deep-seated metamorphic differentiation and recrystallization towards trondhjemitic end products with granoblastic textures. These relicts probably represent enclaves of an early Archean protocrust upon which the Wawa supracrustals were originally deposited, as has been proposed by Collins and Quirke (1926, p.25-26).

North- to northwest-trending diabase dikes intrude all other rock units.

An important geologic feature within the map-area is the contact zone between supracrustal metavolcanics-metasediments of the western limit of the Wawa greenstone belt and the granitic complex to the west. The contact is similar to that in Lastheels Township as described by Sage (1979), but with fault-controlled intrusive relations dominating and metamorphic facies of upper greenschist to upper amphibolite grade. In most places, the contact is obscured by overburden or is gradational over short distances; xenoliths are not abundant except near infrequent agmatite zones.

Structural Geology

The structural geology of the map-area has resulted from a complex tectonic history (Figure 1). Within the supracrustals, metamorphic structures generally conform in orientation to the granitic contact, with progressive steepening of dips occurring to the south. The belt is roughly arcuate and convex to the east, with graded bedding and pillow top determinations consistently to the southeast. Limited exposure of supracrustal rocks renders stratigraphic interpretations uncertain though structural data suggest, in agreement with Goodwin (1962) and Cooke (1937), that the Doré sediments occupy the axial area of the South Range Syncline which is overturned to the north and trends north of east (Goodwin 1962, p.565). To the north, the Catfish Lake Anticline trends eastwards from the Tremblay Lake Fault to Catfish Lake and, together with the South Range Syncline, has been cross-folded by the northwest-trending Doré Cross Anticline. Three north-trending transverse faults cut across the area, horizontally displacing fold axes and lithologic units by about 1 km of left-hand movement. These include the Black Trout Lake and Tremblay Faults. Younger secondary rank faults trend northeast across the map-area and are possibly related to yet another deformational event. Faulting has, in places, exerted control on the emplacement of diabase and quartz veins.



LEGEND

A Tremblay Fault
B Black Trout Lake Fault
C Dore Cross Anticline
D South Range Syncline
E Catfish Lake Anticline

1 Early phase intermediate to felsic intrusive rocks, includes granitic gneiss, granofels, cataclasite and paleosomes of strongly foliated melanocratic rocks with incipient granitization.
2 Mafic metavolcanics; pillowed to massive flows and tuffites, derived mafic hornfels and migmatitic gneiss; subvolcanic intrusives.
3 Felsic metavolcanics; pyroclastics, flows, tuffites and derived felsic hornfels, schists and migmatite; also subvolcanic intrusives, ironstone.
4 Metasediments; massive to laminated wacke and argillite, derived migmatitic paragneiss; also polymictic conglomerate, and turbidites (Dore series).
5 Late phase intermediate to felsic intrusive rocks; massive to sub-foliated; includes subvolcanic equivalents, agmatite and very late quartz veins.

Figure 1 — Generalized geology of the Molybdenite Lake area.

Economic Geology

At least twelve widely distributed molybdenum-quartz vein occurrences are present in the vicinity of Molybdenite Lake. Most occurrences consist of small, erratically distributed, northeast-trending milky quartz vein systems containing spotty low-grade to trace mineralization. On the main occurrence, which covers an area of approximately 100 by 300 m, disseminated to massive mineralization is associated with a large-scale network of discontinuous to stockwork-like quartz veins. The veins strike N30E and dip 30 degrees or more to the west. They intrude a leucocratic trondhjemite-granodiorite gneiss that contains abundant melanocratic phases. Mineralization is erratic and some of the veins appear to be barren under hand lens. The highest concentrations of molybdenite are associated with larger veins up to 1.2 m wide, with MoS_2 occurring mostly as massive smears (up to 1 cm thick) along the quartz vein contacts and in slip planes and fractures within both quartz veins and gneiss which are disposed at various angles to the contacts. Pods and disseminations of euhedral molybdenite in hexagonal flakes up to 1.5 cm across occur in the quartz and in the granitic rocks for up to 0.3 m from the contact. Biotite selvages are associated with some of the veins and tourmaline, pyrite and bismuthinite (mineral identification by the Geoscience Laboratories, Ontario Geological Survey, Toronto) are minor accessories.

An anticlinal axis, trending northwest across the south of Molybdenite Lake, and a system of northeast-trending fault zones, which transect the lake in at least five places, probably directed the regional movement of vein-forming fluids which precipitated molybdenite. The mineralized veins are spatially associated with melanocratic paleosomes in the trondhjemitic gneises.

The increasing value and demand for molybdenum warrant careful consideration of the potential of the Molybdenite Lake prospect. Economic mineralization has not been substantiated at this occurrence. However, because of the erratic distribution of molybdenum-quartz veins, previous workers have indicated uncertainty in the determination of average grades and tonnage. Very finely disseminated molybdemite and random high concentrations also complicate attempts at evaluation.

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PRECAMBRIAN — SPECIAL PROJECTS

No. S2 Abitibi Alteration Study

E.C. Grunsky[1]

THIS PROJECT WAS FUNDED BY THE ONTARIO MINISTRY OF NORTHERN AFFAIRS THROUGH THE NORTHERN ONTARIO GEOLOGICAL SURVEY (NOGS) PROGRAM.

Introduction

Examination of altered and unaltered volcanic rocks in the Kirkland Lake area of the Abitibi Belt is being continued into the second year of a three-year study. The purpose of the study is to determine the style and nature of the alteration of volcanic rocks as reflected in the chemistry and petrography and, by using computer-based methods, to study any possible correlations between alteration patterns and the presence of precious and base metal deposits. The area of study is currently restricted to Ben Nevis and Clifford Townships (Figure 1). The rocks of this area consist of a suite of proximal calc-alkaline volcanic flows and pyroclastics, classified as part of the Blake River Group (Jensen 1978) and situated in the centre of a large east-trending synclinorium.

Many precious and base metal deposits have extensive halos of alteration caused by the circulation of hydrothermal fluids (Sangster and Scott 1976). Early Precambrian 'greenstone' belts have been shown to contain numerous chemically and petrographically anomalous areas (Lavin 1976; Brooker 1979; Beswick and Nichol 1979), many of which contain producing mines or proven deposits. These anomalous areas are composed of volcanics that have been altered in their chemistry, mineralogy and, in extreme cases, texture. The bedrock chemistry of Ben Nevis and Clifford Townships has been shown to be anomalous by Wolfe (1977), who reported several Zn anomalies in the bedrock chemistry. The largest of these anomalies is over the Canagau Mines Limited deposit in eastern Ben Nevis Township (see Jensen 1975a). The deposit consists of massive and disseminated base-metal sulphides containing 0.15-0.84 percent Cu, 0.5-8.0 percent Pb and 0.03-11.5 percent Zn, and precious metals at concentrations of 0.005-4.6 ounces of Au per ton, and 0.14-5.6 ounces of Ag per ton (Jensen 1975a). A large halo of carbonatization surrounding the deposit was investigated by the author during the field seasons of 1979 and 1980. A sampling program was carried out during both field seasons and the samples were submitted for chemical analysis and petrographic study. Existing samples collected by Wolfe (1977) and Jensen (1975a) were also submitted. As of September 1980, sample collection had been completed and the samples are currently being analyzed for major and minor elements, as well as Ba, Co, Cr, Cu, Li, Ni, Pb, Zn, Sr, U, Y, and Zr.

The Ben Nevis area shows poor electromagnetic and magnetic profiles, as indicated by regional airborne surveys (Ontario Geological Survey 1978). The stratigraphy

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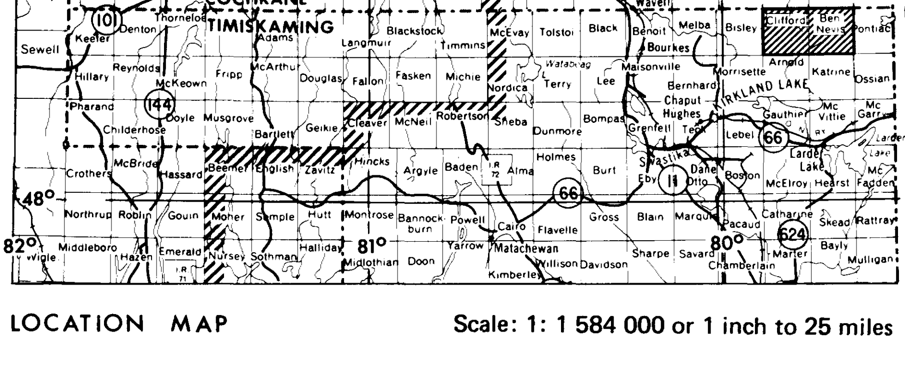

LOCATION MAP

Scale: 1: 1 584 000 or 1 inch to 25 miles

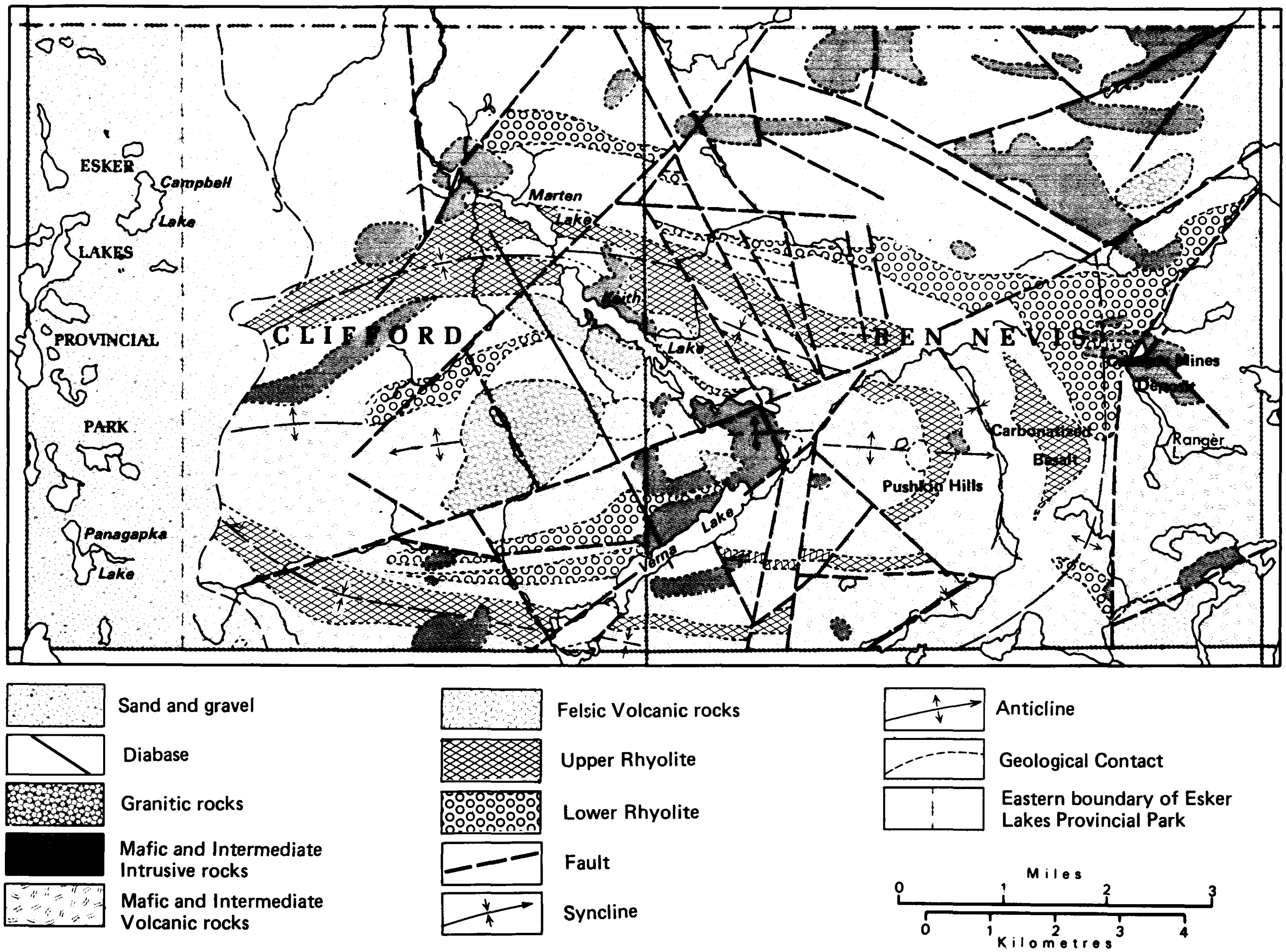

Figure 1 — Geological map of Clifford and Ben Nevis Townships (modified from Jensen 1975a).

of the area is gently dipping, thus making it difficult to determine the stratigraphy on a local scale and to apply standard geophysical exploration methods. This situation is similar to the Noranda area of Quebec, where many ore deposits occur well beneath the limits of geophysical detection, but where success has been achieved using geological and geochemical exploration methods (Boldy 1979). In the Noranda area, carbonatization is not a strong feature, either regionally or around ore deposits, although pervasive silicification is quite common. A situation analogous to that in the Noranda area is indicated by what may be silicified andesitic flows 2.4 km west of the Canagau Mines Limited deposit in the Pushkin Hills (Harold Gibson, Falconbridge Copper Limited, personal communication 1980). Lithologically the Noranda and Ben Nevis areas are distinct; however, the similarities between the two are worth noting as both contain volcanic centres.

Wolfe (1977) showed that the anomalous distribution of Zn in Ben Nevis and Clifford Townships extends over an area much larger than the actual mineral deposits. One of the objectives of this study is to examine any other chemical anomalies which may exist, as well as any important petrographic features that accompany alteration. The zone of carbonatization extends eastward into Pontiac and Ossian Townships, and samples previously collected by Wolfe (1977) and Jensen (1975b) will be incorporated into the study if possible.

Additional background information to this study can be found in Grunsky (1979).

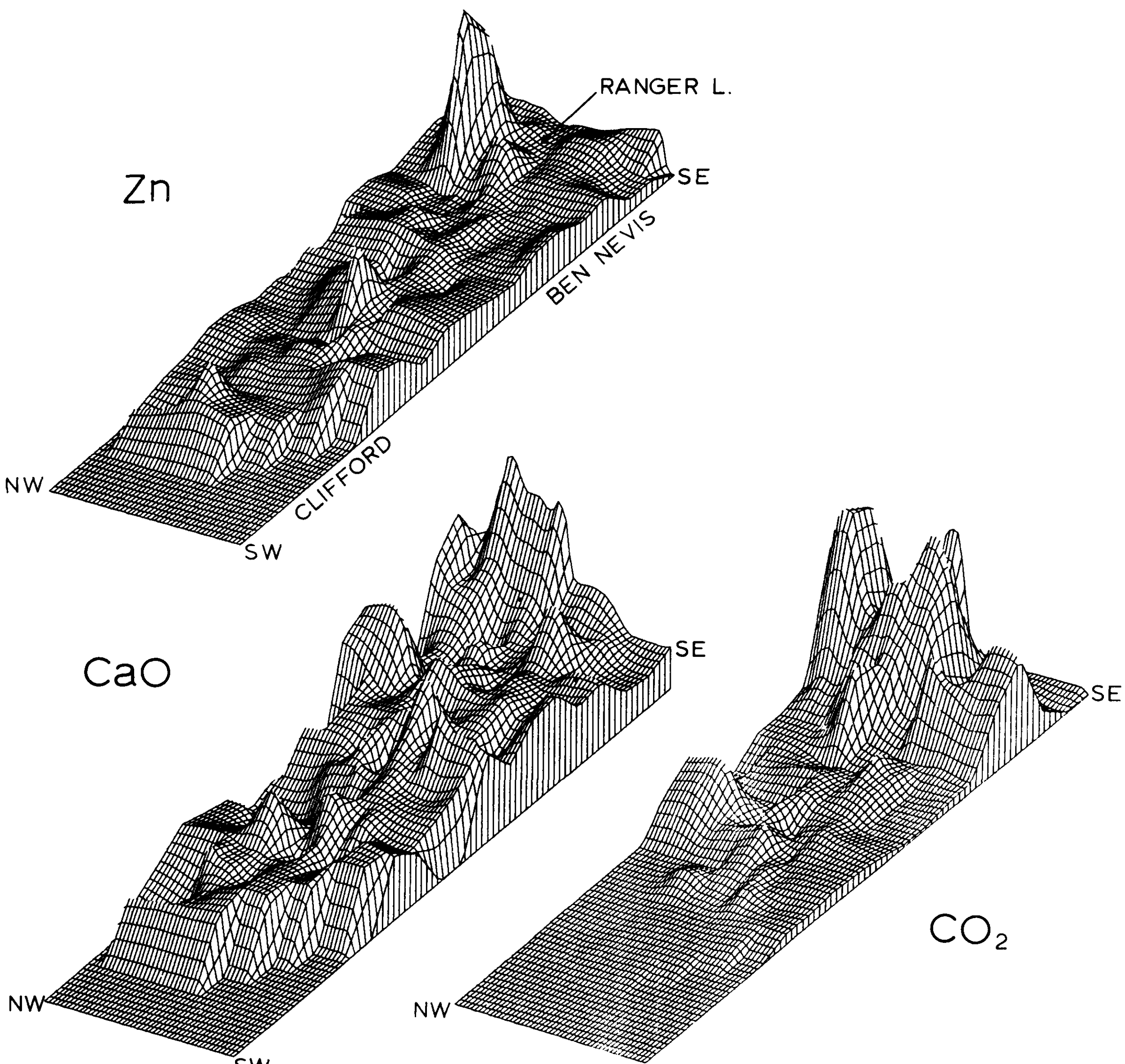

Figure 2—Perspective plots of Zn, CaO and CO_2 concentrations (uncorrected) over Clifford and Ben Nevis Townships.

Geology

The geology of Ben Nevis, Clifford, Pontiac and Ossian Townships has been mapped in detail by Jensen (1975a, b). Subsequent investigation by the author in 1979 and 1980 has revealed additional information that aids in the study of alteration phenomena. Carbonatization is the main type of alteration in the area and occurs as both a pervasive and non-pervasive (void filling) feature. Pervasive alteration has altered the colour, mineralogy and composition of the rock, and is most intense in the vicinity of the Canagau Mines Limited property. Progessing outwards from the centre of carbonatization, the pervasive alteration decreases and carbonate occurs in the form of amygdule and fracture fillings (non-pervasive), and the rocks show their original colour and mineralogy more distinctly. However, local zones of pervasive carbonatization were found to occur well away from the central zone. Background alteration in the Ben Nevis area consists of weak chloritization and silicification reflected by chlorite and quartz fillings in amygdules and along fractures. Silicification appears to be widespread in the Pushkin Hills area but is rarely pervasive and generally occurs as extensive quartz vein networks. The background alteration disappears as pervasive carbonatization increases, suggesting that carbonatization possibly replaced the earlier chloritization and silicification.

Since carbonatization masks the original colour of the rock, and in some cases the texture, field classification in areas of poor outcrop exposure is quite difficult. This situation occurs east of Ranger Lake, where an area previously mapped by Jensen (1975a) as felsic volcanics is, in fact, predominantly calc-alkaline andesite to basalt in compostion, with only a few thin units of felsic volcanics. Detailed mapping at 1:4 800, outcrop stripping, subsequent chemical analyses and petrographic examination verify this (Figure 1).

Figure 2 displays computer-generated perspective plots of CO_2, CaO and Zn values for approximately 400 bedrock samples that have been analyzed by the Geoscience Laboratories of the Ontario Geological Survey. The hills represent anomalies of these elements, but the plots are only approximate since there are missing sample localities and the chemistry has not been corrected for rock type (i.e. CaO (basalt) $>$ CaO(rhyolite)). It should be noted that CO_2 displays a larger anomaly than does Zn, suggesting that some elements may be regionally more extensive with respect to alteration halos. The CaO anomaly is coincident with the CO_2 anomaly (calcite) which may indicate that there have been some bulk chemical changes in the area of alteration. Insufficient information is available at this point to indicate whether the background alteration can be quantified by a similar approach.

Classifications of volcanic rocks can be based on either petrographic or chemical information, or both. Recently there has been a tendency to classify volcanics by chemical composition alone. Many classification schemes exist (e.g. Goodwin 1967; Irvine and Baragar 1971; Middlemost 1972; Jensen 1976) and are acceptable provided that the rocks are not significantly altered. These classification schemes may assign anomalous names to altered volcanic rocks, depending on the type of alteration. As pointed out by Church (1975), variations in the alkali content of volcanic rocks can cause large errors in normative plagioclase compositions, thus making the classification scheme of Irvine and Baragar (1971) unreliable. Similarly, in areas of silicification, classifications based on SiO_2 content will be unreliable. Gelinas *et al.* (1977), in working out chemostratigraphic sections of the Abitibi Belt in Quebec, rejected chemical analyses that displayed abnormal normative minerals or abnormal normative mineral quantities. While this may work for regional stratigraphic syntheses, it would eliminate most information in the area of the Canagau Mines Limited deposit, since almost all of the rocks in that area are altered. A primary objective of this study is to provide methods of outlining potential target areas for exploration. It is therefore important to be able to distinguish the chemical environment of volcanics. An attempt to classify the volcanics in the Ben Nevis area using the methods outlined by Irvine and Baragar (1971) failed in the areas of moderate to strong alteration since the Ca component is part of the alteration effect. The classification scheme of Jensen (1976) works considerably better than others and suggests that Al, Fe, Ti and Mg may not have been as mobile as Ca. Further work is required to determine how reliable the Jensen classification scheme is. This will be done partly through petrographic study. It should be noted that Jensen's colour classification does not work in the altered rocks.

The author is currently conducting petrographic studies and, using computer-based methods, an examination of both major and trace elements in altered and unaltered areas. The purpose is to establish what, if any, correlations exist between chemistry, mineralogy and economic mineralization

Mineral Exploration and Economic Geology

A history of mineral exploration and a description of the economic geology have been given by Jensen (1975a) and Grunsky (1979). The reader is referred to these earlier reports for detailed accounts.

Since 1979, one property has been examined and has had work filed for assessment credits (Assessment Files Research Office, Ontario Geological Survey, Toronto). This property, known as the Harper Silver-Gold prospect, consists of nine claims located about 0.5 km north of the Canagau Mines Limited property. Work consisted of 12.8 km of line-cutting, followed by ground electromagnetic and magnetic surveys. No description of mineralization was included, although the report states that pyrite was observed in rhyolites and dacites on the claim group and that the claims overlie the main andesite-rhyolite contact. No further work was reported.

Recommendations for Exploration

Because of poor exposure, shallow dip of the bedding and flat geophysical survey profiles, the Ben Nevis area is a difficult target for exploration. This does not indicate, however, that the potential for a significant mineral deposit does not exist. As documented by Boldy (1979), the Noranda area of Quebec has had several discoveries of base-metal deposits that were undetected by geophysical surveys and are located at considerable depth. In the Noranda area, a combination of geological, geochemical and structural geological work located several orebodies. Some of the deposits were located through surface mineralization and alteration effects, while others were found without these indications. The fact that the Ben Nevis area displays alteration, although different from that in the Noranda area, and that a preliminary understanding of the geology and structure already exists, indicates it is still a potential target for further exploration. It should be noted that the carbonatization zones in the Ben Nevis area may have masked out any other alteration features that either predated or co-existed with the carbonatization. An attempt will be made to ascertain whether there are multiple alteration effects.

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No. S3 Morgan Lake - Nelson Lake Area, District of Sudbury

T.L. Muir[1]

THIS PROJECT WAS FUNDED BY THE ONTARIO MINISTRY OF NORTHERN AFFAIRS THROUGH THE NORTHERN ONTARIO GEOLOGICAL SURVEY (NOGS) PROGRAM.

Location

The map-area is located about 25 km northwest of Sudbury, covers approximately 223 km^2, and comprises Morgan and Lumsden Townships and the south half of Bowell Township. Mapping was done at a scale of 1:15 840 (1 inch to 1/4 mile). No highways or railways lie within the map-area, but several regional roads and some logging, powerline and defunct-mine roads provide access for traversing in much of the area. The southwestern part of Morgan Township is accessible by private roads in Dowling Township that lead to Moose and West Morgan Lakes; Nelson Lake provides access to the northeastern part of the map-area. The southwestern part of Bowell Township is poorly accessible. Extensive interconnecting swamps inhibit access to some areas in southeastern Lumsden Township.

Mineral Exploration

Unless otherwise stated, the information on exploration activity reported here was obtained from the Resident Geologist's Files, Ontario Ministry of Natural Resources, Sudbury, or from the Source Mineral Deposit Record Files, Ontario Geological Survey, Toronto.

Mineral exploration in the Sudbury area dates back to the 1880s. Although some recorded work in the Morgan Lake-Nelson Lake Area dates to the early 1940s, much of the assessment file material is from the 1950s and early 1960s. The last work submitted was in 1974. Inco Limited and Falconbridge Nickel Mines Limited currently control much of the staked portions of the map-area through patented or leased claims. All submitted work pertains to exploration for nickel-copper sulphides related to the Sudbury Irruptive Complex, including the Foy 'Offset'. Most work was conducted in Bowell and Morgan Townships; the relative lack of work in Lumsden Township may reflect the small proportion of Irruptive rocks that are exposed there.

The earliest recorded base-metal exploration on the Foy 'Offset', dates from 1943, although sulphide mineralization in this 'Offset' was known as early as 1905. In 1944, North Range Nickel Mines Limited submitted results of geological mapping and magnetometer surveys on two groups of claims overlying part of the Foy 'Offset'. In 1953, T. Mungovan submitted the results of a magnetometer survey on a group of claims in Morgan Township. In 1962, R.C. Dennie submitted the results of a few short

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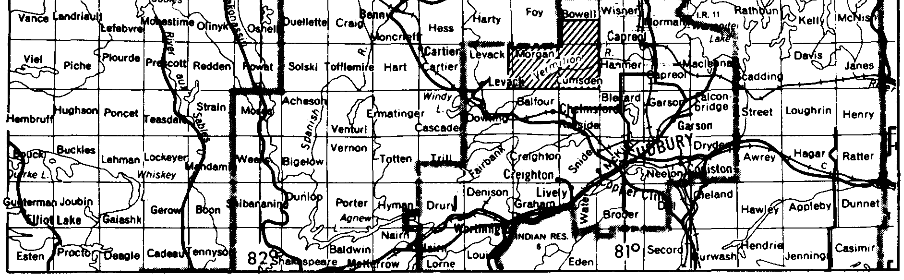

LOCATION MAP

Scale: 1:1 584 000 or 1 inch to 25 miles

diamond-drill holes in Lumsden Township. In 1969, Lake Kozak Mines Limited submitted the results of a magnetometer and electromagnetic survey on a group of claims in Morgan Township.

The Sudbury Irruptive Complex extends across the map-area and underlies the Whitewater Group; thus exploration by some companies has been widespread and has occurred over a period of years. A significant accumulated amount of work throughout the map-area has been undertaken by Falconbridge Nickel Mines Limited and Inco Limited (particularly the latter), at least since 1948 and 1949 respectively. Falconbridge Nickel Mines Limited submitted the results of diamond-drilling from various localities between 1948 and 1972, and a magnetometer and geological survey in 1972. Inco Limited submitted the results of diamond-drilling from various localities between 1949 and 1970, and magnetometer and electromagnetic surveys in 1952, 1953 and 1974. During the 1980 field season diamond-drilling was observed, in progress, in Bowell Township.

General Geology

Published geological maps of the present map-area are not detailed; they consist of preliminary maps by Thompson (1960a, b) and compilation maps by Card (1965, 1969), Meyn (1966) and Burwasser (1977). Aeromagnetic maps of the area (ODM-GSC 1965) are also available.

Major lithologic divisions of the rocks within the Morgan Lake-Nelson Lake area (Figure 1), are similar to those of the Capreol area (Muir 1979; Muir *et al.* 1980) and, in general, are easily determined. The major Middle Precambrian units are continuous throughout the map-area; however, some subdivisions of the major units are gradational from one to another, while others are completely heterogeneous and thus can be traced only with considerable difficulty. The general geology is shown in Figure 1 and the following description is highly generalized.

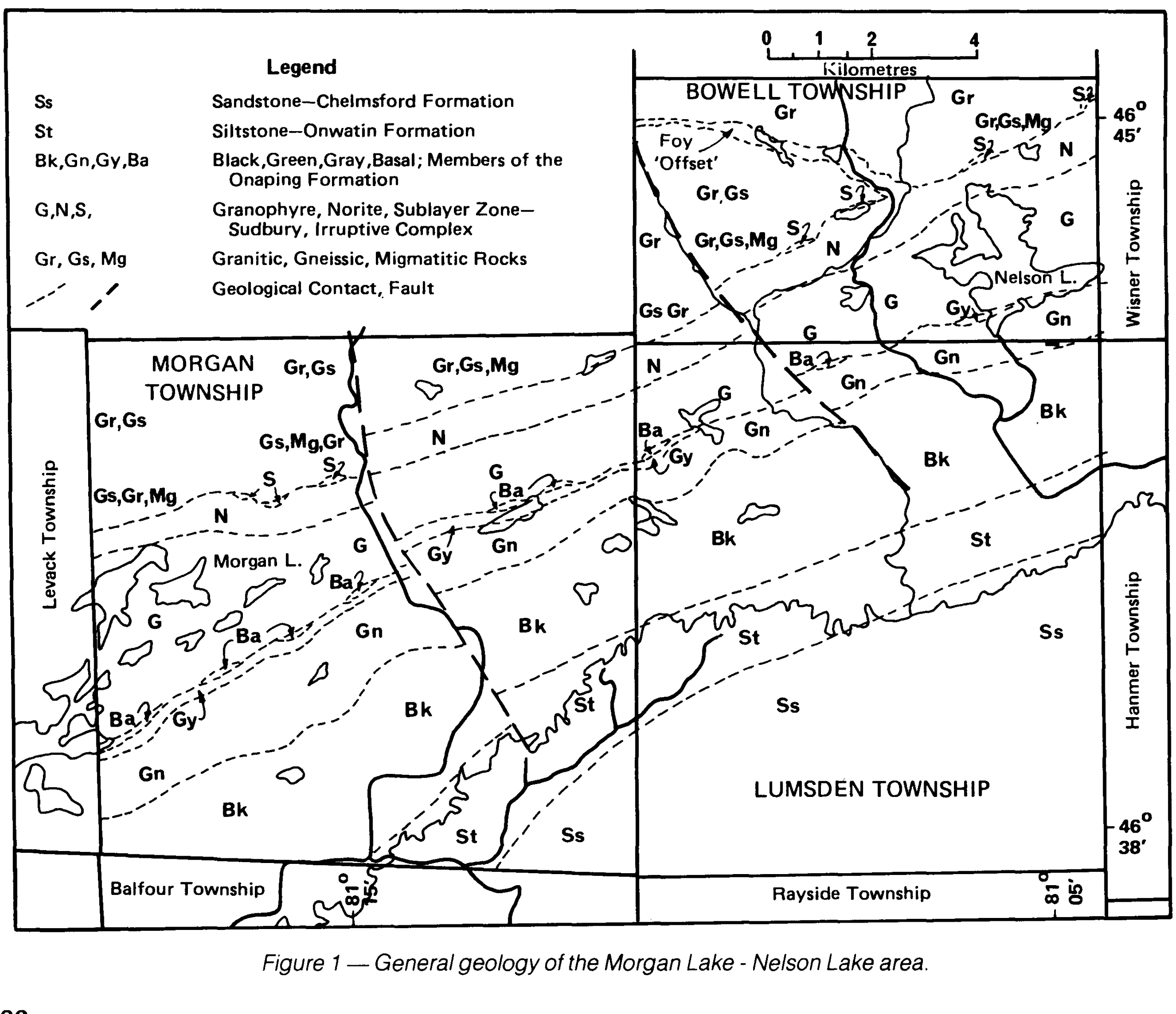

Figure 1 — General geology of the Morgan Lake - Nelson Lake area.

The oldest rocks (basement) are Early Precambrian and consist of a wide variety of metamorphosed granitic rocks, as well as amphibolites, metasediments, gabbros and diabases. A large part of the basement in Bowell Township consists of weakly to strongly foliated, microcline-porphyroblastic, biotite-hornblende quartz monzonite to granodiorite. The northern portion of the basement in Morgan Township and the western portion of the basement in Bowell Township consist mainly of an assortment of weakly foliated to gneissic rocks that range from granite to quartz diorite in composition. Locally there are remnants of gneissic to migmatitic amphibolites and metasediments. The above-mentioned basement rocks have been intruded by massive and porphyritic Early Precambrian diabase dikes. Less-altered, fine-grained diabasic dikes are locally present and are believed to be related to Nipissing-type gabbro intrusions.

Near the Sudbury Irruptive Complex, the basement rocks commonly consist of an increasing proportion of weakly foliated to gneissic amphibolites and migmatitic amphibolites with lesser amounts of foliated to gneissic granitic rocks. The metamorphic fabric of the rocks becomes chaotic near the Irruptive and the rocks show evidence of plastic deformation or brittle fracturing and block rotation, or both. Complex felsic to mafic breccias occur at or near the footwall of the Irruptive and may be, in part, rheomorphic. Sudbury-type breccias occur throughout the basement rocks but are more common in the vicinity of the Irruptive. Fragments of foreign rocks found in the larger breccia bodies indicate significant movement of material within the brecciated zones.

The Sudbury Irruptive Complex is Middle Precambrian in age and has intruded along the interface between the basement rocks and the overlying Onaping Formation. This Complex is comprised of three major lithologies: 1) the lowermost Sublayer Zone, which consists of a number of complex breccias and locally contains nickel-copper-platinum sulphide mineralization; 2) an overlying body of massive norite; and 3) an uppermost body of texturally variable granophyre. Although the Sublayer Zone breccias have been grouped into three main types (gabbroic, leucocratic and hybrid), the writer feels that some of the leucocratic breccias were derived from the remobilization (rheomorphism) of footwall rocks. Field evidence obtained by the writer suggests that some leucocratic breccias predate the norite, which in turn predates the gabbroic sublayer breccia, and that the granophyre postdates the norite. No relationship between the granophyre and the gabbroic sublayer breccia was established. The Foy 'Offset' is a type of gabbroic sublayer breccia and is present as a west-northwest- to west-trending complex igneous breccia dike that intruded the basement rocks.

The Whitewater Group of rocks is Middle Precambrian in age, overlies the Sudbury Irruptive Complex, and consists, from lower to upper sections, of the Onaping Formation, the Onwatin Formation and Chelmsford Formation. The Onaping Formation has been subdivided by the writer into four members which are, from lower to upper:

(1) a discontinuous Basal Member consisting of subvolcanic to volcanic felsic breccias;
(2) a discontinuous Grey Member consisting of massive, grey, igneous-textured rocks that may in part be pyroclastic and in part flow or hypabyssal intrusive, and which locally contain numerous subangular to subrounded felsic fragments (volcanic and sedimentary);
(3) a Green Member consisting of a wide variety of lapilli tuff with lesser lapillistone and tuff-breccia; and
(4) a Black Member consisting of lapilli tuff with lesser lapillistone and tuff.

The presence of blocks of lapilli tuff in a lapilli tuff matrix, as well as such features as cored bombs, pumice, shards and various degrees of welding, attests to the volcanic nature of the Green and Black Members. Textural and lithologic features within the Grey and Basal Members suggest a similar or closely related origin. The contact of the Onaping Formation with the granophyre suggests that local assimilation of the Onaping Formation and hybridization of the granophyre have occurred.

The Onwatin Formation is present in only a few small outcrops in the map-area and consists of finely laminated black slate. The Chelmsford Formation consists of a sequence of thinly- to thickly-bedded wacke and thinly laminated siltstone considered to be turbidites.

Late Precambrian, west-northwest-trending, olivine diabase dikes intrude all of the above-mentioned rocks.

Structural Geology

The granitic, gneissic and migmatitic basement rocks have undergone extensive deformation and folding. Dips of gneissosity vary from about 10 degrees to vertical. However, gneissosity is highly irregular in development, orientation and occurrence, and no large scale structural pattern has yet been recognized. Near the Irruptive, the disarray of gneissic and migmatitic rocks and the presence of large, foliated, amphibolitic blocks suggest a tectonic history uncommon to "greenstone-gneiss" terrains.

The contact between the Irruptive and the basement rocks in the map-area is generally considered to dip to the south-southeast. Locally the contact dips in a northerly direction, but it is not known if these are primary or post-deformational dips. Likewise it is assumed that the Onaping Formation dips to the south. Bedding attitudes indicate that sediments of the Chelmsford Formation have been compressed to form open, doubly plunging folds, whose axes approximately parallel the east-northeast trend of the Sudbury Basin and plunge east-northeast and west-southwest at a low angle. Bedding dips are generally much less than 40 degrees but are locally almost vertical.

The main lithologies are offset by two major faults, the Sandcherry Creek Fault in Morgan Township and the Wingekisinaw River Fault in Bowell and Lumsden Townships. Several smaller faults are probably present in the map-area, but these could not be confidently established.

Economic Geology

Nickel-copper-platinum sulphide mineralization has been the main target of exploration in the Morgan Lake-Nelson Lake map-area. All significant deposits known to the writer are associated directly with the Sublayer Zone of the Sudbury Irruptive Complex, including the Foy 'Offset'. Because of the shape of the Irruptive, there has been much diamond-drilling (generally vertical) through the norite and granophyre in order to intersect the Sublayer Zone at depth. Common sulphide minerals identified in the field are pyrrhotite-pentlandite, chalcopyrite and pyrite. Most of the mineral rights are held by Inco Limited and Falconbridge Nickel Mines Limited.

Very fine to coarse fragments and patches of sulphides ($<$0.5 mm to about 1.5 cm) occur in the members of the Onaping Formation. The Black Member is particularly noted for such fragments, and an old pit and trench system was found in southwestern Morgan Township where the sulphides are present in unusual concentrations. Identifiable sulphide minerals in the Onaping Formation include pyrrhotite-pentlandite, chalcopyrite and pyrite. The similarity of sulphide mineralogy in the Onaping Formation and in the Sublayer Zone is of particular interest in terms of the genetic relationship between these rocks. Gold is a major by-product of the smelting of the nickel-copper-platinum ore from mines in the Sudbury Irruptive Complex.

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No. S4 Footwall of the Sudbury Irruptive, District of Sudbury

Burkhard O. Dressler[1]

THIS PROJECT WAS FUNDED BY THE ONTARIO MINISTRY OF NORTHERN AFFAIRS THROUGH THE NORTHERN ONTARIO GEOLOGICAL SURVEY (NOGS) PROGRAM.

Introduction

During the second year of a four year project initiated in 1979 (see Dressler 1979), the author investigated an area extending from Windy Lake near the Town of Levack southward to about 9.2 km northwest of Worthington. Some time was also spent completing a detailed investigation and mapping project north of the Coleman and Strathcona Mines in Levack Township (see Dressler, this volume).

The aim of the present study is to obtain a better understanding of the origin and controls of mineralization environments associated with the Sudbury Irruptive and to make contributions that may lead to a better understanding of its origin.

The investigation is co-ordinated with and complementary to projects of the Mineral Deposits Section, Ontario Geological Survey.

[1]Geologist, Precambrian Geology Section, Ontario Geological Survey, Toronto.

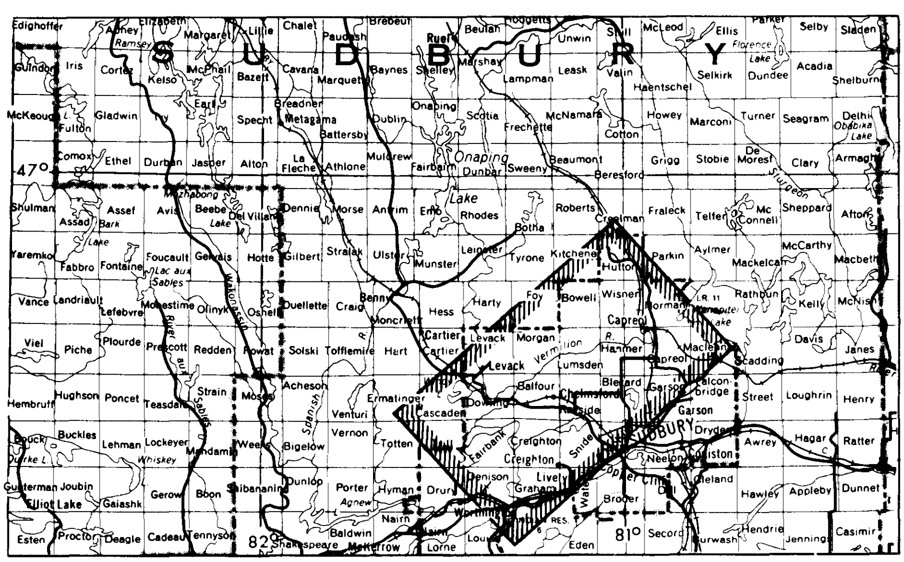
1980 Field Investigations

During the 1980 field season emphasis was placed on the following sub-projects:

1) Completion of the detailed mapping of Levack Township, and investigation of the area north of the Coleman and Strathcona Mines.
2) Detailed investigation of the footwall rocks and mapping of an area perpendicular to the Irruptive across Ministic Lake, Cascaden Township.
3) Study of the Sublayer and 'megabreccia', Sultana property, Drury and Trill Townships.
4) Study of the Sudbury-type breccia, its distribution and orientation in the North Range and West Range of the Irruptive.

1) Detailed Mapping, Levack Township

The results of the general mapping project in Levack Township are described by the author elsewhere in this volume.



LOCATION MAP

Scale: 1:1 584 000 or 1 inch to 25 miles

Most producing and past-producing mines of the North Range of the Sudbury Nickel Irruptive are located in an area extending approximately from the Hardy Mine, near Levack, eastward to the Longvack Mine. Economic deposits are not known to exist east of this area. The following is advanced as an explanation for this relationship. I thankfully acknowledge fruitful discussions with Peter Snajds, Falconbridge Nickel Mines Limited, Falconbridge.

South of the North Range mines, the Irruptive appears to be thicker than east of the Longvack Mine. A zone of contact metamorphic alteration within the footwall rocks seems to be wider immediately north of the mines than further to the east (Figure 1). Slickensides along the vertical Longvack Fault indicate a northwestward and approximately 30 degrees upward movement of a fault block that is bounded by the Longvack and Fecunis Lake Faults and by a northeastward-striking fault 1.3 to 3.1 km

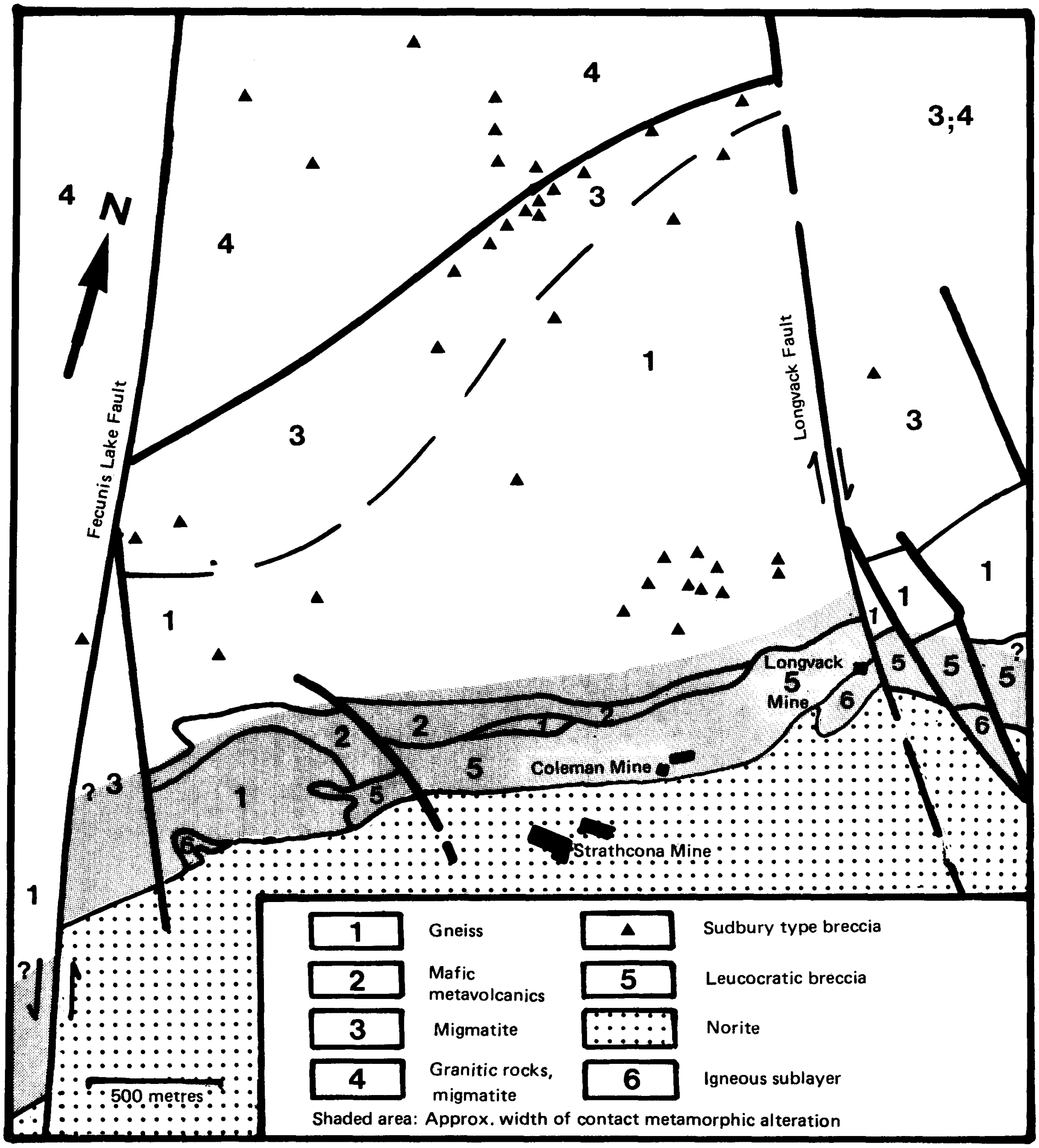


Figure 1 — Structural Interpretation of the Strathcona-Coleman Mines area, Levack Township.

north of the Irruptive. The rocks immediately south of and along this northeastward-trending fault are characterized by severe Sudbury-type brecciation. The author therefore believes that the funnel-shaped Irruptive and part of the footwall, including several formerly deep-seated orebodies, were uplifted to a position where they are now economically viable.

It should also be noted that the copper-zone orebodies, i.e. chalcopyrite dikes and veins that occur in the footwall at the Strathcona Mine, lie in a wide zone of contact metamorphic alteration of the footwall rocks (Figure 1). At present it is perhaps somewhat speculative to relate the remobilization of the copper ore into dikes to the stronger contact metamorphic alteration of the Sublayer (Dressler, this volume) and footwall rocks, which is inferred to have occurred at depth. The concept, however, appeals to the author who believes that not only common Sudbury nickel-copper ores, but also copper-zone mineralization, could very well be present east of the Longvack Mine. The orebodies would be at a greater depth than those at the Strathcona and Coleman Mines.

2) Footwall Rocks, Ministic Lake

The author mapped in detail an area, approximately 4.5 km wide and 7.5 km long, located around Ministic Lake and oriented perpendicular to the footwall – Irruptive contact. Numerous rock specimens were collected for petrographic and geochemical investigations.

This West Range sector of the Sudbury Irruptive was chosen as an area in which to study and compare the width and intensity of contact metamorphic footwall alteration, the distribution and orientation of Sudbury-type breccia bodies, and the shock metamorphic deformation of rock-forming minerals with similar features along the North Range, and also to investigate the Sublayer and the Ministic Offset.

The Ministic Lake study area is underlain by granitic rocks, dark gneissic metavolcanics, granodioritic gneisses, migmatites, diabase and olivine diabase. The Sublayer is not very well exposed. The 'leucocratic breccia' (Dressler, this volume) is characterized by a very strong granophyric remobilization of its matrix. The only outcrop of igneous sublayer observed by the author shows it in contact with the Irruptive norite. The norite is brecciated at the contact. The Sublayer contains inclusions of the Irruptive norite up to approximately 1 m in size.

3) 'Sublayer' and 'Megabreccia', Sultana Property

The 'megabreccia' (Pattison 1979) is commonly located between the Sublayer leucocratic breccia and the more or less undisturbed footwall. It is characterized by large footwall blocks commonly intruded by granophyric leucocratic breccia.

The Sublayer and the megabreccia are very well exposed at the Sultana Property of Falconbridge Nickel Mines Limited. The property is located approximately 9 km northwest of Worthington in the West Range of the Irruptive. The Sublayer and the neighbouring footwall granites were mapped at a scale of approximately 1:8 000; numerous samples were taken in order to study and determine petrographically the composition of rock fragments in the sublayer and the megabreccia.

A great variety of mafic rocks was observed within these rock units, i.e. ultramafic rocks, gabbro, diabase, glomeroporphyritic diabase and porphyritic diabase. Fragments of Huronian Supergroup arkosic quartz sandstones up to 2 m in size were also observed.

Igneous sublayer and megabreccia comprise more than 95 percent of the breccia zone. The leucocratic breccia was observed in only a few places. It occurs between the igneous sublayer and the footwall, but was also observed between the megabreccia and the more or less undisturbed footwall.

4) Study of the Sudbury-Type Breccia

While mapping Levack Township (Dressler, this volume) and the Ministic Lake area, the author studied the distribution and orientation of Sudbury-type breccia bodies. More than 100 measurements were taken in the West Range footwall rocks. They will be statistically compared with over 200 measurements taken north of the Irruptive. Both sets of measurements will subsequently be compared with other structural data, such as joint, foliation, and fault direction measurements. In 1979 and 1980, several thousand joint measurements were taken by T.L. Muir's (Geologist, Precambrian Geology Section, Ontario Geological Survey, Toronto) and the author's junior field assistants.

Many specimens of Sudbury-type breccia matrix and of host rocks were taken for geochemical investigation. A larger breccia zone immediately northwest of Windy Lake in Cascaden Township was sampled in greater detail, in order to study chemical and petrographic variations within the breccia body as it cuts across various host rocks.

Economic Geology

Several producing and past-producing mines and many mineralized showings are known to occur in the Sublayer zones and offsets investigated by the author. No attempt, however, is made here to discuss the voluminous literature on the economic geology of the Sudbury Basin or to describe the many mines and mineralized showings.

A tentative interpretation of the Strathcona-Coleman Mines area was presented in an earlier section of this paper. For a detailed description of the Sublayer, which is the ore-bearing unit of the Sudbury Irruptive, the reader is referred to Pattison (1979).

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No. S5 Levack Township, District of Sudbury

Burkhard O. Dressler[1]

THIS PROJECT WAS FUNDED BY THE ONTARIO MINISTRY OF NORTHERN AFFAIRS THROUGH THE NORTHERN ONTARIO GEOLOGICAL SURVEY (NOGS) PROGRAM

Location and Access

Levack Township lies in the District of Sudbury about 30 km northwest of the City of Sudbury. Its centre is near Latitude 46°40'N and Longitude 81°24'W.

Access to the area is via Highway 144 from Sudbury and a regional road to Onaping Falls and Levack. Mining roads provide access to almost all sectors of the township. The northwestern part is accessible by helicopter only.

Mineral Exploration

Mineral exploration in the Sudbury mining camp dates back to the 1880s. In 1888 and 1889 James Stobie and two local inhabitants employed by Rinaldo McConnell discovered the Levack Mine and the Big Levack showings. In 1913 the Levack Mine was put into operation by Mond Nickel Company Limited and in 1929 was acquired by Inco Limited. In the early 1930s the mine was closed, but it was reopened in 1937 and has been in operation since that time.

In 1889 several occurrences of copper-nickel mineralization were found by M. Windekenisaw near what is now known as the Strathcona Mine. Originally held by Strathcona Mines Limited, the property and adjoining claims were acquired between 1928 and 1944 by Falconbridge Nickel Mines Limited. In 1951 a diamond-drill program was initiated. Production commenced in 1968.

Most of the mines within Levack Township came into production only in the 1950s and 1960s.

At present Inco Limited operates three mines in the area, the Coleman Mine, the McCreedy Mine (formerly the Levack Mine) and the McCreedy West Mine (formerly the Levack West Mine). Falconbridge Nickel Mines Limited operates two mines, the Strathcona Mine and the Onaping Mine, and has one mine, the Fraser Mine, under development, with production scheduled to begin in 1981. Most of the exploration in the area has been carried out by these two companies. Numerous holes were dia-

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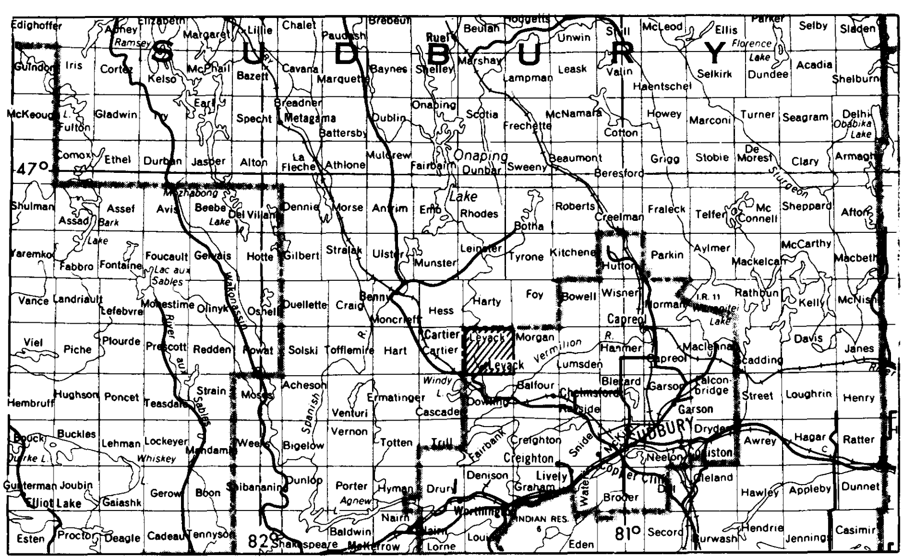

LOCATION MAP

Scale: 1:1 584 000 or 1 inch to 25 miles

mond-drilled and all the ground near the Nickel Irruptive-footwall contact was covered by detailed geophysical surveys.

In the southwestern corner of the township, Canada Radium Corporation Limited diamond-drilled 16 holes up to 90 m in length (reported in 1955). In 1956 Inspiration Mining and Development Company Limited diamond-drilled a 618 m hole, also in southwestern Levack Township.

In the late 1950s Levack Nickel Nines Limited diamond-drilled five holes totalling 680 m in an area approximately 1.2 km west of Levack.

General Geology

The bedrock in the area is of Precambrian age and is covered by a discontinuous mantle of Pleistocene and Recent deposits.

The oldest rocks are Early Precambrian granodioritic gneisses, mafic metavolcanics, migmatites, granitic rocks, and diabases. In the southern part of the map-area, i.e. just north of the Nickel Irruptive, the gneisses and metavolcanics exhibit granulite facies mineralogy; in the central and northern parts, they exhibit amphibolite facies mineralogy. Most of the northern part of the area is underlain by granitic rocks. Late Early Precambrian diabase dikes are numerous and cut all other Early Precambrian rocks. Rock units related to the Sudbury basin and present in the map-area are the Onaping Formation, the Sudbury-type breccia, the Sublayer, and the Nickel Irruptive; all are of Middle Precambrian age.

Only the Basal Breccia Member and the lower portion of the Grey Member of the Onaping Formation (Whitewater Group) are present in the area. The Basal Breccia Member consists of Huronian quartz sandstone and arkose fragments and granitic and metavolcanic fragments set in a grey, very fine-grained matrix that resembles the matrix of the Sudbury-type breccia or the fine groundmass of the Onaping tuff. The Grey Member of the Onaping Formation consists of country rock fragments and recrystallized glass fragments. The matrix of the rock is composed of fragments of quartz and feldspar, glass shards and submicroscopic mineral fragments.

The Sudbury-type breccia is abundant in the map-area. It forms large zones, smaller patches and dikes, and consists mostly of locally derived, subangular, rounded rock fragments in a fine-grained, dark grey, rock flour matrix.

The copper-nickel ores of the Sudbury mining camp are associated with the Sublayer that occurs along the lower contact of the Nickel Irruptive. Two variants of Sublayer rocks can be recognized: the "leucocratic breccia" and the "igneous sublayer" (Pattison 1979). The leucocratic breccia is very well exposed just north of the Strathcona and Coleman Mines and consists of fragments of footwall rocks and of mafic and ultramafic rocks set in a fine-grained, light-grey to pinkish matrix. The matrix is described by Pattison (1979, p.262) as "mosaic-granoblastic-metamorphic". The igneous sublayer is best exposed near the intersection of the Seal Lake road and the Coleman Mine road. It commonly lies between the main Irruptive and the leucocratic breccia and is characterized by a great variety of mafic and ultramafic rock fragments set in a medium-grained gabbroic matrix.

The rocks of the Sudbury Nickel Irruptive intrude between the leucocratic breccia (or, where this is absent, the footwall) and the Onaping Formation. The Irruptive consists of a lower norite part and an upper granophyre (micropegmatite) part. These two rock types are separated by a unit commonly termed "transition zone norite". Northwest-striking, Late Precambrian olivine diabase dikes intrude all of the above mentioned rock units.

Economic Geology

Literature on the economic geology of the Sudbury Basin is voluminous. No attempt is therefore made to discuss it here. The reader is referred to Dressler (this volume) for some details on the mineral occurrences associated with the Irruptive in Levack Township.

In the southwestern part of Levack Township, minor disseminated pyrite, pyrrhotite and chalcopyrite occur in migmatitic gneisses in a narrow zone which parallels a northwest-striking diabase dike. The dike can be traced for a distance of about 425 m (Resident Geologist's Files, Ontario Ministry of Natural Resources, Sudbury).

About 0.8 km west of the Town of Levack, a surface showing of chalcopyrite, pyrrhotite and pyrite is located in the northeastern corner of claim S31981 (Resident Geologist's Files, Ontario Ministry of Natural Resources, Sudbury). The mineralization forms stringers and blebs within a 3 m wide zone in a granitic breccia. To the northwest, the zone terminates prior to intersecting a diabase dike. Two samples from the zone returned the following assays (Levack Nickel Mines Limited):

0.01 and 0.12 ounce of Pt per ton
0.02 and 0.19 ounce of Pd per ton

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1979: The Sudbury Sublayer; Canadian Mineralogist, Vol.17, p.257-274.

No. S6 Hill Lake Area, District of Timiskaming

G.W. Johns[1]

THIS PROJECT WAS FUNDED BY THE ONTARIO MINISTRY OF NORTHERN AFFAIRS THROUGH THE NORTHERN ONTARIO GEOLOGICAL SURVEY (NOGS) PROGRAM.

Introduction

The Hill Lake area was mapped at a scale of 1:15 840. The map-area comprises the Townships of Tudhope, Bryce, Robillard, Dack and Beauchamp, and the southern quarter of Truax Township. Except for Tudhope Township and parts of Bryce Township, access to the outcrop areas may be readily attained via all-weather gravel roads. Highway 560 provides access to parts of Tudhope and Truax Townships. Highway 65 crosses the southwest corner of Tudhope Township.

Mineral Exploration

The area around Elk Lake was initially prospected for silver at the turn of the century (Moorhouse 1944). Prospecting for gold has been carried out from the late 1920s to the present.

Claims have recently been staked in Bryce and Dack Townships. Northern Silver Fox Resources Incorporated is currently undertaking underground exploration and sampling of the old Silver Jackpot Mine in lot 10, concession VI, Tudhope Township.

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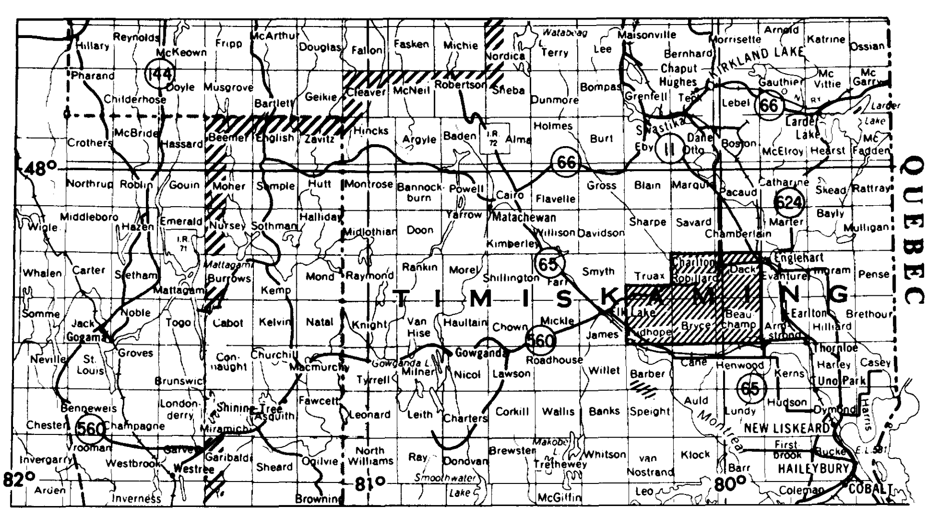
Data series maps have been published for Bryce, Dack and Robillard Townships (Ploeger *et al.* 1979a, b, c). Assessment work in Tudhope Township is on file in the Assessment Files Research Office, Toronto and the Resident Geologist's Office, Kirkland Lake. There has been no work filed for either Truax or Beauchamp Townships.

General Geology

Tudhope Township was mapped early in the century (Knight 1907). In 1921 and 1922, Burrows and Hopkins (1922) mapped the Blanche River area, which included Robillard, Dack, Beauchamp and Bryce Townships. In 1940, Moorhouse (1941) mapped Tudhope, Bryce, Robillard, Dack and Beauchamp Townships.

Rocks exposed in the map-area consist of Early Precambrian komatiitic metavolcanics, pillowed and massive mafic flows, intermediate to mafic pyroclastic rocks and intrusions, all of which have been intruded by foliated granodiorite. Unconformably overlying these rocks are sedimentary rocks of the Middle Precambrian Cobalt Group. Both the Early and Middle Precambrian rocks have been intruded by Nipissing Diabase sills.

Jensen (1978, 1979) has divided the Early Precambrian metavolcanics in the Kirkland Lake-Larder Lake



LOCATION MAP

Scale: 1:1 584 000 or 1 inch to 25 miles

area into groups. It is possible to subdivide the metavolcanics in the Hill Lake area into similar groups.

In Dack Township, the lowest group has an exposed thickness of 2390-3000 m, the basal portion of which has been intruded by the Round Lake Batholith. These rocks consist of dark green, fine-grained, pillowed mafic flows; massive, medium-grained, mafic flows; thin ultramafic flows; and small ultramafic intrusions. Minor intermediate to felsic tuffs were also noted. In the vicinity of Charlton, there is a sequence of highly altered mafic and ultramafic komatiites (Jensen, personal communication, 1980) and mafic flows intruded by syenitic dikes. This group is similar to Jensen's (1978) Wabewawa Group.

Overlying the previous group is a sequence, 4400 m thick in Dack Township, of fine-grained, pillowed mafic flows interbedded with fine-grained, black, featureless mafic flows and intermediate to mafic pyroclastic rocks toward the top of the sequence. These rocks are similar to those described as the Catharine Group (Jensen 1978). In Tudhope, Bryce and Robillard Townships, the base of this group has been intruded by the Round Lake Batholith.

Conformably overlying these mafic metavolcanics is at least 4480 m of intermediate to mafic, coarse- and fine-grained pyroclastic rocks. These rocks vary laterally from an unsorted assemblage of pyroclastic breccia, tuff breccia, lapilli tuff and tuff in Bryce and Tudhope Townships to a better sorted, bedded sequence of lapilli tuff, tuff, lapillistone and pyroclastic breccia in Beauchamp and Dack Townships. Interbedded with the pyroclastic rocks at the base of the sequence in these latter two townships are fine-grained pillowed mafic flows and gabbro sills. Jensen (1978) assigned rocks similar to these to the Skead Group. A volcanic vent may be located in the vicinity of Heather Lake, as indicated by the occurrence of very coarse, unsorted pyroclastic breccia.

In Bryce Township, a 5.6 km^2, oval shaped, hypabyssal, feldspar porphyry has been emplaced between the Catharine Group and Skead Group. Many diverse intermediate dikes are also found throughout the metavolcanics.

The metavolcanic sequences have been intruded by the Round Lake Batholith. These rocks are medium-grained, grey to pink, foliated hornblende granodiorite and granite. The contact is intrusive, except in the northeast corner of Dack Township where the batholith is in fault contact with the metavolcanic rocks.

Unconformably overlying the Early Precambrian metavolcanics are sediments belonging to the Cobalt Group of the Middle Precambrian Huronian Supergroup. In northwestern Tudhope and southwestern Truax Townships, moderately sorted Gowganda Formation conglomerate occurs. Central Tudhope Township, southern and eastern Bryce Township, southeastern Dack Township and especially Beauchamp Township are underlain by gently dipping, moderately sorted, pebble to cobble conglomerate, arenite and thinly laminated red argillite of the Gowganda Formation. Overlying this is the Lorrain Formation, consisting of medium-grained, moderately to well sorted feldspathic arenites with pebble conglomerate lenses.

Both the Early and Middle Precambrian rocks have been intruded by Nipissing sills of hypersthene diabase. The reader is referred to Pyke *et al.* (1973) for an account of their distribution.

Structural Geology

The metavolcanics strike northeast and dip southeast. In Dack and Beauchamp Townships, the rocks have been overturned by the intrusion of the Round Lake Batholith.

Regional foliation and shearing have northeasterly trends. The exception to this occurs in southwestern Bryce Township and southeastern Tudhope Township, where there is a strong northwest schistosity and shearing. The youngest faults in the area are those associated with the Lake Timiskaming Rift Valley (Lovell and Caine 1970). The Montreal River Fault, Cross Lake Fault and Lake Timiskaming West Shore Fault cross the map-area in a northwesterly direction. Several smaller faults in the area are also associated with the same structure.

Economic Geology

The area has been prospected for more than seventy years. The early interest was in silver and cobalt, but gold has been of considerable interest since the 1920s.

Gold

Many gold occurrences are known and the majority have been described, with assay results, by Moorhouse (1944). More recent data are available in the Assessment Files Research Office, Toronto and in the Resident Geologist's Office, Kirkland Lake. Thirteen grab samples taken from known showings by the field party and analysed for gold by the Geoscience Laboratories, Ontario Geological Survey, Toronto contained greater than a trace of Au; the highest value, 11 ppm (0.35 ounce per ton), is from the main trench on the Briscoe-Bryce property in Bryce Township.

Mineralized shear zones and porphyries in the metavolcanics and mineralized joints and shear zones in the granodiorite should be examined for gold mineralization. Of particular interest is the area of intense shearing and carbonate alteration southeast of Heather Lake.

Silver and Cobalt

Moorhouse (1944) has described the silver and cobalt properties. At the present, Northern Silver Fox Resources Incorporated is driving an adit easterly towards the old shaft of the Silver Jackpot Mine. They are following an aplite dike and associated carbonate vein that is reputed to contain silver in the shaft (Resident Geologist's Files, Ontario Ministry of Natural Resources, Kirkland Lake).

Thirty-nine grab samples collected by the field party from the map-area were analysed for Ag by the Geoscience Laboratories, Ontario Geological Survey, Toronto. The reported Ag contents were generally low; the highest value was 1.04 ounce per ton in a sample taken from a trench 800 m east of the Silver Jackpot shaft.

Base Metals

Bornite, chalcopyrite and specular hematite occur in carbonate veins within the Nipissing Diabase in western Tudhope Township. The veins, with few exceptions, are associated with aplite dikes and veins. Two grab samples taken by the field party from veins near the Silver Jackpot shaft were assayed by the Geoscience Laboratories, Ontario Geological Survey, Toronto and found to contain 1.2 and 2.58 percent Cu. The Ethel Copper Mine in nearby James Township reported assays of 3.15 percent Cu over 6.3 feet (Mackean 1968).

Uranium

The Sauvé prospect in the northwest quarter, north half, lot 10, concession VI, Tudhope Township contains small amounts of pitchblende in a carbonate vein along the contact of a Nipissing Diabase dike and Gowganda Formation conglomerate. A selected sample of radioactive material contained 1.56 percent U_3O_8 equivalent (Resident Geologist's Files, Ontario Ministry of Natural Resources, Kirkland Lake).

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No. S7 Belmont and Southern Methuen Townships, Peterborough County

J.R. Bartlett[1], J.M. Moore[2] and M.J. Murray[1]

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Location and Access

The map-area includes all of Belmont Township and the southernmost five lots of Methuen Township. The towns of Havelock and Cordova Mines are situated in the southwestern and northeastern parts, respectively, of Belmont Township. Highway 7 traverses the southern part of Belmont Township; county roads 44, 46, and 48 provide access to, respectively, the western, north-central, and southeastern sections of the map-area. Numerous township, concession, fire access, farm and private cottage roads provide excellent access to most of the area, as do Oak, South and Long Lakes in Methuen Township and Round, Cordova, Belmont and Crowe Lakes in Belmont Township. The rivers connecting the latter four lakes are only partially navigable.

Mineral properties in the area are given preliminary description in Table 1 (further details may be found in the report of T.R. Carter, this volume).

The only metal production at present is the recovery of gold from tailings and ore dumps at Cordova Mines by Laisir Limited. Active non-metallic deposits are the National Granite Limited and 3M Canada Incorporated quarries. Diamond-drilling has been carried out during the past four years on high purity calcite and dolomite marbles, and fine-grained metabasalt (trap rock). During 1980, parts of the area were prospected by Gulf Minerals Canada Limited and by C.R. Young of Havelock.

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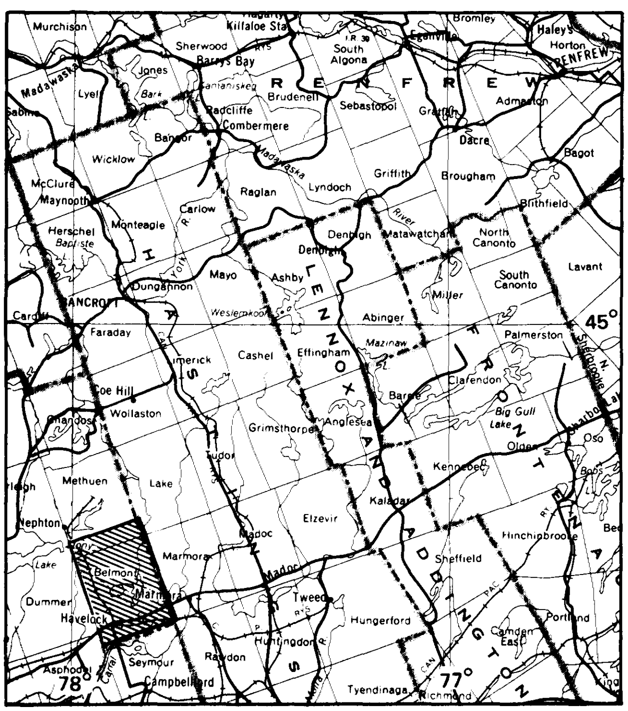

LOCATION MAP **Scale: 1: 1 584 000 or 1 inch to 25 miles**

General Geology

Approximately half of Belmont Township is underlain by Paleozoic rocks, predominantly limestone with minor basal sandstone and conglomerate. The Paleozoic geology of Belmont and Methuen Townships was mapped as part of a regional survey in 1979 by the Engineering and Terrain Geology Section of the Ontario Geological Survey (Carson 1979). Thus, the attention given the Paleozoic rocks in the present map-area during the 1980 field season was minimal, save for the delineation of the contact between Precambrian and Paleozoic rocks.

The geology of those parts of the map-area underlain by Precambrian rocks of the Grenville Supergroup is dominated by metavolcanics. These can be assigned to at least three distinct mafic to felsic volcanic cycles; two additional cycles are present, but are incomplete within the map-area. Cycle I is located between Round Lake and the northern boundary of Belmont Township. Its extent is currently speculative due to complex folding in this area. The base of Cycle I is represented by massive, plagioclase-phyric and amygdaloidal mafic flows which locally possess structures resembling pillows and hyaloclastites. A maximum thickness of 300 to 350 m for the mafic basal portion of Cycle I is suggested. Intermediate and felsic portions of the cycle are expressed solely as pyroclastic and possibly reworked pyroclastic rocks, and are typically intercalated. Felsic tuff is the dominant lithology, although both intermediate and felsic pyroclastic rocks range from tuffs through lapilli-tuffs to tuff-breccias with local pyroclastic breccias. The felsic tuffs commonly contain both lithic fragments and locally silicified pumiceous fragments, and may represent ash flow material. Magnetite tends to be more common in the tuffs toward the top of the cycle. In the north-central part of the township, a marble unit consisting of both calcitic and dolomitic components, and bearing considerable tremolite, appears to cap the Cycle I volcanics. About 1 km

TABLE 1 MINERAL DEPOSITS, BELMONT TOWNSHIP (listed geographically from north and west)

Name	Locality	Deposit Type	Exploration, Mining Activity
(1) National Granite[1]	northwest corner of Belmont Township	uniform coarse pink granite	-active dimension stone quarry
(2) Belmont Calcite (Whitney) Property[2]	5 km. south of town of Oak Lake	pure calcite marble	-geological survey (1975) -drilling: Northumberland Mines Ltd. (1962-63: 5 DDH, 264 m.); Canadian White Pigment Corp. (1976:2 DDH, 225 m.); Preussag Canada Ltd. (1980:9 DDH, 853.6 m.)
(3) Young-Cumming[1] (Deer Lake)	east of Cordova Lake	disseminated sulphides in graphitic schists (Fe, Cu, Zn, Ag, Au)	-geophysical and geochemical surveys -detailed geological mapping (1967) -drilling: Metalridge Mines Ltd. (year unknown); Texas Gulf Sulphur Co. (1957); Keevil (1964: 1 DDH); Syngenore Explorations Ltd. (to 1968: 4 DDH, 855.5 m.); C.R. Young (1976, 1978: 3 DDH, 130 m.)
(4) Round Lake[1] Dolomite	4 km. north of Round Lake	pure dolomite marble	-drilling: (1976-1980: 3 DDH)
(5) Young-Purdy[1]	0.4 km. west of north end of Belmont Lake	magnetite ironstone in mafic metavolcanics	-trenching -drilling -assays
(6) Round Lake[1] Sulphide	1.5 km. north of Round Lake	three stratiform py-po zones in cherts and metawackes (Fe, Cu, Zn)	-trenching -drilling (5 DDH?) -assays
(7) Cordova Gold[2] Mine	Cordova Mines	quartz-ankerite vein-hosted Au, Ag (shear zone in metagabbro)	-trenching -drilling -underground mining see Carter, this volume, for more information
(8) Belmont Iron[2] Mine	1.2 km. southwest of Cordova Mines	contact metasomatic pyrite-magnetite body in marble near metagabbro	-2 open pits (1899-1901) -drilling (1905-06: 6 DDH) -magnetometer survey (1905-06) -shaft (1911-1914: 80 m.)
(9) Ledyard Gold[2] Mine	0.5 km. south of Cordova Mines	quartz-ankerite vein-hosted Au, Ag (shear zone in metagrabbo)	-trenching -drilling -shaft: Ledyard Gold Mines Co. Ltd. (1893-1896: 31 m.) see Carter, this volume, for more information
(10) Beloporine[1, 2] Creek	3 km. west of Round Lake	Paleozoic Limestone	drilling: (1954: 1 DDH, 32 m.); C.R. Young (1977-78: 3 DDH, 113 m.; 1980: 3 DDH, 126 m.)
(11) Crowe River Iron[1]	Crowe River, 2.5 km. north of Crowe Lake	contact metasomatic magnetite deposit in altered mafic metavolcanics (Fe, V, Ti)	
(12) Young-Phillips[1]	0.5 km. west of Belmont Lake opposite Big Island	magnetite and hematite in schist and chert (ironstone?) (beneath Paleozoic limestone)	-drilling: (1 DDH, 40 m.)
(13) Crowe River Trap[1] Rock	east side of Crowe River, immediately north of Crowe Lake	fine- to medium-grained metagabbro	drilling?
(14) Blairton Iron[2] Mine	southwest corner of Crowe Lake at town of Blairton	similar to Crowe River Iron.	-3 open pits (1820-1963) -drilling: (1908, 1910: 13 DDH, 1161 m.); Trent River Mines Ltd. (1951: 2 DDH); W.S. Moore Co. (1957-58: ? DDH, 1511 m.; 1960: 1 DDH, 55.5 m.); Canal Iron Co. (1959: 7 DDH, 688 m.)
(15) 3M Canada Inc.[3]	Preneveau	mafic and intermediate metavolcanics	-large quarry and plant producing roofing granules -exploratory diamond-drilling 1964; 1978 (2 DDH)

1 Information from personal files of C.R. Young, Havelock.
2 Information from Assessment Files Research Office, Ontario Geological Survey, Toronto
3 Information from personal communication with R.M. Reid, Plant Engineer, 3M Canada Inc., Havelock

north of Round Lake, the contact between Cycles I and II is marked by a 50 m thickness of rusty-weathering, locally massively pyritic epiclastic metasediments.

The maximum thickness of the Cycle II metavolcanics is 1000 m. The base of the cycle is easily distinguished, and consists of mafic pillowed and massive flows and hyaloclastites, with minor amygdaloidal and plagioclase-phyric flows, and tuff breccias. Within the mafic base of Cycle II lies a distinctive rusty mudstone unit characterized by the mineral assemblage cummingtonite±garnet±magnetite. Occurring locally and directly overlying this horizon is a calcitic and dolomitic marble unit which pinches out about 4 km north of the northeast end of Round Lake. Overlying this marble in the south are thin mafic to intermediate massive flows; further north, massive and pillowed mafic flows, typically containing large porphyroblasts of hornblende, are in direct contact with the overlying felsic portion of Cycle II. At the northern boundary of the township, massive and pillowed mafic flows, intercalated with intermediate tuffs, contact the overlying distinctive felsic tuff unit which constitutes one-third to one-half of the total thickness of Cycle II. Typically fine-grained and cherty in the south, this lithic tuff coarsens to the north. Toward the stratigraphic top of this unit the tuffs are pyritic. Cycle II is capped by a fairly continuous thin zone of rusty-weathering pyritic siltstone.

Cycle III is much thicker than either of Cycles I or II. The mafic unit which constitutes the base of this cycle is about 3.5 km thick and comprises massive and pillowed flows and hyaloclastites, in flow units 20 to 70 m thick. Flow and pillow breccias are developed locally in the area. This unit is best exposed south of Lost Lake and on Cordova Lake. Cherty space-fillings are locally abundant in the flows. Magnetitic intermediate and, more rarely, felsic tuff horizons, as well as sparse magnetite-, magnetite-garnet-, and magnetite-cummingtonite-bearing siltstones and mudstones, are intercalated with the mafic flows in the middle portion of the mafic unit. In the upper portion of this unit, fine- to medium-grained, locally plagioclase-phyric mafic dikes cut the mafic metavolcanics. These dikes locally grade into gabbroic rocks. A magnetite-quartz ironstone band is present near the top of the mafic unit and is traceable for 3 to 4 km, lying atop flow-top breccias. Some intermediate tuffs outcrop along the west shore of Belmont Lake; however, no felsic metavolcanics, save one band of tuff on the east shore of Belmont Lake, occur south of Cordova Lake. Felsic tuffs east of Cordova Lake likely represent the uppermost part of Cycle III, which is capped in this area by rusty-weathering, pyritic siltstones and chlorite- ±cummingtonite-±garnet-bearing mudstones.

A predominantly dolomitic marble overlies the mafic metavolcanics of Cycle III along the northwestern part of Belmont Lake and further to the north along the Crowe River. Calcitic marbles and carbonate-bearing wackes occupy the northeast side of Belmont Lake. A calcitic and dolomitic marble unit, with associated carbonate-bearing wackes, abuts and apparently truncates the Cycle III mafic metavolcanics in the northern Cordova Lake area.

The rocks underlying the eastern and central parts of Belmont Lake are mainly metamorphosed pebble to cobble conglomerates and wackes containing variable amounts of carbonate in their matrices, and siltstones and mudstones. These rocks lie unconformably on top of the Cycle III metavolcanics and were likely derived mainly from Cycle III felsic tuffs, mafic flows and quartz-magnetite ironstones, and deposited in a carbonate-rich environment.

Mafic and intermediate metavolcanics, which likely represent a fourth volcanic cycle, are exposed southeast of Belmont Lake. They continue along strike to the southwest of Cordova Mines. The westernmost rocks of this cycle are typically amygdaloidal and/or plagioclase-phyric mafic flows. About 2 km east of Belmont Lake, highly amygdaloidal intermediate flows with extensive flow-top breccias are the common rock type, while intermediate tuff-breccias and felsic tuffs occur locally. Massive and amygdaloidal mafic flows predominate west of the Crowe River, north of Crowe Lake. This cycle was probably formed in a dominantly subaerial environment, as opposed to a submarine environment for Cycles I, II, and III.

In the Oak Lake to Long Lake region of southern Methuen Township, there occur intermediate and felsic tuffs, with rare narrow mafic flows. Previously mapped as meta-arkoses (Hewitt 1960), these metavolcanics likely belong to a volcanic cycle which precedes Cycle I, though the two cycles are currently difficult to relate stratigraphically.

In the extreme northern part of the map-area, muscovite is commonly present in the felsic tuffs; however, its incipient breakdown is apparent in the Long Lake area, coincidental with the increasing abundance of granitic dikes and larger granite bodies south and west of South Lake. Here the granites are generally massive and medium- to coarse-grained, and are leucocratic to slightly biotitic. North of Long Lake the granite is typically porphyritic.

The metagabbroic and associated intrusive rocks are important in this map-area, as they are directly related to the formation of all previously mined deposits. The Cordova metagabbro is the largest mafic intrusive body in the map-area with sedimentary-like structures; it is locally layered. It intruded a marble unit which bears little surficial expression, to produce skarn deposits such as those at the Belmont and Blairton Iron Mines. South of the town of Cordova Mines, the metagabbro is locally sheared and cut by mineralized quartz and quartz-ankerite veins. South of the site of the Ledyard Gold Mine, the shears become progressively smaller and fewer.

Most metagabbro occurrences in the map-area are similar lithologically to the Cordova metagabbro. They are generally medium- to coarse- to locally very coarse-grained, and consist of amphibole and plagioclase, with very minor relict pyroxene. Fine-grained phases, such as those south of Cordova Lake, are transitional to dikes. In addition to the Cordova gabbro, notable occurrences of metagabbro outcrop on and north of Round Lake, where the gabbro intrudes intermediate and felsic tuffs, and north of Long Lake, where the body is very large and only partially lies within the map-area.

The gabbroic intrusions are multi-phase, multi-pulse features. A local, very fine-grained phase was intruded and slightly brecciated by the coarse-grained gabbro, Later dioritic to quartz dioritic to granodioritic phases were then injected, and considerably brecciated the original phases. Thus some small, commonly peripheral, granodiorite-diorite bodies are genetically, as well as spatially, related to the metagabbros.

Structure and Metamorphism

Superficially, the southeastern part of the area resembles a homocline, with rock units striking roughly north and dipping moderately to steeply eastward. This terrain is bounded on the west and north by kilometer-scale folds, some of them doubly-plunging. There are three generations of folding. The first (D_1) was isoclinal and produced penetrative cleavage, almost everywhere nearly parallel to bedding. D_2 folds deformed cleavage and layering, and have a weaker axial-plane crenulation cleavage. They increase in size from hand specimen to outcrop-scale in the southeast, to map-scale in northwestern Belmont and southern Methuen Townships. A regional curvature in their axial surface trends is probably related to a third phase of open folding. D_1/D_2 cleavage intersections and D_2 minor fold axes form a prominent lineation, generally east-trending, which has a major reversal only in the doubly-plunging D_2 antiform of Oak Lake.

Pillow orientation in lavas and grain gradation in metasediments demonstrate that the successive volcanic cycles become younger toward the east (except in the areas of map-scale D_2 folds), and thus lie mainly on a single limb of a D_1 fold. The metaconglomerates and metasandstones of Belmont Lake, however, contain several northerly-striking axial surface traces, and appear to lie in discordant contact with adjacent metasediments and metavolcanics.

No major faults were mapped. Post-D_2 movements are locally important; parts of the west contact of the Cordova metagabbro appear to be faulted, and east-southeast- to east-northeast-striking (cross-cutting) shears in the gabbro host mineralized quartz-ankerite veins.

Few metamorphic index minerals were observed. Metamorphic grade increases from southeast to northwest, from middle greenschist facies (biotite zone) in east-central Belmont Township to middle-upper amphibolite facies in southern Methuen Township where felsic metavolcanics show incipient migmatization. There is thus a positive correlation between the size of D_2 folds and metamorphic grade.

Economic Geology

Metallic Deposits

Four main types of metallic mineralization have been recognized in the area:

1) stratiform sulphides in volcanogenic metasediments (e.g. Young-Cumming (Deer Lake) property east of Cordova Lake);
2) magnetite ironstones;
3) contact metasomatic iron deposits in altered carbonate and volcanic rocks (e.g. Belmont and Blairton Iron Mines and Crowe River Iron deposit); and
4) gold-bearing quartz-ankerite veins in mafic rocks (e.g. Cordova Gold Mine; Ledyard Gold Mine).

The first two types appear to be related to volcanic-exhalative activity at or near the close of individual cycles of volcanism; the third relates to the intrusion of the Cordova metagabbro; and the last type is likely associated with late hydrothermal activity and/or regional metamorphism post-dating emplacement of the metagabbro.

Non-Metallic Deposits

Two non-metallic deposit types are actively being utilized: mafic and intermediate metavolcanics and fine-grained metagabbro are used in the manufacture of roofing tiles; granite is used for the creation of ornamental stone. High purity Precambrian carbonate metasediments (see Table 1) have potential in the chemical industry, and Paleozoic carbonate rocks are potential sources of aggregate.

Recommendations

Base and precious metal potential of the volcanogenic metasediments warrants further exploration. Suitable grade and tonnage are most likely to be encountered where beds at the top of a volcanic cycle have been involved in D_1/D_2 interference patterns, as has occurred east of Cordova Lake. Additional vein gold mineralization may be encountered within, and possibly adjacent to, the Cordova metagabbro, and the possibility of analogous deposits within mafic metavolcanics should not be ignored. The proximity of the area to urban centres makes industrial mineral production favourable, particularly the relatively high-value specialties such as high-purity carbonates for chemical production.

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No. S8 Ardoch Lake Area, Frontenac County

Liba Pauk[1]

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Introduction

The Ardoch Lake area is located about 25 km northwest of Sharbot Lake and includes parts of Clarendon and Palmerston Townships. The area, about 250 km^2 in extent, is bounded by Latitudes 44°52′30″ and 45°00′N and Longitudes 76°45′ and 77°00′W.

The area is readily accessible via Highways 509 and 506. A large number of township, tourist and farm roads give access to most parts of the area. Crotch Lake provides excellent water access in the southeastern part of the area.

The region was mapped by Smith (1956) at a scale of 1:63 360 (1 inch to 1 mile).

Mineral Exploration

Mineral exploration, concentrating on gold, was initiated in the area at the beginning of this century. The most important mine in the area was the Boerth Gold Mine (The Boerth Mining Company of Ontario) which operated between 1900 and 1904. The James Mine (James Mines Limited) was worked briefly on lot 32, concession IV, Clarendon Township. Two pits were found in this area (Smith 1956).

Two marble quarries which operated in the 1960s are located along Highway 506 about 4 km east of Plevna. It is apparent that operations were halted when crystalline dolomite, contaminated by large quartz veins and accumulations of calc-silicate minerals, was encountered.

Interest in the old gold prospects was revived during the 1950s, and thirteen diamond-drill holes were put down in the vicinity of the Boerth property and Swaugers Lake (Assessment Files Research Office, Ontario Geological Survey, Toronto).

The Geochemical Reconnaissance program of the Geological Survey of Canada (1977) revealed anomalies of Zn, Cu, As, Mo and Hg in the area of James Lake and Little Green Lake. In 1977, geological mapping and soil sampling was carried out for St. Joseph Explorations Limited. Only weak to moderate anomalies of Cu, Pb and Zn were encountered (Assessment Files Research Office, Ontario Geological Survey, Toronto).

The most explored part of the area, from the late 1960s to the present, is the southeastern part which is underlain by the Cross Lake gneiss and metavolcanics. The

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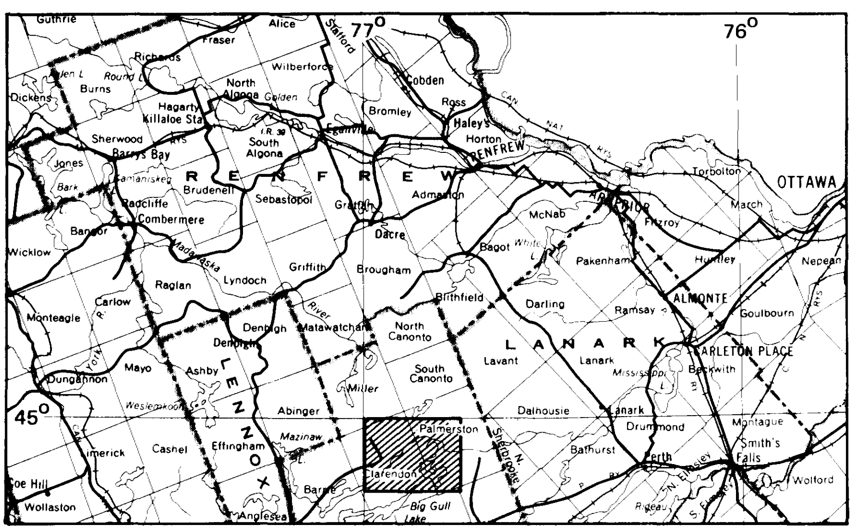

LOCATION MAP Scale: 1:1,584,000 or 1 inch to 25 miles exploration targets are numerous pegmatite dikes and sills in gneisses and metavolcanics. A large number of claims were staked east and west of Pine (Coxvale) Lake and east, southeast and northeast of Crotch Lake. An area of about 25 km^2 was covered by ground and airborne radiometric surveys, and trenching was carried out in most areas of interest. Diamond-drilling has been concentrated in the Crotch Lake area, where 75 holes totalling 4000 m have been put down (Assessment Files Research Office, Ontario Geological Survey, Toronto). AJM Explorations Limited is presently conducting a diamond-drilling program in the vicinity of Crotch Lake.

General Geology

The geology of the Ardoch Lake map-area is dominated by a northeast-trending belt of metavolcanics and metasediments. These rocks are considered to be the oldest in the area and are correlated with the Hermon and Mayo Groups of the Grenville Supergroup. The metavolcanic suite is represented by mafic to intermediate flows and fine- to coarse-grained intermediate pyroclastic rocks. The metavolcanics are overlain by metasediments consisting largely of marble, dolomitic marble, wackes and siliceous metasediments. Deposition of the two groups is thought to have been, in part, contemporaneous. The metavolcanics in the northern part of the area show a higher degree of recrystallization and reconstitution, their primary structures and textures having been completely obliterated, compared to metavolcanics in the southern part of the area, which display some original structural and textural characteristics.

The supracrustal rocks were intruded by the Abinger granitic pluton in the northwestern part of the area and by the Cross Lake Pluton in the southeastern part of the area. The Abinger pluton, within the map-area, is a fine-grained leucocratic biotite-muscovite gneiss, and its contact with the older metasediments and metavolcanics is migmatitic. The Cross Lake Pluton is composed of coarse- to fine-grained biotite to biotite-hornblende gneiss with inclusions of metavolcanics. A small gabbro-diorite stock occupies the core of the Plevna synform.

The Flinton Group of clastic and carbonate metasediments outcrop in a narrow belt in the central part of the map-area. The rocks of the Flinton Group rest unconformably on an erosional surface formed on the older Precambrian units (Moore and Thompson 1972). Metamorphism reached amphibolite facies rank throughout the area.

Structural Geology

The complex structural pattern of the rocks in the area can be attributed to at least two major periods of deformation. The first phase of deformation produced isoclinal folds with northeast (N40-60E) striking axial planes and steeply dipping axial plane foliations essentially parallel to the bedding. Subsequent refolding resulted in more open, northeast-trending, structures (e.g. Plevna synform and antiform). All major structures are gently plunging (10-30 degrees) to the northeast, as indicated by the presence of quartz and hornblende rodding lineations and by the direction of pebble deformation in metaconglomerate.

No major strike-slip faults or shear zones were observed in the area. There are, however, two crosscutting faults that leave their imprints on the topography. The northwest (N45W) trending Plevna Fault is expressed by an abrupt change in topography. No lateral displacement or associated shear zone was observed. The Crotch Lake fault zone, striking N60W, occupies a depression in the topography and has about 300 m of lateral displacement. Both faults follow a predominant direction of major joints. Jointing in the Cross Lake Pluton has a strike of N40-60W and a steep dip.

Economic Geology

The major base-metal mineral potential lies in an area, located between Swaugers and Little Green Lakes, which is underlain by metatuffs, metawackes and intercalated marble. Small amounts of pyrite occur in parallel and crosscutting quartz veins. Narrow arsenopyrite-bearing quartz veins are found in small pits and trenches located about 400 m northeast of Swaugers Lake. Recent assays of dump samples from this showing, and from the nearby Boerth Mine, yielded 0.03 to 0.15 ounces of Au per ton and 0.01 to 2.46 ounces of Ag per ton (personal communication, D. Riddell 1979). Parallel quartz veinlets with disseminated chalcopyrite occur in the vicinity of the old James Gold Mine, west of Little Green Lake. Other small test pits on narrow, rusty weathered quartz veins were encountered in this area during the 1980 field season.

The intermediate metavolcanics occupying the southern limb of the Cross Lake antiform show minor disseminated pyrite and pyrrhotite mineralization in a narrow gossan zone traced for about 3.2 km northeastward along strike.

In the younger Flinton Group, the most favourable base-metal occurrence is in the Myers Cave Formation, where sulphide mineralization is associated with quartz veins in dolomitic marble. A small pit on a galena-bearing quartz vein is located 200 m south of Swaugers Lake. A quartz vein showing molybdenite mineralization was found in dolomitic marble about 1.6 km west of Ardoch.

Pegmatite dikes and sills, showing yellow earthy coatings of secondary molybdenum minerals (molybdite) and minor molybdenite, are associated with the Cross Lake Pluton in the northeast and with the Abinger granitic pluton in northwest part of the area.

The Cross Lake Pluton and adjacent metavolcanics host a large number of uraniferous pegmatites which have radiometric anomalies three to ten times background.

Three major types of pegmatites were recorded:

1) Pegmatites parallel to the regional strike, usually in the metavolcanics and, less commonly, in the gneisses.

2) Pegmatites parallel to the prevailing regional system of joints, occurring in both metavolcanics and gneisses.
3) Discordant, curving and discontinuous bodies occurring mostly in the gneisses.
Although all three types may show considerable radiometric anomalies, the most promising are the pegmatites of the first type. Their considerable size, in at least two dimensions, makes them favourable exploration targets.

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No. S9 Kirkland Lake Area, Stratigraphic Mapping, District of Timiskaming

N.F. Trowell[1]

THE WORK REPORTED HERE IS PART OF THE KIRKLAND LAKE AREA GEOSCIENTIFIC SURVEYS. IT IS EQUALLY FUNDED BY THE FEDERAL DEPARTMENT OF REGIONAL ECONOMIC EXPANSION AND THE ONTARIO MINISTRY OF NORTHERN AFFAIRS UNDER THE COMMUNITY AND RURAL RESOURCE DEVELOPMENT SUBSIDIARY AGREEMENT.

Introduction

Field work done in 1980 represents the second part of a three-year study under the Kirkland Lake Incentives Program (KLIP) to carry out stratigraphic mapping of an area straddling the Kirkland Lake-Larder Lake 'break' from the Quebec border west to Highway 11. In 1979, alkalic volcanic rocks and associated sedimentary rocks of the Timiskaming Group, together with the ultramafic volcanic rocks and sedimentary rocks north of Larder Lake were studied (Downes 1979). In 1980, the author spent a short time in early August examining the various lithologies near the Kirkland Lake-Larder Lake 'break'.

Initiation of this program was an offshoot of regional and stratigraphic mapping of the Kirkland Lake and Larder Lake areas at a scale of 1:63 360 by L.S. Jensen (1978a and b).

Kirkland Lake is primarily a gold camp, and the main impetus of this study is towards applying stratigraphic mapping to understanding the controls of gold mineralization. Additional attention has been paid to base metals and uranium (in the alkalic volcanic rocks).

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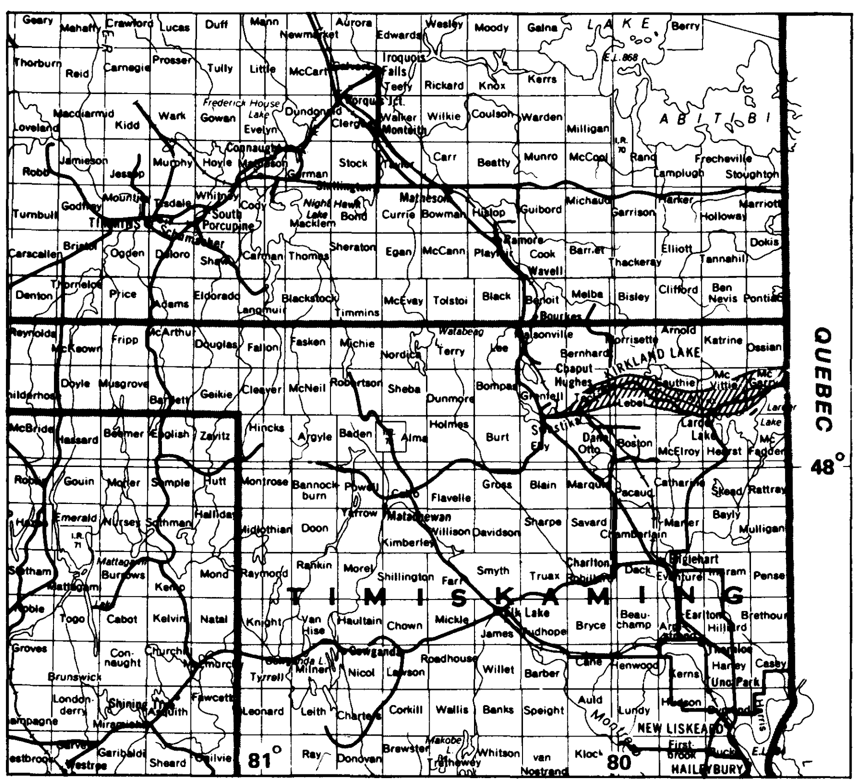

LOCATION MAP

Scale: 1: 1 584 000 or 1 inch to 25 miles

The objectives can be summarized as follows:

(1) To determine the extent to which gold mineralization is controlled by:

a) stratigraphy and lithology;
b) alteration, i.e. carbonatization and silicification;
c) structure, i.e. folding or association with fault zones.

(2) To determine the relative age relationships of:

a) rock units on either side of the 'break' and also the amount of displacement along the 'break';
b) the alkalic volcanic rocks and associated sedimentary rocks (Timiskaming Group) to the sedimentary rocks and associated ultramafic and mafic volcanic rocks around Larder Lake.

Summary

Downes (1979) elucidated the stratigraphy and structure in the Larder Lake area. Further work allowed him to refine his ideas (Downes 1980). Major observations on the gold mineralization and conclusions of his study (Downes 1980, p.101, 102) are as follows:

Gold Mineralization

At the Kerr Addison Mine mineralization occurs in two main modes:

1) 'Green carbonate': A fuchsite bearing dolomitized ultramafic volcanic rock. Gold occurs as free gold in quartz veins related to the metasomatic alteration but not actually in the green carbonate itself.

2) Flow ores: This includes several lithological types, the only common denominator being that they are all pyritic. Gold is hosted by the pyrite and varies in grade depending on the grain size of the pyrite, fine grained higher grade, coarse-grained lower grade (Kerr Addison Staff). The nature of these ores is currently under investigation by the author.

At Barber Larder and Cheminis, ore zones are in a pyritic carbonatized hyaloclastite unit and a pyritic cherty tuff.

Conclusions

1) The Larder Lake 'break' possesses a Strong Structural expression as separating two domains of fold axis orientations.

2) Carbonate alteration cross cuts this 'Break' and also appears to be most intensely developed in fold hinge zones — appearing to be a late tectonic event.

3) One form of gold mineralization in the Kerr Addison Mine is associated with quartz veining and a potassic metasomatism that was spatially related to the carbonate alteration, and hence a late tectonic event.

Future work will be directed towards tracing out the stratigraphy developed by Downes (1979, 1980) with particular attention being given to an examination of the syenite-alkalic volcanic domain and Kirkland Lake Fault in the western portion of the area.

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Engineering and Terrain Geology Programs

Summary of Activities of the Engineering and Terrain Geology Section, 1980

Owen L. White[1]

Nine field parties were active in mapping the surficial deposits throughout the Province, five in southern Ontario and four in northern Ontario. In addition, one party collected field data on aggregate resources in the North Bay, Hearst and Kapuskasing areas, and two field parties continued studies on the Paleozoic rocks of Manitoulin Island and central southern Ontario. Many of the field parties were funded by other Ministries of the Ontario Government and by the Federal Department of Regional and Economic Expansion.

P.J. Barnett concluded his study of the Quaternary geology of Renfrew County by spending several weeks on specific outstanding projects in the area and by checking several new exposures. Preliminary maps of the eastern portion of Renfrew County were published in November 1980 and maps of the western portion of the County will follow in the summer of 1981.

P.F. Finamore mapped the Coe Hill area immediately to the south of Bancroft. Drift is thin, and there is considerable bedrock exposure except where drumlins and extensive, fine- to medium-grained sands occur. Esker ridges provide local supplies of gravel. Cross-cutting striae and a variety of stratigraphic sequences were found, suggesting that local re-advances of the ice occurred during the recession of the glacier.

To the south of Coe Hill, J.G. Leyland mapped the Campbellford-Trenton area which embraces parts of three very different physiographic regions: the Lake Iroquois plain, the Peterborough drumlin field and the Dummer Moraine. Drift in the map-area was deposited by ice advancing from both the north and the southeast, with some areas providing evidence for the overriding of the northern ice deposits by a late advance of ice from the southeast. The till in the northern part of the area, forming part of the Dummer Moraine, is coarse and extremely stony. In the south, sand till is generally mantled by Lake Iroquois deposits. Lake Iroquois was also responsible for prominent shoreline and near-shore features which have provided good sources of aggregate. Farther to the north, eskers provide useful sources of aggregate.

D.R. Sharpe commenced mapping of the Brampton area, which embraces part of Metropolitan Toronto and extends across the developed areas of Mississauga, Bramalea and Brampton to include the edge of the Niagara Escarpment. Halton Till covers more than 70 percent of the Brampton area and is itself covered, in part, by a veneer of sand, silt and clay deposited in glacial Lake Peel.

In the southwestern corner of the Province, E.V. Sado completed the mapping of Essex County to bring the early studies of the area into a modern stratigraphic context. The oldest till in the area is the stony clay Catfish Creek Till deposited by ice out of the Huron basin. This, in turn, is overlain by the clayey silt Port Stanley Till deposited by ice out of the Erie basin. Overlying this younger till is a variety of glaciolacustrine and glaciofluvial gravel, sand, silt and clay deposits. The surficial gravels are thin, so that local supplies of sand and gravel must be supplemented by crushed stone from Amherstburg and imported material from the United States.

In northern Ontario, the mapping of the surficial deposits continued in the northwest and the northeast. V.K. Prest completed his work in the Red Lake-Madsen area. Ice moving to the southwest covered the area and deposited a stony sand-silt till. Two prominent moraines (the Hartman and the Lac Seul) were constructed during the advance of the ice, and when the ice receded, the waters of glacial Lake Agassiz covered most of the area. Aggregate supplies in the Red Lake area are scattered, but are more plentiful in the Madsen area where several eskers are situated in accessible locations. Apart from the usual demands for aggregate for highways, forest access roads and general construction, considerable demand exists for mine backfill. Aggregate resources in both areas should be carefully husbanded to ensure they remain available for extraction.

[1]Chief, Engineering and Terrain Geology Section, Ontario Geological Survey, Toronto.

C.M. Tucker continued his investigations in the vicinity of Timmins with the mapping of the Dana Lake area and reconnaissance investigations in the Pamour area. The Dana Lake area is covered to a large degree with a bouldery silty sand till through which many bedrock areas are exposed. Five eskers, which provide the bulk of the sand and gravel deposits in the area, were identified. The entire map-area except the very highest ground was inundated by glacial Lake Barlow-Ojibway, with the resulting deposition of silt and clay in the deeper basins of the lake and the development of shoreline features. Some of these abandoned shoreline features have been excavated to supply local aggregate needs.

In the Kirkland Lake area, C.L. Baker mapped the Magusi River area, the last of a group of four map-areas to be investigated. The eastern portion of the area has many bedrock outcrops and knobs and a thin discontinuous cover of silty sand till. Several eskers, including the prominent Munro esker, are located west of the area of rock outcrops. When the ice disappeared, the waters of glacial Lakes Barlow and Ojibway inundated the area, depositing thick deposits of clay and silt over the till, the eskers and the associated glaciofluvial deposits. These fine-grained deposits now form part of the Great Clay Belt of northern Ontario. Many dunes, up to 12 m high, were formed on the fine sands which flank the eskers. The sand and gravel resources of the area are considerable, but they are not likely to be utilized in the near future because of the absence of urban areas and the considerable distance between the resource and the centres of demand. A mineralogical study of the Munro esker complex has been started, the objective being to define parameters useful in mineral exploration.

In the Cobalt area, Marjatta Perttunen commenced a regional mapping project, which also involves a detailed study of till lithology directed at the potential use of drift for prospecting purposes. The ice which invaded the Cobalt area moved generally in a south to southwest direction, except where the large preglacial valleys (e.g. Montreal River, Lake Timiskaming) controlled the movement. The till which was deposited ranges widely in texture (clayey silt to gravelly sand) and lithology (calcareous to non-calcareous) across the area. Generally only one till was found in any one location, although on the shores of Lake Timiskaming, a 25 m section consisting of two tills was investigated. Major glaciofluvial features are located along the Montreal River Fault, in the valley of the Montreal River and in the Latchford area. Other smaller deposits are found throughout the map-area. Barlow-Ojibway clays, up to 30 m or more in thickness, cover the northeastern corner of the map-area and represent the southernmost extent of these deposits. The major glaciofluvial features are currently being worked for sand and gravel supplies for the area. Aggregate deposits in Barr and Kittson Townships are not readily accessible and remain undeveloped.

W.D. Scott and J.Z. Fraser investigated the aggregate resource potential in the vicinity of North Bay, Hearst and Kapuskasing. In the North Bay area, extensive resources of both crushable gravel and sand were recognized. Although the resources at several large commercial operations are rapidly diminishing, other sources should be available to adequately supply demand from the North Bay market. In the Hearst area, most of the potential resources of sand and gravel are covered by till deposited during the last ice advance in the area (the Cochrane Re-advance). Several pits have been developed in some of these buried deposits, but other potentially useful deposits have not yet been opened. Crushable aggregate in the area does not appear to be plentiful and the deposits which are recognized as being potentially useful should be set aside for aggregate extraction before other uses of the land are approved. In the Kapuskasing area, aggregate to the west of the town is in very short supply and quarried crushed stone may become even more widely used than at present. To the east of the town, two large esker systems supply the bulk of the sand and gravel demands, despite their being buried by up to 5 m of till.

On Manitoulin Island, M.D. Johnson continued, from last year, the mapping and sampling of the Paleozoic rocks, extending the fieldwork in 1980 to the northern and western parts of the island. Six holes were drilled after the 1979 field season and 13 more are being drilled to an average depth of about 50 m following the 1980 field season. Samples from the core will be chemically analyzed for major and trace elements.

D.M. Carson continued the mapping of the Paleozoic bedrock of central southern Ontario into the Belleville-Kingston area and north from Lake Ontario to include the Paleozoic/Precambrian overlap, and still further north, to include the Paleozoic outliers on the Precambrian Shield. Paleozoic rocks range in age from Cambrian (?) (Potsdam Formation) to Middle Ordovician (Simcoe Group) and include sandstone, shale and limestone. The Gull River Formation (Simcoe Group) is the source of high quality rock for crushed stone production.

No. 17 Quaternary Geology of the Brampton Area (30M/12), Southern Ontario

D.R. Sharpe[1]

Introduction

The Brampton area is located between Latitudes 43°30′ and 43°45′N and Longitudes 79°30′ and 80°00′W. It consists of portions of the Regional Municipalities of Halton, Peel and York, the Municipality of Metropolitan Toronto and Wellington County.

A shortened field season resulted in the mapping of only about two-thirds of the area, mainly in the north-central portion of the map-area.

Physiography and Bedrock Geology

The western segment of the map-area includes parts of the main topographic feature in southern Ontario, the Niagara Escarpment. Below the escarpment is a relatively plane surface of Halton Till, which dips to the southeast and is deeply dissected by Oakville and Etobicoke Creeks, and the Credit and Humber Rivers.

The Niagara Escarpment is the erosional edge of the Silurian Amabel Formation, consisting of thick-bedded white dolostone. The lower slopes of the escarpment are underlain by the Fossil Hill and Reynales Formations, as well as rocks of the Cataract Group. These rocks include various dolostones, shales and coarse clastic sediments.

The plain to the east is underlain by soft red shales of the Queenston Formation (west half of the map-area) and the interbedded dolostone and grey shale of the Georgian Bay Formation (east half of the map-area). The lithology of the underlying bedrock has a dramatic influence on the glacial drift in the Brampton area.

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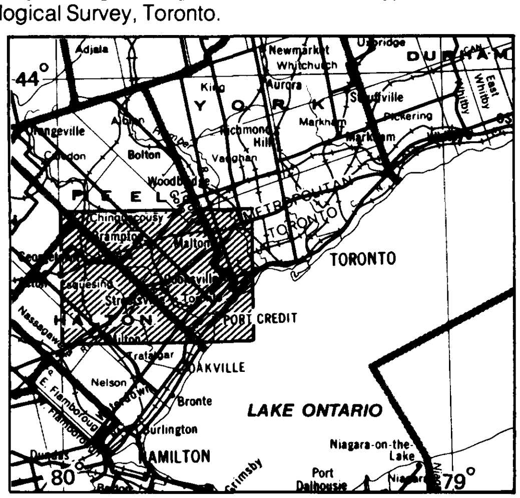

LOCATION MAP Scale: 1: 1 584 000 or 1 inch to 25 miles

Previous Work

The bedrock geology of the area has been mapped by Caley (1940) and by Telford *et al.* (1976). Watt (1957, 1968) carried out detailed Pleistocene studies in the Boroughs of North York and Etobicoke. Hewitt (1969) compiled the Quaternary geology for the Brampton map-area and reported on the industrial minerals in the area. Karrow (1963, 1968) mapped the Hamilton area to the south and Guelph area to the west and White (1975) mapped the Bolton area to the north.

Quaternary Geology

The standard stratigraphy for this area is found at the nearby Woodbridge site (Karrow and Morgan 1975) where eight units have been described. Only four main units have been encountered by the present survey. This is less than the six units recognised by Watt (1968) in the Etobicoke area of the east half of the Brampton sheet.

The oldest unit found to date is a coarse, stony-sand-silt till, yellowish brown in colour. This occurs only in a few places along the Humber River and Etobicoke Creek, and was referred to as the 'middle till' by Watt (1968). This till is probably equivalent to the unnamed, former Lower Leaside Till in the Toronto area, and may be equivalent to the Wentworth Till to the west of the area. A few exposures of what may be an even older till were noted in some river cuts very close to the water level. If it can be demonstrated that this till is a separate unit, it could be the equivalent of Watt's (1968) 'lowest till'.

Stratified deposits of lacustrine and fluvial origin, which have considerable areal extent and thickness, overlie the stony-silt till and appear to be associated with the overlying Halton Till. The vertical changes in the sediments provide an excellent record of the advance of the Halton ice.

The impressive feature of the Quaternary geology in the Brampton area is the extent, thickness and variability of the Halton Till. It forms the dominant sediment in the Brampton area, covering more than 70 percent of the land surface. It is thicker in the south and east (greater than 10 m in places) and thins to less than 1 m in the north and west. The Halton Till is basically a gritty-silt till with 2 to 5 percent stone content and a dark yellowish brown colour similar to the rocks from which it was derived, the weathered Georgian Bay Formation. Locally it varies to a Queenston shale-rich till, particularly within a metre of the shale rock contact. In the northern portions of the map-area, the till has a strong lacustrine character where lake sediments and flow tills become interbedded.

Compositional banding within the Halton Till is common in places and reflects the differing substrata: Georgian Bay grey shales and limestone, Queenstone red shale or lacustrine sand, silt and clay.

A very loose, cobbly sandy till occurs above the Niagara escarpment and is underlain by white Amabel dolostone. This is thought to be an older till because of the presence of a shale-rich till above the Escarpment west of Milton.

Glacial Lake Peel Deposits

The upper portions of the drift in the Brampton area include a variable sediment cover consisting of lacustrine fine sand, silt and clay, debris-flows of silt, clay, sand and clasts, and flowtill of various textures, as well as Halton Till with faint lacustrine bands. These deposits have been termed the 'Wildfield Till and Lacustrine–Wildfield Till Complex' by White (1975) in the Bolton area to the north. However, as the till members of the above deposits cannot be distinguished from the Halton Till in the Brampton area, these deposits could be considered as having formed in a lacustrine environment in front of the Halton ice (i.e. Glacial Lake Peel). Evidence for any re-advance of this ice is lacking in the Brampton area. Till units are interbedded with lacustrine material as flowtill off this receding ice margin.

Economic Geology

The area is very active with quarry operations for brick and tile making, building stone and aggregates; these activities are summarized by Hewitt (1969).

Sand and gravel resources in the area are quite limited. The Brampton esker is an important source of sand, but gravel supplies are scarce. Significant resources near the base of the Niagara Escarpment include extensive outwash deposits buried by the Halton Till between Cheltenham and Stewarttown, and outwash deposits flanking the escarpment near Limehouse and along the terraces of the Credit River, north of Georgetown. However, most of these sand and gravel deposits contain high percentages of soft shale.

Drilling of the buried outwash deposits would help define their resource potential.

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No. 18 Quaternary Geology of Renfrew County, Southern Ontario

P.J. Barnett[1]

Introduction

Field mapping of the Quaternary geology of about 5000 km^2 of Renfrew County commenced in 1977 and was completed during the summer of 1979. Summaries of this work have been previously published (Barnett 1977, 1978, 1979) and preliminary maps for the Fort Coulonge, Cobden and Renfrew areas are available (Barnett, 1980; Barnett and Clarke, 1980a,b).

During the 1980 field season, additional detailed field investigations were carried out in selected areas, and visits were made to several new exposures not previously examined, and to sand and gravel operations within Renfrew County. The remainder of the summer was spent compiling and interpreting both laboratory and field data for the Bancroft and Renfrew County field areas.

Noteworthy observations made this past summer include:

1) an additional locality of fine-grained till overlying probable marine sediments in the Indian River Valley near Alice;

2) the presence of several end moraine fragments south of Alice in the highland area;

3) a large area of marine reworked ice-contact stratified sediments (kames, eskers), presently with little or no topographic relief, and several buried eskers between Davis Mills and Alice;

4) evidence for the stagnation of the glacier in the highland areas (e.g. Doré Bay area) as opposed to an active lobal ice-margin within the Ottawa River Valley;

5) several additional high level shoreline features (175 m above sea level) in the White Lake area. The whale bones which were found in the Hanson pit near White Lake are on display at the Pembroke Museum.

[1]Geologist, Engineering and Terrain Geology Section, Southern Ontario Geological Survey, Toronto.

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No. S10 Quaternary Geology of Red Lake and Madsen Areas (52N/4, 52K/13), District of Kenora (Patricia Portion)

V.K. Prest[1]

THIS PROJECT WAS FUNDED BY THE ONTARIO MINISTRY OF NORTHERN AFFAIRS THROUGH THE REGIONAL PRIORITY BUDGET PROGRAM.

Introduction

The Red Lake-Madsen area is bounded by Latitudes 51°15′ and 50°45′N and Longitudes 93°30′ and 94°00′W. The communities of Red Lake, Balmertown, Cochenour and McKenzie Island are located in the southwestern part of the Red Lake map-area (52N/4), and Madsen and Starratt-Olsen are in the adjoining northwestern part of the Madsen map-area (52K/13). In all, these communities house some 4500 persons, mainly dependent on the mining industry, though logging operations and sport-fishing services are viable sustaining operations. Reconnaissance surficial studies and field mapping were undertaken over a broad region in 1978. Mapping of the Red Lake and Madsen map-areas, on a scale of 1:50 000, was carried out mainly during the summers of 1979 and 1980. Airphoto studies helped to delineate certain outcrop areas and some bold rock knobs, but for the most part ground traverses were necessary to better delineate the areas of bedrock, till, sand and gravel, clay and silt, and organic sediments. Traversing in most parts of Red Lake map-area was arduous due to former logging operations and forest fires, with consequent windfall and dense second growth. Logging operations in recent years and the 1980 forest fire have provided good traversing conditions and ready access to large parts of the Madsen map-area. The bedrock is Early Precambrian (Archean) in age and consists mainly of siliceous granitoid intrusive rocks, mafic to felsic volcanic rocks, and minor sedimentary rocks.

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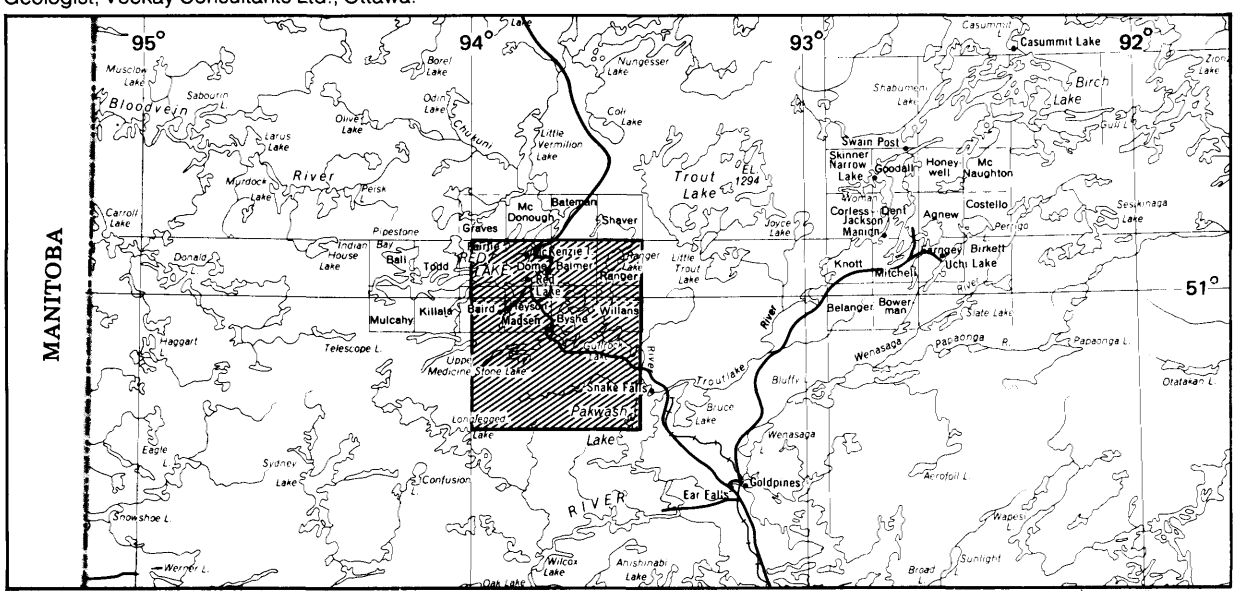
Physiography

The area, which is generally low-lying, is drained to the southeast by the Chukuni River into the English River system, and thence westward to Lake Winnipeg. From the northwestern corner to the southeastern corner of the map-area, a distance of about 60 km, the drop in elevation is only 22 m. Within the map-area, however, local relief is greater, with rocky areas rising some 60 to 100 m above the nearby major lakes which form part of the Chukuni system. The most notable features are the drift ridges of two important end moraine systems: the Lac Seul Moraine (Trout Lake Ridge) in the northeastern corner of the Red Lake map-area and the Hartman Moraine



LOCATION MAP

Scale: 1:1 584 000 or 1 inch to 25 miles

in the southeastern corner of the Madsen map-area. Information on these moraines, including their location, is given by Prest (1963, 1968a, b) and Zoltai (1961, 1965). Bedrock outcrops predominate in the southwestern portion of the Red Lake map-area and in the western part of the Madsen map-area.

Quaternary Geology

The area was scoured by the Late Wisconsinan-Laurentide Ice Sheet, thus removing any earlier deposits. In general the ice flowed southwest to south-southwest, influenced locally, to some degree, by bedrock topography. This trend is indicated by glacial striae, crag-and-tail hills, drumlins and, to a lesser extent, by eskers. Numerous minor moraines transverse to the direction of ice flow indicate former ice-frontal positions. The ice flow was westward, however, when the Hartman and Lac Seul Moraines were being deposited. During glacial recession, the ice fronted or stood in glacial Lake Agassiz. Only part of the crest of the Trout Lake Ridge and, perhaps, part of the Hartman Moraine and some rock knobs in the southern part of the Madsen map-area remained above the surface of the lake.

A stony and commonly bouldery, sandy-silt till blankets a large part of the region in the form of ground moraine, especially in the northern and eastern parts. In the west, where bedrock is prominent, relatively little till has been deposited. The till was deposited from the base of the ice sheet and was subsequently reworked in glacial Lake Agassiz, resulting in a very bouldery surface in some areas. Boulders and stony till also occur as transverse ridges, having formed at the base of the ice sheet where it entered deep water in the glacial lake. Boulders in some of these ridges are commonly a metre or more in diameter. Elsewhere the ridges are composed of small boulder- to cobble-sized materials, and are rarely gravelly or sandy. Boulders and till are also important components of the Lac Seul and Hartman End Moraine systems; boulders one to several metres in diameter occur in parts of these moraines. Sand and gravel are also component parts of these moraines, though most of these materials resulted from the combined action of the glacier, its direct meltwater, and the glacial lake. Thus most of the sand and gravel occurs in immeasurable quantities as beach and terrace deposits on the sides of the morainic system.

There is only one well-defined esker in the Red Lake map-area, located on the eastern side of Ranger Lake and the northern end of Gullrock Lake where its sand and gravel is not currently needed. Elsewhere in the area, meltwaters have issued from short channels which lack up-ice continuity. Thus, the glaciofluvial deposits occur as widely scattered, small, irregular-shaped lobes or ridges which provide sand and some gravel for local usage.

The Madsen map-area is more fortunate with respect to readily accessible sand and gravel resources because Highway 105 crosses two eskers and a sideroad leads to others south of Stone Lake and Genessee Lake. Wave-action in glacial Lake Agassiz has also produced raised beaches on some of the glaciofluvial deposits, thereby providing concentrations of sized gravels. There are also large irregular masses of glaciofluvial material washed out from beneath the ice into glacial Lake Agassiz; although this material is generally sandy, there are local concentrations of gravelly materials. Glacial lake clay is widespread in the Madsen map-area and appears to be quite thick, since some prominent ridges are completely mantled by clay; however, no thick sections have been observed. Organic sediments (peat and muck) cover large areas in the southeastern part of the Madsen map-area where large tracts of swampy terrain overlie glacial lake clay.

Economic Geology

The drift materials of economic interest are sand and gravel deposits. Gravel is trucked northward to the towns of Red Lake and Balmertown, and crushed and sized stone is transported as far as Madsen and Cochenour, a distance of up to 40 km. The smaller glaciofluvial bodies in the Cochenour-Balmertown area have supplied sand for mine fill and pebbly sand or pea-gravel for concrete mix. They have also been used for local road construction (e.g. the Nungesser Road). A lake-modified deposit, located between the Town of Madsen and Faulkenham Lake, has recently proved useful in nearby highway construction. The glaciofluvial deposits have also facilitated the development of logging roads in the central and southeastern parts of the Madsen map-area. In cases where the thin mantle of washed till around bedrock knobs has had to be used, many of the roads become too mucky for wet weather use. The small irregular bodies encountered in these areas should be worked with great care, as they constitute a limited resource. The use of such sand and gravel areas for garbage and sewage dumps should be avoided.

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No. S11 Quaternary Geology of the Dana Lake Area (42A/5), Districts of Cochrane, Timiskaming and Sudbury

C. M. Tucker[1]

THIS PROJECT WAS FUNDED BY THE ONTARIO MINISTRY OF NORTHERN AFFAIRS THROUGH THE NORTHERN ONTARIO GEOLOGICAL SURVEY (NOGS) PROGRAM.

Introduction

The mapping of surficial deposits in the Dana Lake area (42A/5), at a scale of 1:50 000, was completed during the 1980 field season. The area is approximately 1030 km^2 in size and is bounded by Latitudes 48°15′ and 48°30′N and Longitudes 81°30′ and 82°00′W.

Approximately 15 weeks were spent in the field describing surficial deposits, measuring indicators of ice movement and recording Quaternary stratigraphy. Previous investigations of Quaternary deposits which are of significance to the Dana Lake area were conducted by Hughes (1955, 1956, 1960a, 1960b, 1961, 1965), Boissonneau (1966), Skinner (1973), Brereton and Elson (1979), Lee (1979) and Tucker and Sharpe (1980).

Bedrock Geology

The bedrock geology of the Dana Lake map-area has been compiled by Pyke *et al.* (1973). The eastern half of the area is underlain by intermediate to mafic metavolcanics, felsic metavolcanics and metasediments, all of which are Early Precambrian (Archean) in age and belong to the Abitibi metavolcanic-metasedimentary belt. A large, metamorphosed, Early Precambrian mafic intrusion, roughly circular in outline, dominates the north-central part of the area. The remainder of the area is underlain by Early Precambrian felsic intrusive rocks. Numerous north-trending, Late Precambrian diabase dikes cut all other rock types. Middleton (1974) reports that two copper and zinc producers were located in Godfrey Township during the period from 1966 to 1971.

Physiography

The Dana Lake map-area lies north of the Hudson Bay-St. Lawrence drainage divide and forms part of the Northern Clay Belt. Although elevations range from 290 m above sea level in the northwestern corner of the map-area to 412 m east of Warren Lake in Keefer Township, most of the terrain is approximately 320 m above sea level. Generally, the high-relief ground is confined to the southwest-central portion of the map-area and is characterized

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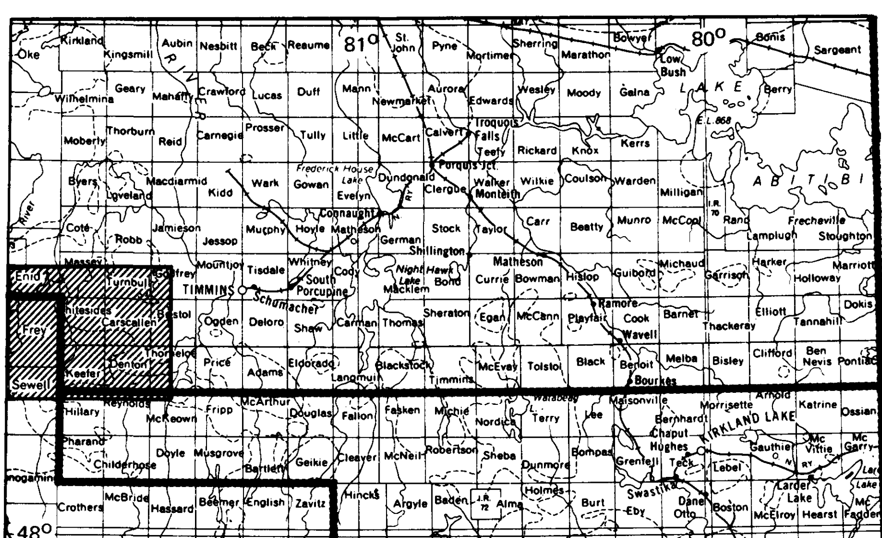

LOCATION MAP

Scale: 1: 1 584 000 or 1 inch to 25 miles

by numerous bedrock knobs and glaciofluvial/ice-contact deposits. Planar areas are found in the lowlands located around the perimeter of the map-area and are typically covered by glaciolacustrine deposits.

Major water courses include the Tatachikapika, Kamiskotia and Nat Rivers, all of which flow to the north or northeast. The largest lakes are Bromley Lake, located in the northwestern corner of the map-area, Opishing, Star and Dana Lakes found in the central portion, and Kenogamissi Lake situated on the southeastern perimeter of the area.

Quaternary Geology and Surficial Deposits

Morphologic indicators and till-clast orientations indicate that the last ice to affect the Dana Lake map-area moved in a general south-southwesterly direction. Towards the eastern perimeter of the area striae have a slight south-southeasterly orientation which is considered a function of ice splaying around the higher central ground.

Large concentrations of till, located in Carscallen and Bristol Townships, are considered to be correlative with the last major flow of the Laurentide Ice Sheet. They have a silty-sand matrix and are greyish-brown in colour. On average, clast lithologies are 31 percent felsic to intermediate intrusives, 24 percent mafic to ultramafic intrusives, 1 percent metasediments, 16 percent felsic to intermediate metavolcanics, 27 percent mafic to ultramafic metavolcanics, 3 percent Paleozoic limestone and dolostone, and less than 1 percent each of Paleozoic sandstone and chert. This till unit is referred to as the Matheson Till by Hughes (1955) and the Adam Till by Skinner (1973). There are no outcrops of the clay-rich Cochrane Till in the Dana Lake map-area.

Glaciofluvial and ice-contact deposits are concentrated in five southerly trending esker complexes. These are located along Nat River, Frey Lake, Dana Lake, Parliament Lake and Little Waterhen Creek. In the first and last cases the eskers are poorly preserved and are visible only as beaded remnants. A pause in deglaciation is recorded by the presence of ice-contact material, in the form of kame moraine, around the Parliament Lake basin in Carscallen Township. This moraine is associated with the Parliament Lake esker and numerous crevasse fillings.

Most of the terrain below 328 m has been heavily modified by the action of glacial Lake Barlow-Ojibway. Between this elevation and 298 m there are significant concentrations of beach material and shallow-water sands. Terrain below 298 m is generally covered by deep-water silt and clay. Field evidence in the Parliament Lake and Cripple Creek areas (well-incised meltwater channels, boulder pavements and ice stagnation deposits) suggests that, during the initial retreat of the Laurentide Ice Sheet, all ground above 315 m was subaerially exposed and that Lake Barlow-Ojibway subsequently rose to higher levels. The dominant beach level is located at an elevation of 328 m and all beaches higher than this are younger and relate to short-lived fluctuations in water levels. The highest recorded beaches occur at approximately 354 m in Carscallen and Hillary Townships, while the lowest and youngest beaches are situated at 295 m.

Much of the shallow-water sand found on the southeastern sides of the eskers and on the sand plain near Tatachikapika River was reworked into northwesterly oriented parabolic dunes as the deposits were exposed by falling water levels during postglacial times.

Alluvium is generally silty to sandy in nature, except for short stretches along the Nat and Tatachikapika Rivers where it is derived from glaciofluvial and ice-contact material.

Organic deposits are ubiquitous and occur most extensively on the planar lowlands.

Economic Deposits

Major sand and gravel deposits are concentrated in the five previously mentioned eskers which, along with their associated outwash and deltaic deposits, are currently being worked on a limited scale. The Dana Lake esker is the largest of such deposits. Dana, Star and Keefer Lakes are also heavily utilized recreational areas.

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No. S12 Quaternary Geology of the Magusi River Area (32D/5), Districts of Cochrane and Timiskaming

C.L. Baker[1]

THE WORK REPORTED HERE IS PART OF THE KIRKLAND LAKE AREA GEOSCIENTIFIC SURVEYS. IT IS FUNDED EQUALLY BY THE FEDERAL DEPARTMENT OF REGIONAL ECONOMIC EXPANSION AND THE ONTARIO MINISTRY OF NORTHERN AFFAIRS UNDER THE COMMUNITY AND RURAL RESOURCE DEVELOPMENT SUBSIDIARY AGREEMENT.

Introduction

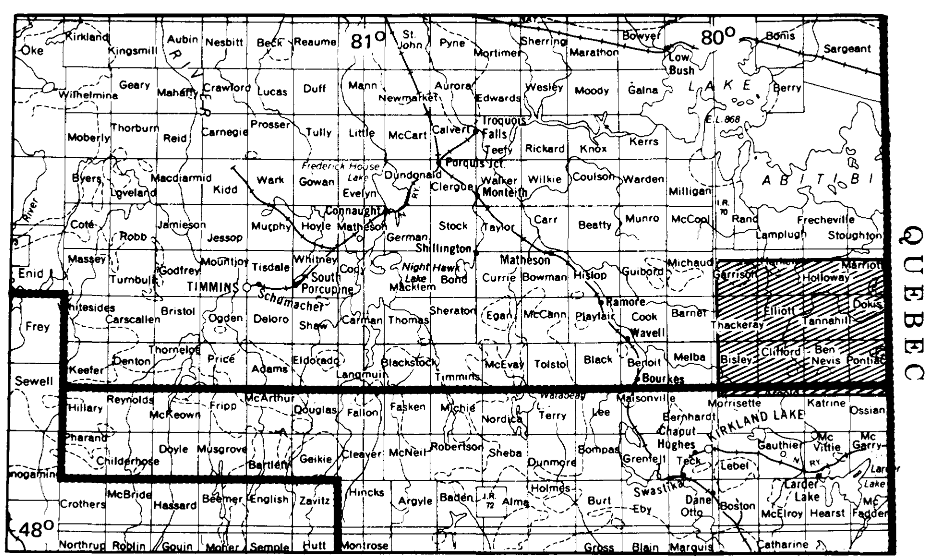
The Magusi River map-area (32D/5) is bounded by Latitudes 48°15′ and 48°30′N and Longitudes 79°30′ and 80°00′W. Quaternary mapping completed during this, the third year of the Kirkland Lake Initiatives Program (KLIP) involved the examination and assessment of materials as they occur in natural and man-made exposures, river and creek banks, road cuts and excavations. These observations were supplemented by traverses along abandoned drilling and lumbering roads, test pitting, and the use of soil probing equipment. Helicopter support was employed in the delineation of surficial units, particularly in the northeastern quadrant of the area which is largely inaccessible by other means. Extensive use was made of 1:15 840 scale airphotos and, to a lesser degree, 1:63 360 scale airphotos.

Additional projects which were undertaken included regional till sampling of the Kirkland Lake area for subsequent geochemical analysis of the heavy minerals to provide a data base in aid of drift exploration. A study of an esker-delta complex on the Munro Esker, east of Kirkland Lake, was commenced in an attempt to define parameters affecting the use of glaciofluvial systems as an exploration tool. Details and results of these projects will be provided at a later date.

[1]Geologist, Engineering and Terrain Geology Section, Ontario Geological Survey, Toronto.

Bedrock Geology

The Magusi River map-area is largely underlain by metavolcanic ultramafic, mafic and intermediate rocks of Early Precambrian (Archean) age. Felsic metavolcanics have been noted within the area, the majority being located in the southern half. Narrow northeast-trending bands of metasediments are located in Garrison and Harker Townships. Stratigraphically above these lithologies are major intrusive rocks which are distributed throughout the area, although most occurrences are of a relatively small areal extent. A large felsic intrusive complex of Early Precambrian age is located in the central part of Garrison Township, with other notable occurrences in Clifford, Harker and Pontiac Townships. The youngest rocks in the area are the diabase dikes, the majority of which trend north or northeast, and which transect all other lithologies.



LOCATION MAP

Scale: 1: 1 584 000 or 1 inch to 25 miles

Physiography

The spatial arrangement of Quaternary materials, combined with the topography of the map-area, gives rise to three physiographic divisions. The most extensive of these consists of thin discontinuous drift cover over large rock outcrops and bedrock knobs. This division covers most of the eastern half of the area and part of the southwestern quadrant. The bedrock control in such areas accounts for the high relief which, in some instances, exceeds 150 m. The second physiographic division consists of fine-grained glaciolacustrine sediments belonging to the Great Clay Belt, and contains several rock protrusions of varying areal extent. These deposits are for the most part located in Elliot, Harker and Tannahill Townships. The topography of the clay belt is generally level to gently rolling but, where the clay thins over bedrock or dissection is advanced, relief can increase sharply. Eskers, associated glaciofluvial sediments, and coarse-grained glaciolacustrine (sand) deposits form the third physiographic division. The premier example of this division is the Munro Esker, which trends northward through Esker Lakes Provincial Park and hence northwestward into Garrison Township. Morphology of the ground surface varies from esker ridge and kettle through hummocky to level. Eolian deposits have developed along the Munro Esker and are most prominent in Clifford and Arnold Townships.

Quaternary Geology

The oldest Quaternary deposit noted in the Magusi River map-area is a Wisconsinan silty-sand till. The till is best exposed on the rocky highlands in the southeastern corner of the area, where the unit's discontinuous nature and rapid variations in thickness, texture and composition are illustrated. Striae and associated directional features indicate glacial ice movement to the southeast (S18E).

Abundant glaciofluvial deposits occur throughout the study area, the most notable being the Munro Esker. Stretching across the western half of the map-area, its course determined by a fault-controlled bedrock valley, the esker reaches a width of 6 km and has a maximum relief of 45 m. A second large esker trends northwestward in the eastern half of the area, and several smaller eskers, with lengths of up to 5 km, are positioned throughout the area. Large tracts of deltaic sedimentation associated with esker systems have been identified in eastern Harker and central Holloway Townships.

When the ice-front withdrew, glacial Lakes Barlow and Ojibway inundated the area, their presence being recorded by washed outcrops and the development, most often on the easily reworked glaciofluvial material, of beach and bar features. The highest (earliest) levels of the lake occur at an elevation of approximately 380 m in Katrine Township and rise to the northeast. Brief stabilizations of the lake during its regression are recorded by beaches at (approximately) 335 m in Clifford Township and in the 305 m to 320 m range in Holloway Township.

Deep-water (fine-grained) glaciolacustrine sediments deposited in glacial Lakes Barlow and Ojibway occur as clay, varved clay and, to a limited degree, silt. The upper limit of the clay rises from 320 m along the southern edge of the map-area to 350 m in the northern sectors. Shallow-water (coarse-grained) glaciolacustrine sand and minor gravel were developed from reworking of till and glaciofluvial deposits, as well as being a facies of deltaic sedimentation. In the latter instance, the sand can achieve thicknesses of up to several metres and display a consistent texture. Reworked till tends to be highly variable in texture and thickness, occurring as a discontinuous thin deposit around bedrock knobs.

Once lake levels had dropped significantly to expose the land, eolian processes became active in the development of dunes on the Munro Esker and flanking sediments where the surficial material consists of fine- to medium-grained sand. Dunes reach heights of 12 m and lengths of up to 2 km.

Upon emergence of the land, accumulations of organic matter, in the form of peat and muck, began to form in swamps and along stream courses. Mappable deposits of organic-rich alluvium occur along the flood plain of the Magusi River from its junction with Webster Creek to the central part of Dokis Township.

Economic Geology

The extensive aggregate deposits of the Magusi River map-area remain undeveloped due to the lack of demand and the considerable distance of the area from surrounding population centres. Reserves in all esker systems, especially the Munro, can be considered extremely high, as can the volume of gravel contained within the delta located south of Harker Lake. Products which could be produced from the deposits include crushed stone, granular A and C, sand fill and asphalt aggregates. The large sand deposits flanking the eskers and eolian material may be utilized as fill or sand cushion, although instances may arise where compaction is a problem.

Peat bogs in the map-area are generally shallow, although several have a large areal extent. Some of these peat bogs may have potential for the development of horticultural peat-moss extraction at some time in the future.

No use has been made of the clay deposits of the area, as these are considered to be too high in lime. Site-specific testing has not been carried out, however, to establish whether a particular area might contain favourable material.

No. S13 Quaternary Geology of the Cobalt Area (31 M/5), District of Timiskaming

Marjatta Perttunen[1]

THIS PROJECT WAS FUNDED BY THE ONTARIO MINISTRY OF NORTHERN AFFAIRS THROUGH THE NORTHERN ONTARIO GEOLOGICAL SURVEY (NOGS) PROGRAM.

Introduction

Mapping of the surficial deposits in the Cobalt area (at a scale of 1:50 000) was carried out during the 1980 field season. The field area covers approximately 910 km^2 and is bounded by Latitudes 47°15′ and 47°30′N and Longitudes 79°30′ and 80°00′W. The Ontario-Quebec border runs down the centre of Lake Timiskaming and the northeastern corner of the map-sheet lies within the province of Quebec. During the field season, surficial deposits were described, indicators of ice movement were measured, and Quaternary stratigraphy was recorded.

Twenty-seven till samples were collected along two traverses, 10 and 13 km in length and oriented in the direction of ice movement. The purpose of this study is to attempt to measure the distance of transport of till, with the aid of till lithology, in order to facilitate drift prospecting in the map-area.

Previous investigations of Quaternary deposits in the area were conducted by Boissonneau (1968), Roed (1979) and Vincent and Hardy (1979).

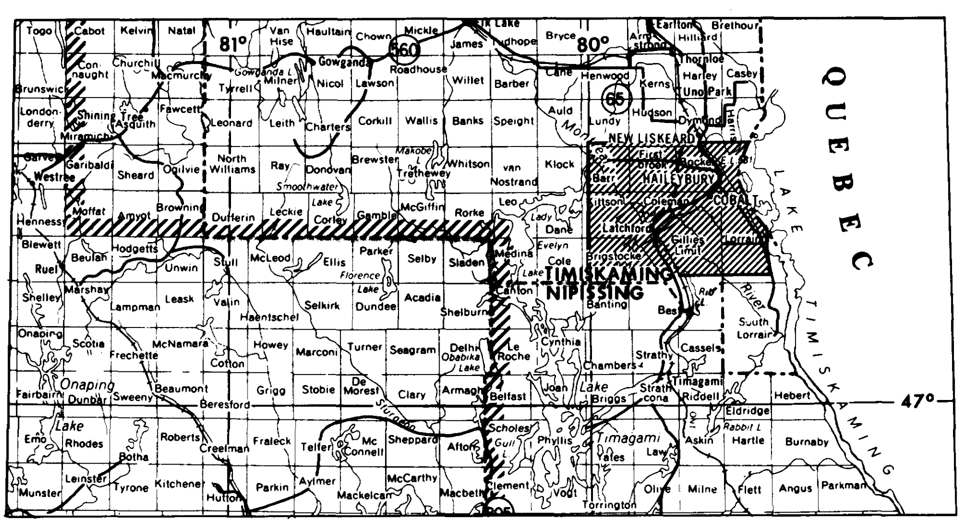
[1]Geologist, Engineering and Terrain Geology Section, Ontario Geological Survey, Toronto.

Bedrock Geology

The bedrock geology of the Cobalt area is described in reports and maps by Todd (1926), Anima-Nipissing Lake area; Thomson (1956), Bucke Township; Thomson (1963a,b,c), Cobalt Silver Area; Lovell and de Grijs (1976), Lorrain Township; and Johns and Van Steenburgh (1980), Firstbrook Lake area. The Cobalt map-area is underlain by rocks of Precambrian age, except in the northeastern part (southern Dymond Township and eastern Bucke Township) where Paleozoic limestones and shales occur. The southeastern part of the map-area is underlain by Early Precambrian (Archean) mafic to intermediate metavolcanics, and granitic and migmatitic rocks. The remainder of the Precambrian terrain consists of Middle Precambrian Cobalt Group rocks: conglomerates, tillites, quartz sandstone, siltstones and argillites. Nipissing Diabase of Middle Precambrian age is widespread in the form of dikes and sills.

The town of Cobalt, world-famous for its past silver production, still boasts four producing mines, although numerous other past-producers have ceased to operate.

The potential for silver-cobalt and gold-silver mineralization is considered high in the vicinity of Cobalt (Springer 1977).



LOCATION MAP

Scale: 1 inch to 25 miles

Physiography

The northern part of the Cobalt map-area lies within the southern end of the Little Clay Belt. It is situated in a physiographic division of the Canadian Shield known as the Cobalt Plain (Bostock 1970). The map-area is characterized by numerous lakes. The largest one is Lake Timiskaming, which is part of the Ottawa River system and forms the eastern border of the map-area. The second largest lake is Lake Anima-Nipissing in the southwestern part of the map-area.

The main water course is the Montreal River, which flows from the northwestern to the southeastern part of the map-area; it has three dams, one at Latchford, a power house at Hound Chute and a compressed air plant at Ragged Chute.

Elevations range from 178 m to 440 m above sea level. Most of the terrain is more than 300 m above sea level and thus has not been affected by glacial Lake Barlow-Ojibway. The southern part of the map-area has the highest elevations.

The main fault direction is northwest, with many steep scarps and bedrock talus piles, and many lakes occupying depressions. There are four fault systems: the Latchford, Montreal River, Cross Lake and Timiskaming Faults (Card and Lumbers 1977).

Quaternary Geology and Surficial Deposits

Striae measurements indicate a general southerly direction of the last ice movement of the Laurentide ice sheet, in the range S to S15W. The direction of the ice movement is also shown by fluting in the northwestern part of the map-area and by the drumlinized landscape in the southwestern part. Because of the high bedrock topography, other local striae directions may be the result of glacier movement along the preglacial valleys, e.g. Montreal River and Lake Timiskaming. In the northeastern part of the map-area, southwesterly trending striae were also measured.

The dominant Quaternary unit in the map-area is a thin discontinuous drift cover interspersed with bedrock outcrops and numerous small exposures of till, the upper part of which is oxidized (loose-weathered). Although the till is mostly thin (0.2-2 m), within valleys and depressions it is frequently several metres in thickness. The nature of the till varies greatly. Its composition varies from silty sand or sandy silt to sand or gravel till in the Precambrian bedrock area. In the northeastern part of the area, underlain by Paleozoic bedrock, the till is clayey silt to silt and calcareous. Similar till occurs over an area of Precambrian bedrock several kilometres down-ice from the Paleozoic limestone bedrock.

On the shore of Lake Timiskaming, there are two till beds in an exposure which has a total thickness of approximately 25 m. The lower part is a clayey silt, calcareous till, while the upper bed is a sandy till (1 to 2 m thick).

In the western part of the map-area, there are some hummocky moraine areas, thicknesses of which range from 3 to 30 m. The moraines contain boulder and pebble-rich sandy to gravelly till with possible sand and gravel beds. The hummocky moraines occur near glaciofluvial deposits.

The dominant glaciofluvial complex trends south-southeastward through the central part of the map-area. It contains outwash with some ice-contact deposits. The southern part of the complex follows the Montreal River Fault and, along the southern part of the Montreal River, it consists of older alluvium silts, sands and gravels. The other large glaciofluvial complex is in the Latchford area and extends south of Latchford. It contains esker ridges and rather poorly sorted kames with outwash. The largest esker complex, which is 7 km long in the map-area and contains some kettle holes, trends northeast through Barr and Kittson Townships. Eskers, kames and outwash of limited extent and thickness are commonly found in many valleys.

The Barlow-Ojibway glaciolacustrine varved clays and silts occur up to an elevation of approximately 290 m above sea level. These deposits cover most of the northeastern part of the map-area as an interconnected network surrounding thinly drift-covered rock outcrops and filling the bottom of the Lorrain Valley. In the Haileybury area, the clays can be at least 30 m in thickness (as reported by the Ministry of Transportation and Communications). Glaciolacustrine silts and sands occur along the course of the Montreal River from Mowat Landing (Barr Township) to Bay Lake. Extending along the Montreal River from Latchford to the Hound Chute dam are glaciolacustrine shell-bearing clays (found at 275 m above sea level), varved clays and silts. Glaciolacustrine coarse-grained sand and gravel border the outwash deposits in Firstbrook Township.

Raised beaches and wave-washed beaches of glacial Lake Barlow-Ojibway are found along the shore of Lake Timiskaming below an elevation of approximately 300 m above sea level. Particularly clear lower strandlines occur, at approximately 192 and 210 m above sea level, in the clay deposits of Harris Township and in the area extending from New Liskeard to Haileybury. On the southwestern shore of Firstbrook Lake (Firstbrook Township), the glaciofluvial deposits exhibit a beach scarp, approximately 2.5 km long, at an elevation of 293 m above sea level. According to Vincent and Hardy (1979) the upper limit of the strandlines in the northern part of Lake Timiskaming varies between 293 m and 312 m in elevation. Eolian activity modified the glaciofluvial deposits to produce sand dunes in Firstbrook Township and in Coleman Township.

Recent alluvial deposits are found occasionally along the rivers. Large swamps with peat and muck are common in the western part of the map-area.

Economic Geology

Major sand and gravel deposits are concentrated in the glaciofluvial complex in the central part of the map-area, in part along Highway 11; these are currently being worked. The best undeveloped sand and gravel deposits occur in the previously mentioned esker complex, on the southwest side of the Montreal River in Barr and Kittson Township. However, access to the material is poor. The quality of sand and gravel along the boundary between Brigstocke and Gillies Limit Townships is generally rather inferior. In many valleys, small glaciofluvial deposits (sand, gravel, pebbles) are quite sufficient for local purposes. There are no peat deposits of economic value because of the shallow depths and relatively poor quality (freshness) of the deposits.

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No. S14 Quaternary Geology of the Coe Hill Area (31C/13), Hastings, Peterborough and Haliburton Counties, Southern Ontario

P.F. Finamore[1]

THE WORK REPORTED HERE WAS FUNDED EQUALLY BY THE FEDERAL DEPARTMENT OF REGIONAL ECONOMIC EXPANSION AND THE ONTARIO MINISTRY OF NATURAL RESOURCES UNDER THE MINERALS PROGRAM OF THE EASTERN ONTARIO SUBSIDIARY AGREEMENT.

Introduction

The Coe Hill map-area (NTS 31C/13) is bounded by Latitudes 44°45′ and 45°00′N and Longitudes 77°30′ and 78°00′W. The region is sparsely populated, except in areas where cottagers take up residence during the summer. Forestry and tourism are the major industries. Field mapping was completed during the summer of 1980.

Physiography and Bedrock Geology

The Coe Hill area is in the southwestern part of the Laurentian Highlands division of the Laurentian Physiographic Region (Bostock 1969). The Highlands are characterized by irregular bedrock knobs and ridges separated by bogs and numerous underfit streams and rivers, and range in elevation from about 460 m above sea level in the northeastern part to about 270 m above sea level at the southern end of the map-area.

In general, the topography decreases from north to south, except for that portion in the northern quarter of the map-area where the drainage is to the Ottawa River. The rest of the map-area is part of the Lake Ontario drainage basin. Consequently, the headwaters of the major river systems which orginated in the map-area are characterized by large swamps and deadwaters dotted with lakes and small waterfalls.

The bedrock consists of Middle to Late Precambrian rocks of the Grenville Province. The dominant rock types within the map-area are clastic and carbonate metasediments, metavolcanics, felsic to ultramafic intrusive rocks and their metamorphosed equivalents (Freeman 1978).

Quaternary Geology

Glacial deposits in the Coe Hill area are probably Wis-

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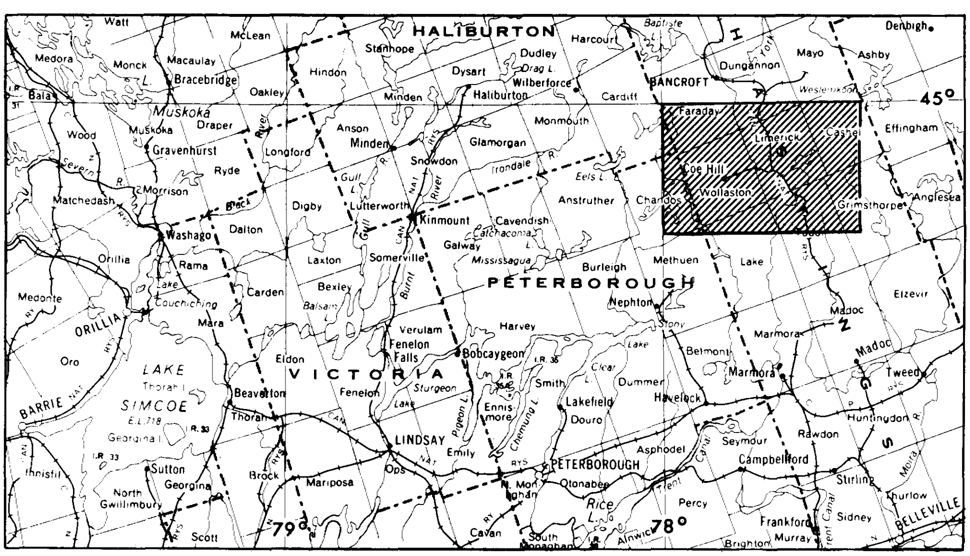

LOCATION MAP

Scale: 1:1,584,000 cr 1 inch to 25 miles consinan in age. Ice movement was generally in a southerly direction, as suggested by various ice flow directional indicators. Local variations that were observed can be attributed to topographic control. One locality east of Mephisto Lake exhibits crosscutting striae, where both sets are oriented approximately north-south but are separated by an angle of about 25 degrees. These striae suggest a possible local readvance. This proposal is further supported by the presence of overridden glaciofluvial sediments 1 km north of this locality.

The texture of the till in the area ranges from stony and gritty silty sand to sand. The till is usually shallow and discontinuous except in areas where a few drumlins or drumlinoid ridges are present. These ridges are usually isolated and form positive topographic features in an otherwise bedrock-controlled topography. Two such ridges can be found 3 km south of Wollaston Lake and 1 km south of Wadsworth Lake.

The till is usually loosely compact in areas where drift cover is shallow and contains a high percentage of stone and sand. In drumlins, the till is atypical, in that the material is loosely to moderately compact and the stone content is relatively low.

In several localities, the till appears to have incorporated glaciolacustrine or glaciofluvial sediments. The incorporated sediments are somewhat contorted in places and occur as inclusions within the till. In one locality, the till directly overlies similar fine-grained sediments, suggesting either a readvance of glacial ice (probably local) or that the stratified sediments were deposited in association with the till.

Glaciofluvial deposits in the form of esker ridges occur in two localities: between Lakes Coulin and Baytree, and between Lakes Limerick and Steenburg. The latter area also exhibits esker fans and kame terraces in association with the esker ridge.

Laminated to thinly bedded glaciolacustrine sediments, overlain by organic material, were observed along the valley of Beaver Creek near Gilmour. These sediments may correlate with Barnett's (1979) glaciolacustrine sediments along the York and Little Mississippi River valleys in the Bancroft map-area. Smaller deposits of glaciolacustrine clayey silts were noted in the vicinity of Mephisto Lake.

The most abundant surficial material in the area is a fine- to medium-grained sand. In the Bancroft area, Barnett (1980) suggests that similar deposits of sand represent distal deltaic top-set beds which infilled former lake basins. This suggestion appears valid because the sands can be found along the upper flanks of topographic depressions at elevations exceeding 350 m above sea level.

Accumulations of organic matter in the form of peat and muck are widespread throughout the map-area. The thickness of the peat is variable and it commonly overlies fine- to very fine-grained sands.

Economic Geology

Although concentrations of base and precious metals have been reported in the map-area, none have as yet proven economically viable. Industrial minerals such as marble and granite have been quarried in the past and appear to be potential sources of building and monument stone. Numerous sand and gravel pits, which are either inactive or active on demand, can be found in the map-area. Aggregate extraction activities are usually associated with various phases of highway construction. The most active area of extraction is located between Lakes Limerick and Steenburg. The most serious limitation of this deposit, as well as others throughout the map-area, is the lack of coarse aggregate. Numerous pits have exhausted portions of the deposit, particularly in areas where coarse aggregate was plentiful. Nevertheless, significant quantities of gravelly sand are readily available.

Field mapping indicates that there are four areas where coarse aggregate may be found in abundance:

1) 1.5 km west of Egan Lake,
2) 2.5km south of Baytree Lake,
3) 3.5 km north of Snow Lake, and
4) Immediately north and south of Baytree Lake.

Further exploration and testing are necessary to determine the overall quality and quantity of the material.

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No. S15 Quaternary Geology of the Campbellford (31C/5), Trenton (31C/4) and Consecon (30N/13) Areas, Prince Edward, Hastings, Northumberland and Peterborough Counties, Southern Ontario

J.G. Leyland,[1] D.R. Sharpe[2] and P.J. Barnett[2]

THE WORK REPORTED HERE WAS FUNDED EQUALLY BY THE FEDERAL DEPARTMENT OF REGIONAL ECONOMIC EXPANSION AND THE ONTARIO MINISTRY OF NATURAL RESOURCES UNDER THE MINERALS PROGRAM OF THE EASTERN ONTARIO SUBSIDIARY AGREEMENT.

Introduction

Mapping of the Campbellford, Trenton and Consecon areas involved the re-examination of three map-areas which were initially described in general by Chapman and Putnam (1951, 1966), and later examined in more detail by Mirynech (1962). Preliminary maps for the area prepared by Mirynech were placed on open file by the Geological Survey of Canada in 1978 (Mirynech 1978). The areas are being remapped in view of recent revisions in the glacial and postglacial history of southern Ontario.

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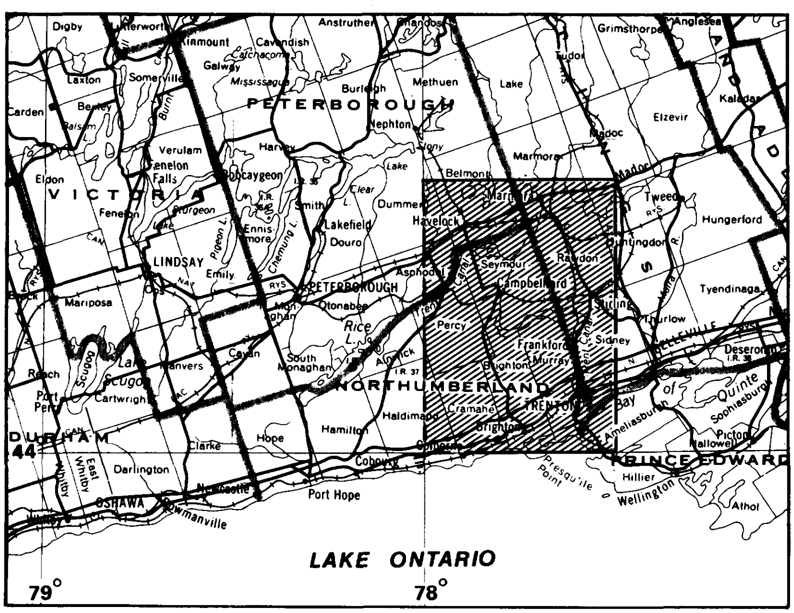
[2]Geologist, Engineering and Terrain Geology Section, Ontario Geological Survey, Toronto.

Location

The Campbellford, Trenton and Consecon map-areas lie between Latitude 44°30′N and Lake Ontario to the south and between Longitudes 77°30′ and 78°00′W. The present survey was conducted in the 1980 field season by J.G. Leyland and assistants.

Bedrock Geology

Bedrock in this area consists primarily of limestone of the Simcoe Group underlain by clastics of the Shadow Lake Formation. The rocks which constitute the formations of the Simcoe Group are composed predominantly of medium- to thick-bedded limestone, shaly limestone and bioclastic limestone, with lesser amounts of dolomitic limestone and calcarenite (Carson 1980a). The Paleozoic



LOCATION MAP   Scale: 1: 1 584 000 or 1 inch to 25 miles geology of the area has been previously reported by Winder (1955), Liberty (1960) and Carson (1980a, b).

Outcrops are best exposed in the northern and southern portions of the map-area where the drift thins, along the Crowe and Trent River valleys, and along portions of the shoreline of the Bay of Quinte and Lake Ontario. Metasediments and metavolcanics of the Grenville Province are exposed in the northernmost portion of the Campbellford area.

Physiography

The map-area is characterized by three east-trending physiographic regions: a southern relatively flat region, a central, highly drumlinized region and a northern hummocky region. These are portions of the Iroquois Plain, Peterborough Drumlin Field and Dummer Moraine, respectively (Chapman and Putman 1966). The southern region begins at the Lake Ontario shoreline and extends several kilometres northward to the central, highly drumlinized region. The transition between the southern and central regions is marked by an abrupt rise in elevation and by well-developed nearshore deposits which are the result of lowering postglacial lake levels. Drift thickness in the central region varies considerably, locally exceeding 125 metres. The northern hummocky region, which is part of the Dummer Moraine, is separated from the central drumlinized area by a transition zone up to several kilometres wide. The drift thins in the northern region and bedrock is often exposed in ditches and streams. A portion of the Oak Ridges Moraine system enters the central drumlinized region from the west, but does not extend across the map-area.

Quaternary Geology

The oldest features in the map-area are the drumlins of the central region. They indicate strong ice flow from the north to northeast and are composed of moderately stony, silty, sandy to sandy silt till. Sometimes the drumlins are flanked by ice-contact deposits, but most often only the crests of the drumlins are exposed, the flanks and intervening lows being covered with lacustrine sands, silts and clays. Water-well data from drumlinized expanses of thick drift indicate a thin mantle of till over stratified sediments. The origin of the underlying sediments has not yet been determined.

The material of the northern hummocky region is also a stony sand till but with a higher content of stone than the till in the central region. The stone fraction of this deposit is almost exclusively angular to subangular Paleozoic fragments, the sands being coarse-grained and poorly sorted. These sediments often interfinger with and/or grade into other deposits, most often silty-sand till or poorly sorted gravels. The origin of this deposit is at present poorly understood, but it was probably deposited as the ice front receded from the area.

In the extreme northern portion of the Campbellford map-area, there are several expanses of Precambrian outcrop. Drift is relatively minor in these areas and is composed mainly of the same stoney sand till.

Evidence in the southern, relatively flat region suggests a late ice advance from the southeast. The data includes glacial striae, an areally limited clayey silt to silty clay till, and contorted lacustrine sediments. Post-glacial lacustrine modification has probably mantled or destroyed much of the evidence for this advance. The surface of the southern region is mantled by nearshore sands to deep-water silts and clays of varying thickness. Silty sand till is occasionally exposed through these deposits and, close to the Lake Ontario shore, the deposits become very thin over bedrock. Although this southeastern ice advance may have overridden and/or eroded deposits of the earlier, major ice movement from the north, a few drumlin forms still remain from the initial northern advance.

Several large, well-developed eskers cross the Trenton and Campbellford map-areas, trending consistently west-southwestward. As the main ice movement, determined from drumlin orientation and glacial striae, was from slightly east of north, it appears that local topography was a controlling influence on orientation of the eskers.

Glacial and Post-Glacial Lakes

At least three raised shorelines have been identified in the Campbellford, Consecon and Trenton map-areas. Features of the highest lake level, Glacial Lake Iroquois, are very well developed in the Trenton map-area and the southern portion of the Campbellford map-area. Nearshore features include very large spits and bars, well-developed bluffs, and the truncation or planing-off of some drumlins to wave base. Where topographic highs have been truncated by wave action, large deposits of overwash sediments have developed on the northwestern side of the features. This indicates that prevailing wind direction during deglaciation was from the southeast. This wind direction also holds true for the less well-developed, lower, post-glacial lake levels.

Nearshore deposits of glacial Lake Iroquois become increasingly well developed northwestwards, but eventually disappear in the northern portion of the Campbellford map-area. This indicates that Lake Iroquois was ice marginal in the north and that lake levels fell before the ice had entirely left the area.

Drainage Channels

A major erosional feature of the map-area runs along the Trent River valley, cutting through surrounding sediments, often to bedrock. Several large bars are present in the valley and are probably related to falling water levels after the main erosional event. The erosion of the river valley was most likely due to the drainage of glacial Lake Algonquin through the Kirkfield outlet.

Economic Geology

Large volumes of aggregate are present in the Campbellford and Trenton map-areas, mainly in the large eskers of both areas and in the extensive raised beach deposits which are best developed in the Trenton area. Numerous pits have been developed in these deposits, many of which are still in operation. There remain, however, large resources of aggregate material which are probably sufficient for local requirements in the foreseeable future.

Several small quarries in the Paleozoic rocks are intermittently operated in the Trenton and Campbellford map-areas. The St. Lawrence Cement Company operates a large quarry, at Colborne in the Consecon map-area, for limestone used in the manufacture of cement.

A basalt quarry is operated by 3M Canada Incorporated for the extraction of 'trap-rock' for highway construction. An open pit iron mine was operated until recently at Marmora but has now been abandoned. Mine waste is presently being processed for sale as aggregate.

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No. S16 Assessment of Aggregate Deposits Near the City of North Bay, Districts of Parry Sound and Nipissing, and Near the Towns of Hearst and Kapuskasing, District of Cochrane

W.D. Scott[1] and J.Z. Fraser[2]

THIS PROJECT WAS FUNDED BY THE ONTARIO MINISTRY OF NORTHERN AFFAIRS THROUGH THE REGIONAL PRIORITY BUDGET.

Introduction

Field mapping of natural aggregate deposits was initiated and completed during the summer of 1980 for the planning areas surrounding three urban centres in northeastern Ontario. The project was initiated at the request of the concerned municipalities and by District Offices of the Ministry of Natural Resources. The work was supported by funds from the Ontario Ministry of Northern Affairs.

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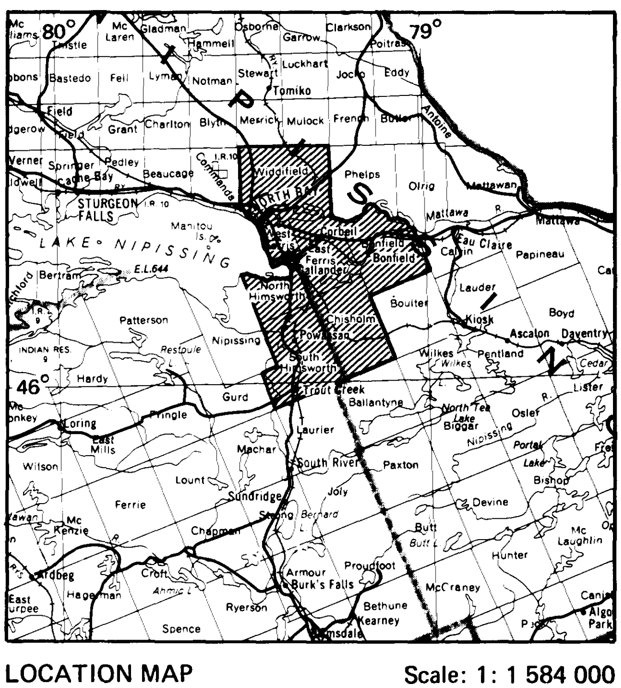


LOCATION MAP

Scale: 1: 1 584 000
or 1 inch to 25 miles

The North Bay project area consists of the City of North Bay (the geographic Townships of West Ferris and Widdifield) and the geographic Townships of East Ferris, North Himsworth, South Himsworth, Chisholm and Bonfield, and covers approximately 1200 km^2. The Hearst project area consists of the geographic Townships of Way, Lowther, Kendall, Casgrain, Hanlan, Devitt and Eilber, and covers approximately 1400 km^2. The Kapuskasing project area consists of the geographic Townships of Idington, Owens, Williamson, O'Brien, Teetzel, Fauquier and Nansen, and covers approximately 1450 km^2.

The objectives of the field component of the program were:

1) to identify and delineate the geological boundaries of all sand and gravel deposits, based on existing geological maps and airphoto interpretation;
2) to assess the type and quality of the aggregate in these deposits and to sample representative material for grain-size and petrographic analysis;
3) to compile an inventory of all known extractive operations in the deposits; and
4) to conduct subsurface examinations (using a backhoe) of potential extractive sites.

The interpretation of the field data and the evaluation of the aggregate resources in the three areas will be published in the Aggregate Resources Inventory Paper series.

General Geology and Aggregate Resources

North Bay Area

The North Bay project area is located on the eastern shore of Lake Nipissing. It lies mainly within the Mattawa Lowland physiographic region, although parts of the area are in the Northern and Algonquin Highlands, located to the north and south respectively (Harrison 1972). The bedrock consists of Precambrian age granitic and sedimentary formations (Lumbers 1971). The bedrock surface is irregular but generally of subdued relief, except in the highland regions. Drift cover is generally thin, but in places exceeds 100 m.

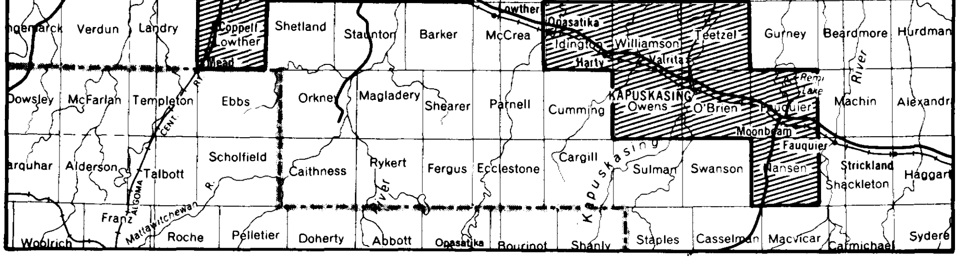
The predominant glacial sediment in the area is a compact, stony, sand to silty-sand till deposited during the main ice advance over the area. Because of its low 'fines' content, the till may be suitable in places for some low-specification construction aggregate. Most of the higher specification aggregate resources are concentrated in moraines and eskers which were deposited at the margin of the glacial ice during its eventual retreat to the north. The Genesee and Rutherglen Moraines were deposited at the ice margin during the Genesee and Sobie-Guillemette Outlet phases of deglaciation, respectively (Harrison 1972), and are located in Chisholm and Bonfield Townships. These deposits have not been extensively exploited in the past, but contain large possible resources of fine-grained aggregate. Gravel is relatively rare, being confined to pockets and lenses within the moraine, and to several well-defined esker ridges which are developed on the moraine surface in the Genesee Moraine and the southern portion of the Rutherglen Moraine.

The Bonfield Esker, which may have been deposited contemporaneously with the Rutherglen Moraine, lies in the central portion of Bonfield Township and contains large possible resources of crushable gravel suitable for a range of road-building and construction aggregates. The present level of extraction in this deposit is relatively low. The only other large-scale aggregate sources in the North Bay area are three parallel, north-trending, esker-delta systems, located in the northern portion of the City of North Bay (geographic Township of Widdifield). These sediments were deposited by south-flowing, sub-glacial meltwater streams during the Sobie-Guillemette Outlet phase, while the ice margin stood just to the north of the Thibault Escarpment. The northern portions of the deposits consist of well-defined, segmented esker ridges composed predominantly of pebble and cobble gravel. These parts of the central and western complexes are presently being extracted at several large commercial operations. The eastern esker-delta complex is relatively unexploited and represents a valuable future aggregate source for the North Bay area.

In the central portion of the deposits, coarse aggregate is usually overlain by a considerable thickness of sandy, braided stream sediment representing deposition during a subsequent period of open-channel flow. Many large pits have been opened in this portion of the central and western deposits and have supplied much of the road-building and construction aggregates used in the City of North Bay. Possible resources of crushable gravel are rapidly diminishing in this area.

The southern portions of the deposits are predominantly extensive sandy deltaic sequences, deposited in deep water ponded against the Thibault Escarpment and the ice margin. The aggregate in these areas consists of well-sorted and -stratified sand and silt, and pit faces show well-developed dewatering structures, consistent with a sub-aqueous mode of deposition. Many large pits have been developed in these sediments in the past and, although possible resources of fine-grained aggregate are still considerable, crushable aggregate resources are very small.

Of the 138 pits studied in the North Bay area, more than 10 were large-scale commercial sources, capable of supplying large amounts of aggregate. Most of these sources are developed in the central and western esker-delta complexes. Sand and gravel resources in these deposits are diminishing rapidly, but large possible resources may be available in the relatively unexploited eastern deposit. Large possible resources of fine aggregate may be available in the Rutherglen and Genessee Moraines and moderate amounts of crushable gravel are available in the Bonfield Esker.



LOCATION MAP

Scale: 1:1,584,000 or 1 inch to 25 miles

Hearst Area

The Hearst project area consists of seven geographic townships, and includes the area immediately surrounding the town as well as much of the land flanking Highway 11 to the east and west. The bedrock in this area forms part of a Precambrian metasediment-metavolcanic complex which underlies much of the region (Bennett 1966). The bedrock surface is irregular but of subdued relief, and is overlain by a veneer of Quaternary sediments.

The dominant surface material is a compact, low stone, silty-clay till deposited by glacial ice which advanced to the southeast during the Cochrane Readvance, the last major ice movement prior to deglaciation of the area (Boissonneau 1966). The till has no value as aggregate because of its high 'fines' content.

The only sand and gravel deposits in the area were laid down prior to the Cochrane Re-advance. The deposits were overridden during that advance and have been buried by 1 to 10 m of till. In places, the morphology of the older deposits has been well preserved, while elsewhere there is no surface indication of the existence of aggregate beneath the till mantle.

Considerable amounts of fine- and coarse-grained aggregate have been extracted from eskers in Casgrain Township and, to a lesser extent, in Eilber and Hanlan Townships (Lee and Scott, in preparation(b)). The deposit in Casgrain Township is by far the largest, and several commercial pits located along the esker ridge supply most of the road-building and construction aggregate used in the Hearst area. The remaining resources in the deposit, especially those of crushable aggregate, are quite small. The field appearance of the deposit, plus preliminary backhoe testing of unexploited subsidiary ridges adjacent to the main deposit, indicate that additional resources of sandy aggregate may be available in the area. The other esker deposits presently being exploited in Eilber and Hanlan Townships are nearing depletion, or contain relatively small amounts of aggregate.

Ice-contact stratified drift deposits, possibly related to an earlier ice-marginal position, are found in several broad, till-covered ridges along Highway 11, near Hallebourg and Ryland. A large pit near Hallebourg exposes fine-grained material, suited only for low specification uses. Large possible resources of similar material may be available in these deposits, but preliminary backhoe testing was inconclusive because of the thickness of the overlying till.

Of the 34 sand and gravel pits studied in the Hearst area, only five or six are capable of supplying a range of construction aggregate. Remaining possible resources, especially of crushable aggregate, are low and a supply problem may exist in the relatively near future.

Kapuskasing Area

The Kapuskasing project area consists of seven geographic townships surrounding the town and flanking portions of Highway 11. The local bedrock is part of the regional Precambrian metasediment-metavolcanic complex which also underlies the Hearst area. The bedrock surface is a low-relief plain, covered by a veneer of Quaternary sediments. Several operations have been opened near Highway 11 to quarry granite and diorite for construction aggregate. Diminishing natural aggregate resources in the western portion of the project area may increase the demand for bedrock-derived aggregate, of which possible resources in the Kapuskasing area are very large.

The predominant surface material, a silty clay till deposited during the Cochrane Re-advance (Lee and Scott, in preparation(a)), has no value as aggregate. Large possible resources of sand and crushable gravel are available from two large esker systems located in the eastern half of the project area and, to a lesser extent, from two smaller esker deposits in the western part of the area. All of the esker deposits predate the Cochrane Re-advance and are therefore buried by variable amounts of till. In most cases, the deposits still have considerable surface expression although covered by more than 5 m of till. In addition to the stripping difficulties in these deposits, extraction is hindered by the characteristically high water table throughout the area; in most cases, large-scale extraction requires considerable pumping and use of dragline equipment.

A large, well-defined segmented esker system extends south from Remi Lake in Fauquier Township to the southern boundary of Nansen Township. A number of large pits have extracted a significant proportion of the aggregate, but considerable quantities may be available in the southern part of Nansen Township and just north of Moonbeam in Fauquier Township. Access to much of the deposit is provided by roads maintained by the Spruce Falls Power and Paper Company Limited. Large possible resources of fine-grained aggregate may be available in a deltaic deposit developed on the western flank of the esker just south of Remi Lake. A partially buried segmented esker system extends south from the northern boundary of Teetzel Township for a distance of more than 30 km to the southern boundary of O'Brien Township. This deposit has also seen considerable extraction in the recent past, but additional resources may be available near O'Brien Lake and further north in Teetzel Township. Again, good access is provided by roads maintained by the Spruce Falls Power and Paper Company Limited.

Two smaller esker deposits, one at the boundary between Owens and Williamson Townships and the other in Idington Township, have been heavily extracted in the past and are now nearing depletion. Except for small, scattered, ice-contact stratified drift deposits near Highway 11, possible aggregate resources are very low in the western portion of the area.

More than 65 sand and gravel pits were visited during the study of the Kapuskasing area, of which more than 10 were commercial sources capable of supplying large amounts of road-building and construction aggregate. With proper resource management the eskers in the eastern portion of the project area may be capable of supplying local aggregate demand for a considerable period of time.

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No. S17 Limestone-Dolostone Assessment Study, Manitoulin Island

M.D. Johnson[1]

THIS PROJECT WAS FUNDED BY THE ONTARIO MINISTRY OF NORTHERN AFFAIRS THROUGH THE NORTHERN ONTARIO GEOLOGICAL SURVEY (NOGS) PROGRAM.

Location

Mapping and sampling of Paleozoic rocks was carried out on the northern and western parts of Manitoulin Island during the 1980 field season. The mapped area is covered by the following 1:50 000 NTS sheets: Kagawong 41G/16, Silver Water 41G/15, Great Duck Island 41G/10 and Meldrum Bay 4G/14. It included the main landmass of the island, bounded on the north, west and south by the North Channel, Mississagi Strait and Lake Huron respectively, and in the south and east by Longitude 82°00′W, and Latitude 45°45′N.

General Geology

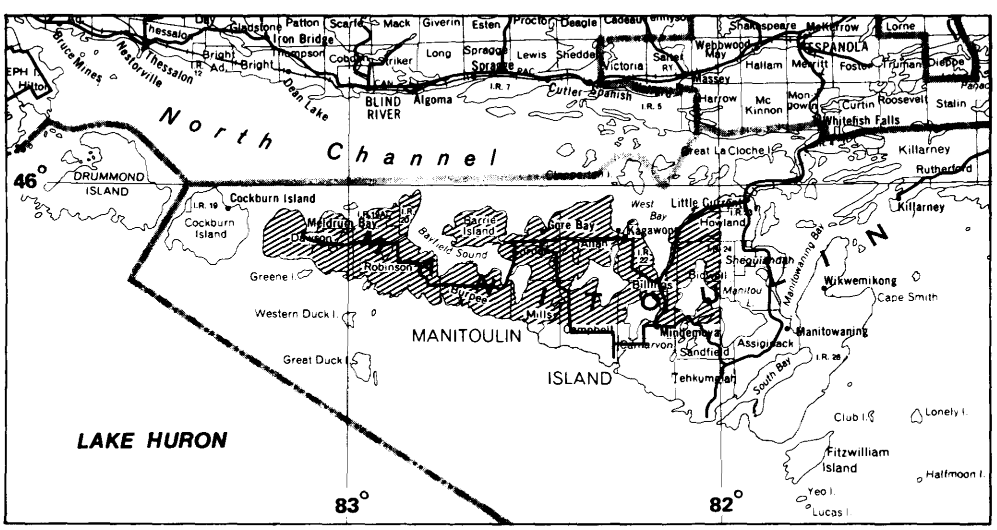
Manitoulin Island is abundant in Paleozoic outcrops, particularly in the southern part where large tracts of bare rock are exposed. The rocks range in age from the Middle Ordovician Lindsay Formation to the Middle Silurian Amabel Formation (Table 1).

[1]Geologist, Engineering and Terrain Geology Section, Ontario Geological Survey, Toronto.

The Lindsay Formation consists of grey, fine to sublithographic limestone with minor dolostone. It is overlain by the Whitby Formation, a shaly unit comprising soft brown shales in its upper part and black, fissile, fossiliferous shales with minor dolostone in its lower part.

Overlying the Whitby Formation is the Georgian Bay Formation, which is composed of lower and upper members, the latter being divided into two sub-members. The lower member is the Wikwemikongsing, which consists of bluish-grey shales. The lower sub-member of the upper member is the Meaford, which contains bluish-grey fine-grained argillaceous dolostone. The overlying Kagawong (upper sub-member) is a brown and grey, finely crystalline dolostone.

Silurian deposition began with the Manitoulin Formation, a brown to bluish-grey fine to sublithographic dolostone. This formation includes reefal (biohermal) and thin inter-reefal (platform) deposits. It is overlain by the Cabot Head Formation, which contains four members (nomenclature of Liberty 1968). These are: the Cabot Head (restricted) Member, a green and red shale; the Dyer Bay Member, a bluish finely crystalline dolostone with shales; the Wingfield Member, a brown sublithographic dolostone interbedded with green shales; and the uppermost St. Edmunds Member, a massive brown and grey, fine- to medium-grained crystalline dolostone.



LOCATION MAP **Scale: 1: 1 584 000 or 1 inch to 25 miles**

TABLE 1 PALEOZOIC STRATIGRAPHY OF MANITOULIN ISLAND (MAINLAND MASS ONLY) AFTER LIBERTY (1968)

MIDDLE SILURIAN		
Amabel Formation		
Fossil Hill Formation		
Mindemoya Formation		
Cabot Head Formation	-St. Edmunds member	
	-Wingfield member	
	-Dyer Bay member	
LOWER SILURIAN		
	-Cabot Head member (restricted)	
Manitoulin Formation		
ORDOVICIAN		
Georgian Bay Formation	-Upper member	-Kagawong beds
		-Meaford beds
	-Lower member	-Wikwemikongsing beds
Whitby Formation		
Lindsay Formation		

TABLE 2 1979 DRILLING ACTIVITIES

Hole Number	Locality Description	NTS Map	UTM Co-ordinates	Depth (Metres)	Formation Encountered
79-11	Province Bay. Shoreline of Lake Huron, n.w. corner of lot 2, con. XIII, Carnarvon Tp.	41G/9	401325mE - 5056600mN	30.62	-Amabel -Fossil Hill
79-12	Mindimoya South. East side of road leading from Mindemoya to Hwy. 542A, lot 21, con. XI, Carnarvon Tp.	41G/9	409175mE - 5057875mN	31.25	-Amabel -Fossil Hill
79-13	Michaels Bay. Lake Huron shoreline at Michaels Bay, at mouth of Manitou River (west bank).	41G/9	413750mE - 5049900mN	31.35	-Amabel
79-14	Manitowaning. Northern part of lot 50, con. II, Assiginack Twp.	41J/13	436625mE - 5044250mM	15.18	-Manitoulin -Georgian Bay
79-15	Wikwemikong Indian Reserve #26. 3.2 km w.n.w. of Quanja Lake at the end of a farm road.	41H/12 and 41H/11	434500mE - 5050650mN	30.61	-Amabel -Fossil Hill
79-16	Wikwemikong Indian Reserve #26. 1.0 km west of Little Bluff, 3.3 km north of Owen Island.	41H/12 and 41H/11	433175mE - 5067200mN	31.25	-Fossil Hill -Mindemoya

TABLE 3 1980 DRILLING ACTIVITIES

Hole Number	Locality Description	Anticipated Depth (m)	NTS Map	UTM Co-ordinates
80-17	Meldrum Bay West. West end of con. road between con. XI, lot 33, and con. XII, lot 33, Dawson Tp.	60	41G/14	332500mE - 5088360mN
80-18	Quarry Bay, Shoreline of Lake Huron, s.e. corner lot 24, con. V, Dawson Tp.	40	41G/14	336500mE - 5081610mN
80-19	Burnett Lake. s.e. corner lot 10, con. XII, Robinson Tp.	30	41G/14	342250mE - 5085950mN
80-20	Ranger Station. n.e. corner lot 23, Con. XII, Robinson Tp.	90	41G/15	351480mE - 5084700mN
80-21	Deadman's Point. Lake Huron shoreline at Deadman's Point, Carroll Wood Bay, s.w. corner lot 15, con. II, Robinson Tp.	45	41G/15	357850mE - 5073850mN
80-22	Helen Bay. North side of Hwy. 540, s.w. corner lot 17, con. VIII, Burpee Tp.	75	41G/15	370750mE - 5075200mN
80-23	Lorne Lake. South shore of Lorne Lake, lot 27, con. III, Burpee Tp.	45	41G/15	374500mE - 5070400mN
80-24	Barrie Island. Northern road allowance of con. road between con. III, lot 15 and con. IV lot 15, Barrie Island.	30	41G/15	371900mE - 5085000mN
80-25	Tobacco Lake West. Road allowance, Hwy. 540B, lot 8, con. IV, Gordon Tp. Adjacent to gravel road to Tobacco Lake.	45	41G/16	385830mE - 5078440mN
80-26	Perivale. s.w. corner lot 10, con. VII, Campbell Tp.	60	41G/16	397400mE - 5067950mN
80-27	Grimsthorpe. Northern road allowance of con. road between con. XII, lot 16 and con. XIII, lot 16, Campbell Tp.	45	41G/16	394930mE - 5062980mN
80-28	Tehkummah. Northern side of con. road between con. II, lot 18 and con. III, lot 18, Tehkummah Tp.	45	41G/9	418000mE - 5056200mN
80-29	Cup & Saucer Quarry. Existing dolostone quarry, lot 29, con VIII, Bidwell Tp. Adjacent to entrance to Cup & Saucer walking trail.	30	41G/16	414500mE - 5078700mN

The overlying Mindemoya Formation is a predominantly thin-bedded, pale grey to light brown, sublithographic to finely crystalline dolostone. Overlying the Mindemoya Formation is the Fossil Hill Formation, a buff to grey-brown, fine- to coarsely-crystalline dolostone. This formation is rich in coral, algal, and brachiopod remains, with beds of chert nodules in its upper part. The contact with the overlying Amabel Formation is gradational.

The Amabel Formation consists of a blue-grey to buff, fine to evenly crystalline dolostone. Both reefal and inter-reefal beds are present. This formation possesses a number of thin chert-rich zones concentrated in the lower part of the unit.

Field Work in 1980

The field work was designed to collect data which would permit assessment of the limestone and dolostone resource capacity of western Manitoulin Island. To this end, a detailed study was made of 1649 localities. At each of these points, data collected included outcrop and lithologic descriptions, faunal analysis and representative samples. Those samples considered most representative are currently being analyzed for major and trace elements. Lithologic and petrographic analysis is being used to develop correlations between the outcrops.

Road-accessible localities were inspected, described and sampled wherever possible, and foot traverses were used in areas of no road access. Road and foot traverse lines were arranged so that individual lines were 3 km apart or less, with samples on those lines being taken at a spacing of 0.3 km, outcrop permitting. Less field time was spent on the Ordovician than on the Silurian rocks because of the lower economic potential of the Ordovician rocks as a result of their lower purity and greater overburden cover.

Drilling in 1979

During the fall of 1979, six diamond-drill holes were completed on Manitoulin Island (Table 2). From these, 170 m of HQ core (6.4 cm diameter) was recovered. Selected intervals from the core are being chemically analyzed for both major and trace elements. Detailed information relating to the core will be released in an open file report.

Drilling in 1980

In addition to the 16 diamond-drill holes already located on the island (Johnson 1979), 13 new holes will be drilled during the fall of 1980 (Table 3).

The holes are all to be continuous core, with an expected yield of about 648 m of HQ core.

Selected intervals of the core will be chemically analyzed. Detailed information from the 1980 core also will be released in an open file report.

Economic Geology

At present, there are three dolostone quarries on Manitoulin Island. The Leason Quarry, near South Baymouth, extracted massive stone from the Amabel Formation to build the dock at South Baymouth. A quarry in the Upper Mindemoya Formation, located 4.7 km east of West Bay on Highway 540, provides small blocks and slabby material for general fill. West of Meldrum Bay, near Mississagi Lighthouse, a new dolostone quarry is being developed by Seely and Arnill Construction of Ontario. This operation will extract dolostone from the massive Amabel Formation for crushed stone. The Indians of the Wikwemikong Unceded Reserve in eastern Manitoulin Island are promoting a project similar to the Seely and Arnill development.

Petroleum exploration on the island was particularly active during the early part of the century, with 104 recorded wells being drilled. These led to at least nine producing oil and gas wells, none of which are presently active.

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No. S18 Paleozoic Geology of the Belleville-Kingston Area, Southern Ontario

D.M. Carson[1]

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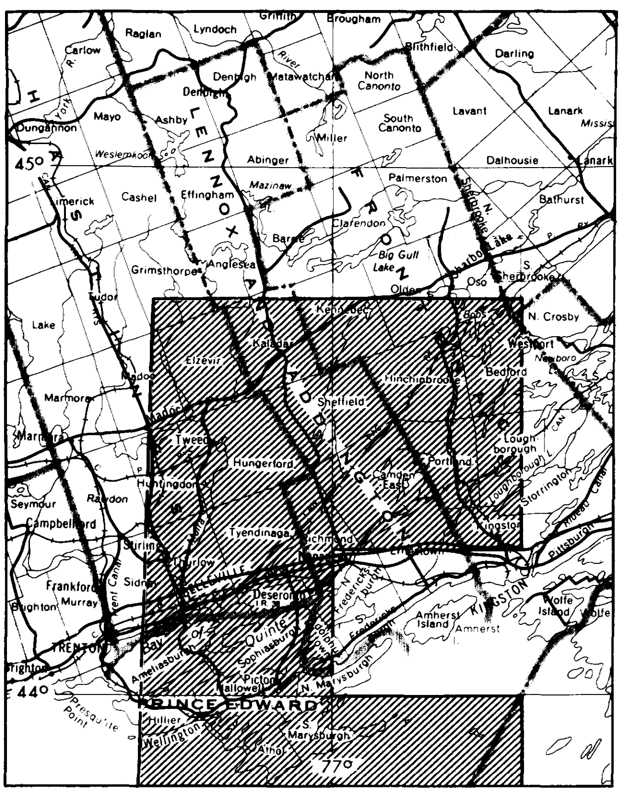
Introduction

Geological mapping of the Belleville-Kingston area involved the examination of seven map-areas, six of which have been previously mapped by B.A. Liberty for the Geological Survey of Canada (Liberty 1961, 1963, 1971). Liberty (1969) provides a summary of the numerous systems of lithostratigraphic nomenclature proposed for the Cambrian and Ordovician succession in the present area and the corresponding rocks in upper New York State.

[1]Geologist, Engineering and Terrain Geology Section, Ontario Geological Survey, Toronto.



LOCATION MAP Scale: 1: 1 584 000 or 1 inch to 25 miles

The terminology used in the present report follows that proposed by Liberty (1964,1969).

Location

During the summer of 1980, geological mapping was completed for the Kaladar (31C/11), Tweed (31C/6), Belleville (31C/3), Wellington (30N/14), Tichborne (31C/10), Sydenham (31C/7) and Yorkshire Island (30N/15) (formerly Duck Island) map-areas. The western half of this region is bounded by Latitude 44°45′N and the Lake Ontario shoreline and by Longitudes 77°00′ and 77°30′W, and includes all of Prince Edward County. The eastern half of the region is bounded by Latitudes 44°45′ and 44°15′N and Longitudes 76°30′ and 77°00′W.

General Geology

Paleozoic bedrock outcrop is abundant throughout Prince Edward County, the Sydenham map-area, the southeastern part of the Tweed map-area and where Paleozoic outliers occur north of the Precambrian-Paleozoic boundary in the Kaladar map-area. Elsewhere, in the Tweed, Belleville, Wellington and Yorkshire Island map-areas, major exposures of Paleozoc bedrock occur primarily along the Salmon and Moira Rivers, and form large cliffs along the Lake Ontario shoreline. Only one outcrop

TABLE 1 GENERAL STRATIGRAPHY OF THE BELLEVILLE-KINGSTON AREA.

Middle Ordovician	Simcoe Group Lindsay Formation (Limestone) Verulam Formation (Limestone and Shale) Bobcaygeon Formation (Limestone) Gull River Formation (Limestone)
Cambro-Ordovician	Basal Group Shadow Lake Formation (Shale, Siltstone, Sandstone and Arkose)
?Cambrian	Potsdam Formation (Sandstone)
Precambrian	Undifferentiated igneous and metamorphic rocks

of Paleozoic limestone was encountered in the Tichborne map-area.

The Paleozoic stratigraphy of the Belleville-Kingston area is summarized in Table 1. Precambrian rocks outcrop throughout the northern parts of the region, and surround Paleozoic outliers in the southern parts of the Kaladar map-area. Broad belts of Precambrian rock also extend southward, west of Stoco Lake in the Tweed map-area and across the northern part of the Sydenham map-area. Granitic inliers occur along the Salmon River about 2 km southwest of Kingsford in the Tweed map-area; 1 and 3 km northwest of Shannonville and 4 km northwest of Ameliasburg in the Belleville map-area; and between Camden and Varty Lakes and along Collins Creek in the Sydenham map-area. To the west of the region, in the Burleigh Falls and Bannockburn map-areas, the main Precambrian-Paleozoic boundary is generally marked by a 3 to 4 m high, north-facing scarp (Carson 1980a,b). In the present area, no such scarp occurs and the contact is not well exposed.

The Potsdam Formation is the oldest Paleozoic rock unit in the area. It is composed of fine- to medium-grained, well-sorted and -rounded, red, orange and buff sandstone, and unconformably overlies the Precambrian basement. Outcrops of the formation occur only in the northeastern part of the Sydenham map-area, north of the village of Holleford.

The Shadow Lake Formation unconformably overlies the Potsdam Formation and consists of generally recessive red and green arkoses, shales, siltstones and sandstones. Some exposures of the formation contain angular quartz clasts up to 5 cm in diameter. Outcrops of the Shadow Lake Formation occur primarily on Paleozoic outliers in the Kaladar map-area, but some smaller exposures are present in the northwestern part of the Tweed map-area and southeast of Tamworth in the Sydenham map-area.

Conformably overlying the Shadow Lake Formation is the Gull River Formation, which is the oldest formation in the Simcoe Group. The Gull River Formation generally consists of light to dark, brown and grey lithographic to finely crystalline, medium-bedded to massive limestone. However, pale green and buff siltstones occur near the middle of the formation in the eastern part of the area and two members can thus be recognized. Individual beds in the formation are generally separated by either thin shaly seams or stylolites. Cephalopods and stromatolites are common fossils in Gull River strata. The formation outcrops extensively in the Sydenham map-area, in the northern part of the Tweed map-area, and in the Paleozoic outliers in the Kaladar map-area. Smaller outcrops of Gull River strata occur along the Salmon River in the Tweed and Belleville map-areas.

The Bobcaygeon Formation conformably overlies the Gull River Formation and can be divided into two members. The lower member of the formation generally consists of brown-grey finely crystalline limestone, brown calcarenitic limestone and brown-grey fossiliferous limestone in beds 10 to 40 cm thick. Fossils such as cephalopods, corals and various species of brachiopods are common in the lower member. The upper member of the Bobcaygeon Formation is composed of thin-bedded, brown, finely crystalline to sublithographic limestone with minor amounts of shale. The formation is exposed throughout the southern and central parts of Tweed map-area and, to a lesser extent, in the northern part of the Belleville map-area.

Conformably overlying the upper member of the Bobcaygeon Formation, and somewhat intergradational with it, is the Verulam Formation. This formation consists of interbedded brown and grey bioclastic limestone, brown finely crystalline limestone and grey shales. The entire formation is thinly bedded and easily eroded. Fossils such as brachiopods, bryozoans and crinoids are abundant in the formation, while fragments of trilobites and corals are somewhat rarer. The formation outcrops throughout the northern and central parts of the Belleville map-area, and forms the base of a 4 to 5 m high cliff along the north shore of Long Point in the Yorkshire Island map-area.

The Lindsay Formation is the youngest Paleozoic rock unit in the study area. It consists of a lower member, composed of blue-grey, finely crystalline, pseudonodular sublithographic limestone that weathers into thin, resistant beds separated by thin shaly interbeds, and an upper member of grey, shaly limestone and calcareous mudstone that is nodular and non-resistant. The lower member of the formation outcrops throughout the southern part of the Belleville map-area and forms the upper part of the 4 to 5 m high cliff on the northern shore of Long Point in the Yorkshire Island map-area. The upper member of the Lindsay Formation outcrops throughout the Wellington map-area and forms a 3 to 4 m high cliff along the north shore of Lake Ontario.

Structural Geology

Strata in the project area are essentially flat-lying except where they drape over topographic irregularities in the Precambrian basement. A large dome structure related to this occurs on Highway 401 about 10 km east of Belleville in the Belleville map-area. Anomalous dipping of strata also occurs at Massasauga Point in the Belleville map-area, where the rocks dip at an angle of 20 degrees to the southwest.

A fault zone reported by Liberty (1963) extends along the Salmon River in the Tweed and Belleville map-areas. This zone is marked by the presence of strata that are stratigraphically lower than those of the surrounding area, but the degree of offset is difficult to determine. This fault may be related to the anomalous dips recorded at Massasauga Point. Other, smaller faults occur in the Tweed map-area on Highway 41 about 5 km north of Roblindale and near Marsh Creek and about 1 km south of Picton in the Wellington map-area.

Small surface faults, possibly related to the release of high horizontal stress (White *et al.* 1974) occur in the Tweed map-area, in the Gull River Formation at a quarry near Roblindale and in a small roadcut about 2 km south of the quarry. These features have less than 1 m of relief and are not traceable for any appreciable distance. Similar structures occur about 4 km east of Belleville on Highway 2 in the Belleville map-area and about 1.5 km west of the hamlet of Thorpe in the Sydenham map-area.

Economic Geology

Two major operations are presently quarrying the limestone in the study area. Standard Aggregates Limited uses rocks quarried from the Gull River Formation at Point Anne, southeast of Belleville in the Belleville map-area, and Lake Ontario Cement Limited quarries the Verulam Formation at Picton for use in the production of cement. Numerous other operations throughout the study area use rock quarried from the Simcoe Group for crushed stone. These quarries are described by Hewitt and Vos (1972).

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Geophysics/Geochemistry Programs

Geophysical, Geochemical and Geochronological Surveys, 1980

R.B. Barlow[1]

Geochemistry Program

The results of a Federal-Provincial lake sediment geochemical survey covering the Quetico-Rainy Lake Area (NTS sheets 52B and 52C) in northwestern Ontario were released in July 1980. The lake sediment survey covered approximately 21 700 km^2 at an average sample density of one sample per 13 km^2. Lake sediments were analyzed for U, Zn, Cu, Pb, Ni, Co, Ag, Mn, Fe, Mo and As, and loss-on-ignition to estimate organic carbon content. In addition, lake waters were analyzed for U, F and pH.

A second season of a regional basal till survey was completed in the Kirkland Lake Area. This project is funded jointly by the Federal Department of Regional and Economic Expansion and the Ontario Ministry of Northern Affairs through the Kirkland Lake Incentives Program (KLIP). Till samples obtained by both reverse circulation rotary drilling and pitting will be analyzed for elements associated with ore mineral suites commonly found in the area.

Additional shallow percussion drill sampling was carried out over a buried massive sulphide mineral occurrence which contains copper, lead and zinc. The purpose of this work is to further evaluate the performance and effectiveness of the method for detecting basal till geochemical dispersion patterns around EM conductors. Back-hoe sampling was introduced to the program this year to investigate detailed occurrences and to increase coverage of regional till sampling in areas of shallow overburden.

Several research programs are also being carried out with respect to gold mineralization. Studies at Queen's University and Imperial College have been introduced to develop special techniques for interpreting the dispersion of free gold in till and the use of tellurium as a pathfinder element for gold.

An orientation study was carried out using gamma-ray spectrometry to map the potassium content of alteration zones associated with gold mineralization at the Kerr Addison Mine. A pattern described by the K count rate/Th count rate ratio is thought to have immediate exploration value in the Larder Lake Area. If further work proves successful, gamma-ray bore-hole logging may have important applications to gold prospecting wherever gold is associated with potassic alteration.

An acid rain research program is being carried out in the Wawa area. This work is directed at examining historic effects on weathering rates by carrying out combined geochemical, geological and limnological studies on lake sediment cores. The lakes allocated for sampling have been chosen so as to represent a 100 km profile through a previously discovered pH gradient believed to have been caused by acid rain.

Gravity Program

During the 1980 summer season, staff of the Geophysics/Geochemistry Section carried out a gravity survey in the Onaping Lake-Chiniguchi Lake Area in northeastern Ontario. This project is the third and final year of a program to obtain gravity data over a 26 300 km2 area which covers the Cobalt embayment to the north and the Grenville Front to the south. A detailed interpretation of this data will begin in 1981 after the data base has been compiled at a scale of 1:250 000.

[1]Chief, Geophysics/Geochemistry Section, Ontario Geological Survey, Toronto.

Airborne Survey Program

The results of four separate airborne geophysical surveys will be released in January 1981. These surveys are sponsored by the Ministry of Northern Affairs and are carried out under the direction of the Geophysics/Geochemistry Section.

A total of 9721 line kilometres of airborne magnetic and electromagnetic data was obtained by Kenting Earth Sciences Limited over the Manitou-Stormy Lakes area. Results will be released on twenty-two photomosaic-based maps at a scale of 1:20 000.

A total of 4100 line kilometres of airborne magnetic and electromagnetic data was obtained by Scintrex Limited over the Homer Township area, the Michipicoten River area and the Michipicoten Island area near Wawa. Results will be released on seven photomosaic-based maps at a scale of 1:20 000.

A total of 14166 line kilometres of airborne magnetic and electromagnetic data was obtained by Questor Surveys Limited over the Atikokan-Mine Centre area. Results will be released on forty-one photomosaic-based maps at a scale of 1:20 000.

A total of 3080 line kilometres of airborne magnetic and electromagnetic data was obtained by Aerodat Limited over the Caribou Lake Area. Results will be released on seven photomosaic-based maps at a scale of 1:20 000.

In addition to the airborne surveying program, Section staff have carried out modelling studies on the four systems utilized. Interpretational aids have been developed for short strike-length conductors and will be published in 1981.

Geochronology Program

During the summer, Section staff completed a sample collection program in the Trout Lakes area, District of Kenora (Patricia Portion). The area is located about 208 km north of Red Lake, Ontario, and is composed of an east-trending, Early Precambrian, metavolcanic-metasedimentary supercrustal belt that is bordered on both sides by granitic batholiths. The purpose of the work is to determine the age relationship between the granite intrusives and the volcanic rocks, and also to date the time sequence of volcanism as represented by a well-developed stratigraphic sequence thought to contain five volcanic cycles. This study is being carried out in co-operation with the Precambrian Section, Ontario Geological Survey, and Dr. L.D. Ayres of the Department of Earth Sciences, University of Manitoba.

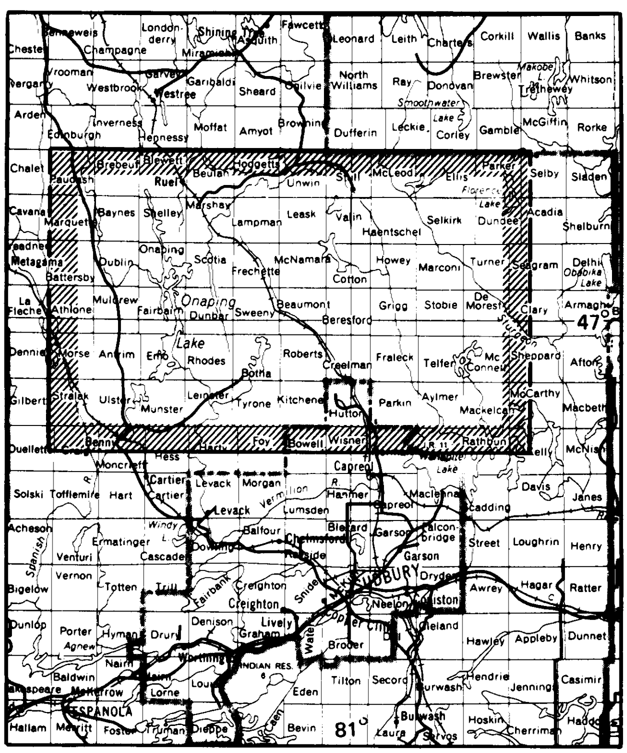
No. 19 A Gravity Survey of the Onaping Lake–Chiniguchi Lake–Welcome Lake Map-Area, District of Sudbury

V.K. Gupta[1]

Introduction

Field work carried out in the summer of 1980 represents the third and final year of the Gravity Field Surveying Program within the Cobalt Embayment and the Grenville Front. The two earlier surveys were in the North Bay-Cobalt and Englehart-Elk Lake areas (Gupta and Wadge 1977) and the Gowganda, Shining Tree and Gogama areas (Gupta and Wadge 1979). An interpretation program combining the survey data from three summers' work will soon be undertaken by the staff of the Geophysics/Geochemistry Section.

[1]Geophysicist, Geophysics/Geochemistry Section, Ontario Geological Survey, Toronto.



LOCATION MAP

Scale: 1:1,584,000 or 1 inch to 25 miles

Location

The survey area, which is bounded by Latitudes 46°45′ and 47°20′N and Longitudes 80°30′ and 81°50′W, covers an area in excess of 6 500 km^2. Access by motor vehicle to the western half of the map-area is provided mainly by Highway 144, which is connected with a few lumbering, mining and recreation access roads. Also, excellent water access in the western half of the region is provided by Onaping Lake which is about 70 km long. Access to the remote areas is dependent upon float-equipped helicopter and fixed-wing aircraft.

Gravity Survey

In a land gravity survey, the following primary data are recorded at each station: the time of observation, in Greenwich Mean Time (GMT); the observed gravimeter scale value; the elevation of the station, with reference to mean sea level; and the grid co-ordinates. During the summer of 1980, an eight man field party, utilizing helicopter and fixed-wing aircraft support, established about 1700 land gravity stations using three Lacoste-Romberg gravimeters (numbers G-294, G-329 and G-417). The average gravity station distribution over the entire area was approximately one station per 4 to 6 km^2.

The gravity observations were tied to control stations established by the Earth Physics Branch, Ottawa, at Sudbury, Gogama, Capreol and Cartier. These stations form part of the National Gravity Network which is tied to the International Gravity Standardization Net 1971. The Lacoste-Romberg meters, which are relatively drift-free, were read at control stations every day at the beginning and end of each traverse. The meters had an average daily drift of less than 0.04 mgals.

Elevations

Vertical control for most of the survey was provided by lake levels, with gravity station elevations being recorded as secondary elevations relative to lake levels. The elevations of many lakes close to bench marks (Geodetic Survey of Canada and Ontario Ministry of Transportation and Communications) were established by precise levelling from these bench marks. Other larger adjacent and interconnected lakes were levelled from these precision-levelled lakes. The elevations of certain other lakes and river systems were established using data from Ontario Hydro dams. Lake levels for the remaining less accessible lakes, and elevations for points on roads, were determined using Wallace and Tiernan altimeters in pair. Appropriate corrections for temperature and humidity variations were applied, and elevation control was provided by occupying a point of known elevation at least once every one to two hours. Some bench marks on the highways and railways were used for altimetry control.

Horizontal Control

The gravity stations were established at identifiable sites and were located on 1:50 000 scale aerial photographs. The station positions were then transferred onto NTS topographic maps (scale 1:50 000) with a six-degree UTM grid superimposed. The gravity stations were digitized with a precision of ±40m.

Rock densities

Over nine hundred density measurements were made on fresh rock samples collected from outcrops at or near gravity station sites. The rock samples were soaked in water for about two hours and agitated to remove air bubbles. The porosity and permeability of the rock types in the area is low and therefore the measured densities should approximate closely the field densities. Mean density values will be assigned to the major rock units of the area under investigation.

Data Reduction and Maps

The gravity survey was carried out to the specifications of the Gravity Division (1976), Energy Mines and Resources, Canada. The field data is now being processed at the Gravity Division, Ottawa. The Bouguer gravity maps, combining the 1980 summer field survey and the 1979 field survey (Gupta and Wadge 1979), will soon be published at a scale of 1:100 000.

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No. 20 Regional Geochemical Lake Sediment and Water Survey, Quetico-Rainy Lake Area, Districts of Thunder Bay and Rainy River

Ian Thomson[1]

The results of a regional geochemical survey of the Quetico-Rainy Lake area of northwestern Ontario were released in July 1980 (Ontario Geological Survey 1980a, 1980b). This joint Federal-Provincial survey was funded by the Ontario Ministry of Natural Resources with management of the field program, analysis and data compilation provided by the Geological Survey of Canada. Planning of this project was carried out jointly by the Ontario Geological Survey and the Geological Survey of Canada.

The survey was completed in the summer of 1979 and covers approximately 21 700 km^2 across the Ontario portions of NTS Sheets 52B (Quetico), and 52C (International Falls). Sampling of the lakes was at an average density of one sample per 13 km^2. Lake sediments were analyzed for U, Zn, Cu, Pb, Ni, Co, Ag, Mn, Fe, Mo, As and loss on ignition. Surface lake waters were analyzed for U, F and pH.

The work was completed to specifications established for the now defunct Federal-Provincial Uranium Reconnaissance Program. Data from the current project are thus compatible with previous surveys carried out elsewhere in Ontario under the program.

Initial interest in the survey has centred on applying the published data to gold exploration and environmental studies, specifically acid precipitation. Most, if not all, the known gold occurrences in this part of Ontario have elevated concentrations of arsenic in or proximal to the gold ore. Arsenic is, therefore, a good indicator for gold mineralization, and private industry has been quick to follow up areas of anomalous arsenic values shown by the survey. The survey also revealed several large areas where the pH of surface lake waters is below 6.0 (the lower limit for normal Shield lakes). The acid lakes (pH 4.5 to 6.0) are remote from urban or industrial sources and occur almost exclusively in areas underlain by granitic and gneissic rock. These bedrock types provide minimal buffering capacity to surface waters, and lakes in these areas are highly susceptible to the effects of acid precipitation (see "Acid Lakes North of Lake Superior" by Ian Thomson, this volume). The low pH values almost certainly reflect acidification due to acid precipitation; at best they indicate lakes that have a high risk of rapidly acidifying under the influence of acid rain.

[1]Geochemist, Geophysics/Geochemistry Section, Ontario Geological Survey, Toronto.

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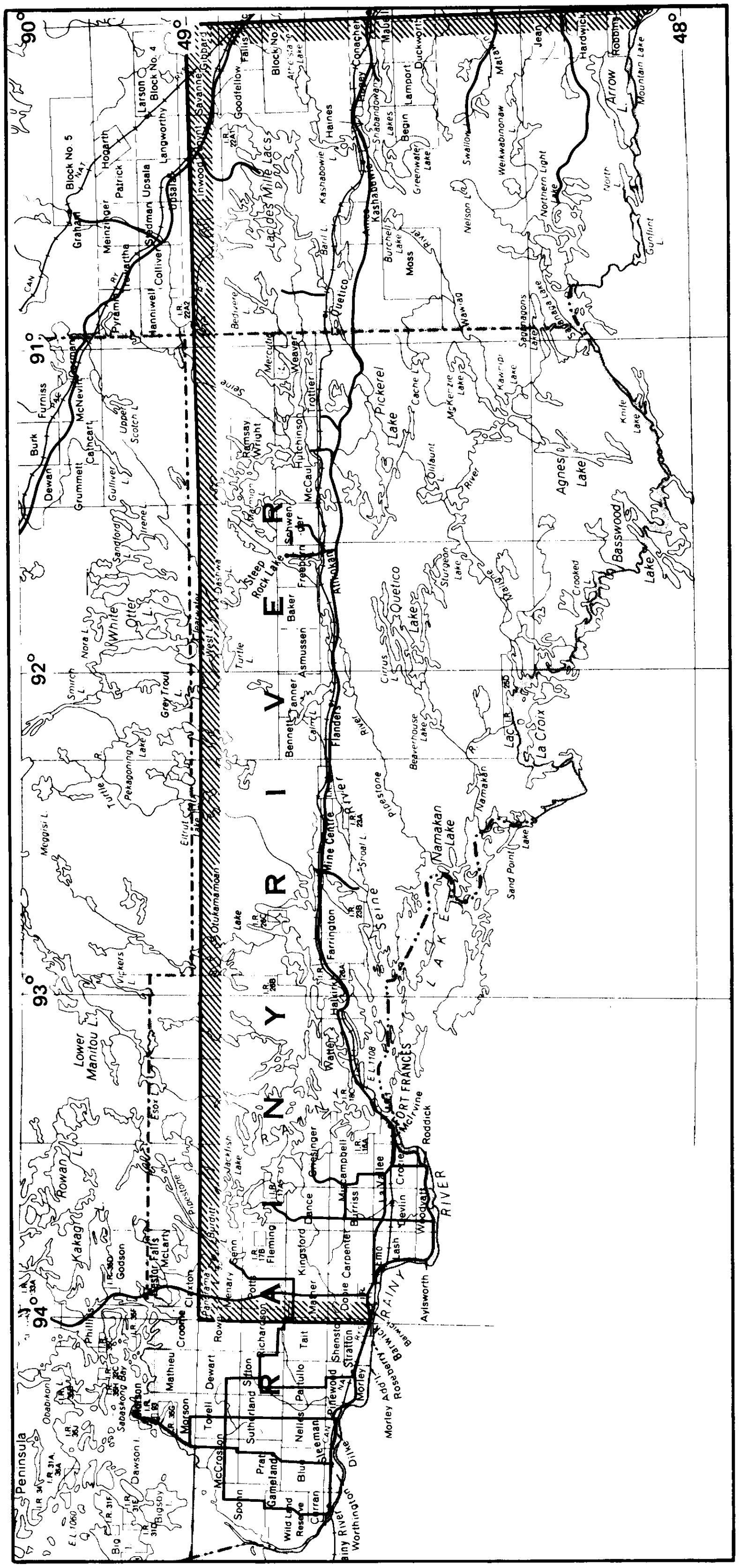


LOCATION MAP

Scale: 1:1,584,000 or 1 inch to 25 miles

No. 21 Acid Lakes North of Lake Superior: Integrated Studies in the Wawa Area, District of Algoma, to Examine the Effects of Acid Precipitation

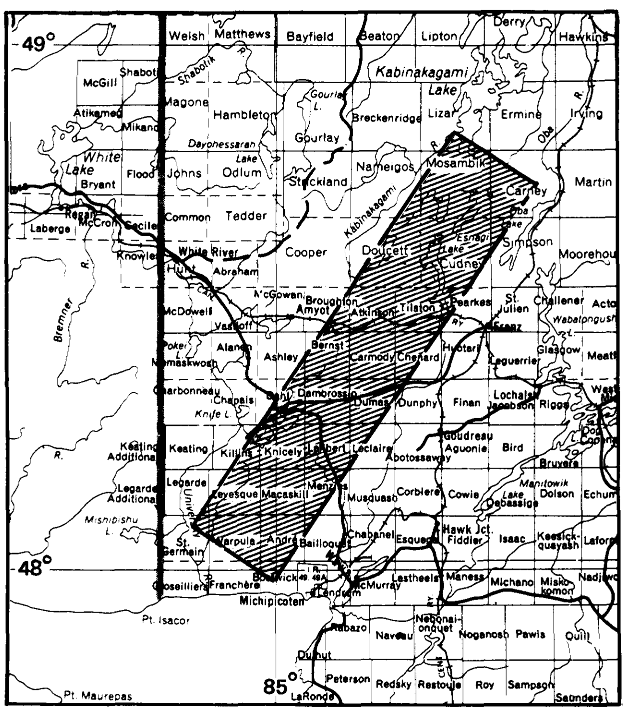
Ian Thomson[1]

Introduction

General Background

In 1980 there is considerable awareness of acid precipitation and its effects on lake systems, fish and wildlife in Ontario. Much scientific effort has been given to the study of individual lake systems, the chemical and biological processes involved in acidification and procedures for ameliorating the effects of acid precipitation. With such studies has come an appreciation of the role of bedrock and overburden composition as factors which control the primary chemistry of water catchment areas, their buffering capacity to mineral acids, and hence susceptibility to "acid rain". To date, however, there have been relatively few systematic regional studies which examine primary rock geochemistry and its interrelationship with acid precipitation.

[1]Geochemist, Geophysics-Geochemistry Section, Ontario Geological Survey, Toronto.



LOCATION MAP

Scale: 1:1,584,000 or 1 inch to 25 miles

Regional geochemical mapping around the north shore of Lake Superior carried out in 1977 and 1978 provides a basis for an examination of the impact of acid rain in an essentially remote area of Ontario (Ontario Geological Survey 1978a, 1978b, 1979a, 1979b). These surveys were completed as part of the National Geochemical Reconnaissance Surveys – Uranium Reconnaissance Program, a joint program funded by the Ontario Ministry of Natural Resources and the Federal Department of Energy, Mines and Resources. The geochemical surveys covered NTS map sheets 52A, 52H (south half), 42D, 42E (south half), 42C, 42F (south half) and 41N, and comprised the collection and analysis of lake sediment and surface water samples at an average density of 1 sample site per 13 km^2. The program was aimed at providing basic geochemical data to aid evaluation of mineral potential and assist mineral exploration. The analytical program therefore stressed elements of interest to geologists and exploration personnel. The results do, however, include heavy metal data of relevance to environmental studies; furthermore, pH was determined on all water samples.

Geographic distribution patterns for elements in lake sediments and waters are found to vary with changing bedrock composition, the presence of mineralization, natural changes in the surface environment and, occasionally, pollution. Remarkably and unexpectedly, the pH of the lake waters was also found to vary systematically within and across the area.

Coker and Shilts (1979) have made a preliminary assessment of the lake water pH patterns. They note that pH values range from 3.1 to 8.3 and show a distinct correlation with geology, as well as an overall trend for values to decrease from northwest to southeast around the north shore of Lake Superior. The regional trend is attributed to acidification of lakes due to acid rain along the eastern shore of Lake Superior (Shaw 1979). The pattern is, however, modified by geology, with areas underlain by resistant, highly siliceous rocks (e.g. granite gneiss and migmatite) having the highest number of acid lakes. Areas underlain by 'greenstone' (regionally metamorphosed sedimentary, volcanic and pyroclastic rocks) show normal or slightly depressed pH values of 6.0 to 7.2. To the north and east, a large area extending east from Lake Nipigon, where the shield rocks are covered by calcareous drift derived from the Hudson Bay Lowland, is characterized by alkaline (pH 7.5 to 8.3) lakes.

These data provided the first documented evidence of large scale acidification of lakes in Ontario west of Sudbury, and are particularly significant for three reasons:
(1) The acid lakes recorded by the surveys occur around the northern and eastern margins of Lake Superior. As such, they are remote from sources of pollution and, if due to the effects of acid rain, must relate to the long range transport of pollution from the midwest and western United States.
(2) The information is virtually synoptic for two large areas. The samples were collected over a very short period of time during two field seasons in the summers of 1977 and 1978 for the western and eastern halves of the area respectively.
(3) The data were obtained, for the most part, from smaller lakes outside the normal Ministry of Natural Resources, Fisheries Branch, and Ontario Ministry of Environment lake monitoring network. In contrast, these groups work mostly with larger lakes where commercial or sport fishing is important. The small lakes are more sensitive to acid rain than the larger water bodies, and may be expected to show the effects of acidification before it is manifested in larger lakes.

Given the above data base, studies were initiated in 1980 to examine further the relationship between geology, lake water chemistry and acid precipitation.

The Wawa Project

The regional geochemical data reveal an extensive zone of acid lakes (pH 4.6 to 6.0) extending west from Wawa to Pukaskwa and White River, in an area underlain largely by granitic rocks. In addition, a general gradient of increasing pH in lake waters from pH 4.6 to 8.3 is discernable extending from the shore of Lake Superior northward and westward to the limits of the regional survey. The gradient is largely developed over granitic and gneissic terrain, but shows perturbations spatially related to the presence of 'greenstone' rocks and areas of calcareous drift.

The iron ore sintering plant at Wawa has been established for many years and is known to be a local source of sulphur dioxide to the atmosphere. A well-developed plume extends northeastward, downwind from the plant, with associated vegetation kill and acidified lakes (Gordon and Gorham 1963). The plume has been studied in great detail (McIlveen, Potvin and Keller 1979) and has been shown to be well defined and essentially localized. It is not considered responsible for the extensive area of acid lakes located west (perpendicular to the prevailing wind) of Wawa.

The present project was conceived by the author and J.A.C. Fortescue (environmental geochemical consultant). It is designed to combine the geological and geochemical expertise of the Ontario Geological Survey with more specialized experience from environmental geochemistry, limnology and palynology in order to 'follow-up' and explain a marked change in lake water pH along a 100 km by 20 km strip of country. The long axis of the sampling strip is oriented northeast, parallel to the prevailing wind direction, and the area extends inland from the north shore of Lake Superior, some 30 km west of Wawa.

Objectives

The principal objectives of the study are:
1) To explain, on the basis of geological, geochemical and limnological information, a gradient in surface lake water pH values from 4.9 to 8.3 along a 100 km by 20 km strip of country west of Wawa.
2) To further establish the apparent relationship between geology and the present pH (acidification) of lake waters.
3) To provide basic data for the further interpretation of regional geochemical maps, which are produced for mineral exploration, in terms of environmental geochemistry, limnology and, in particular, acid precipitation.
4) To provide linking information, in the form of integrated data from geological, geochemical, limnological and palynological studies, that will enable more effective use by nongeologists of the regional geochemical maps published by the Ontario Geological Survey.
5) To establish, by the use of palynology, a time scale in lake sediment columns and to examine the historical development of lakes along the observed pH gradient and over different rock types using sediment chemistry and planktonic fauna. By this means, it may be possible to estimate historical water pH and the rate of acidification of lakes.
6) To examine, by studying present and historical patterns of trace and major elements in lake sediments, the effects of acid precipitation on element dispersion processes and the formation of local and regional geochemical patterns, particularly for elements of consequence to mineral exploration and environmental geochemistry.

Methodology

For the present study, a small team of specialists was formed, consisting of the author, J.A.C. Fortescue, environment geochemist of Enviroquest Incorporated, and J. Terasmae, palynologist, and M.J. Dickman, limnologist – biologist, both of Brock University. In addition, liaison was established with the Ontario Ministry of Environment, Environment Canada and the Fisheries Branch of the Ontario Ministry of Natural Resources. At Wawa, S. Kerr and E. Thomas, fish and wildlife specialists with the local district office of the Ontario Ministry of Natural Resources, provided active support for the field program.

Twenty lakes were selected from the regional survey, at roughly equal distances apart, to form a traverse along the 100 km by 20 km sample area. At each lake, water characteristics (pH, alkalinity, conductivity, temperature, and dissolved O_2) were determined on site. Water samples were collected for later chemical and biological (plankton) examination, and at least two sediment cores

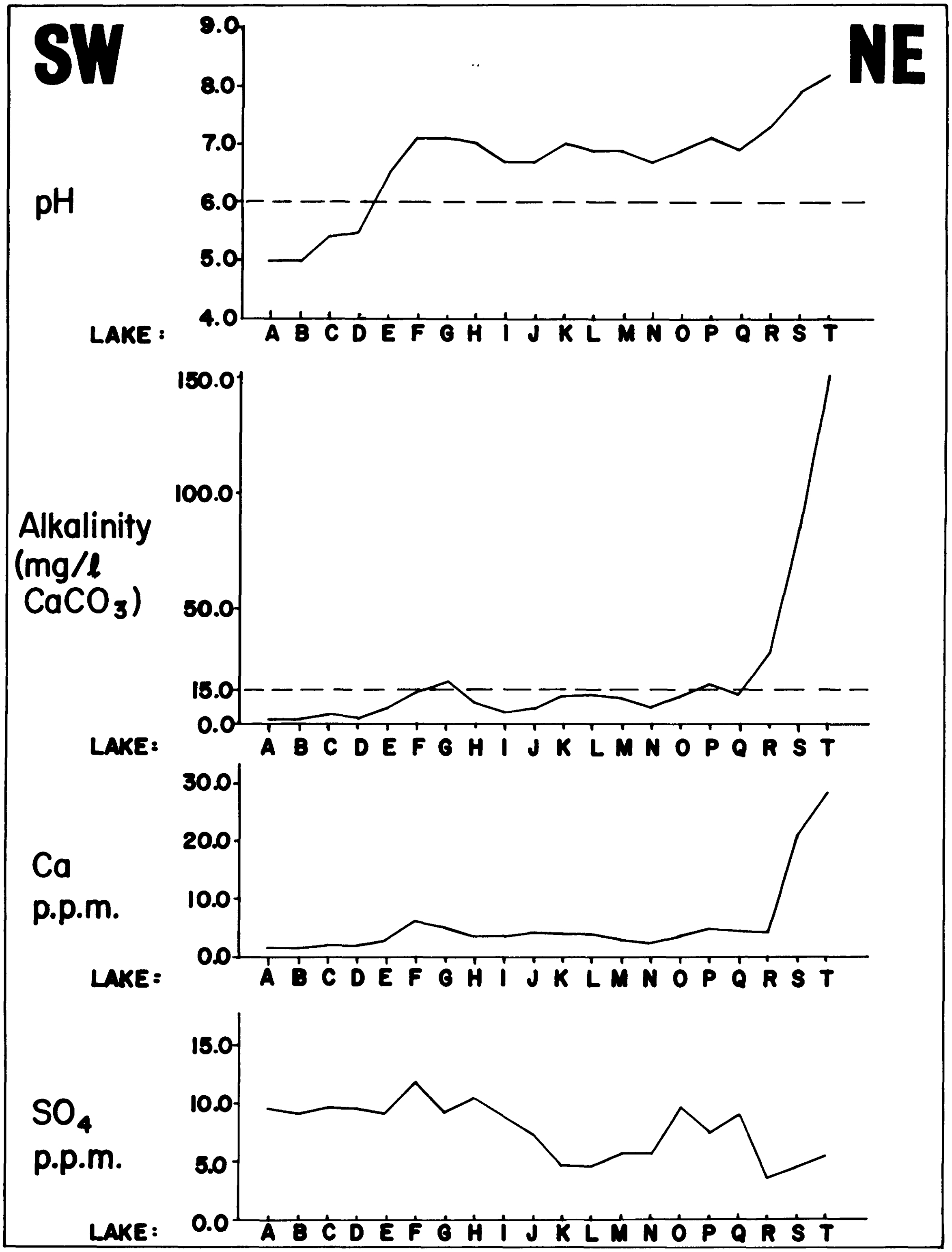


Figure 1—Variation in surface water chemistry of lakes along the Wawa lake traverse.

were collected from the principal profundal basin in each lake.

The field program was completed in 14 days during June 1980 by the four-man team described above. Access to the lakes, which are generally small and remote, was by float-equipped helicopter, with sampling carried out from its platform.

Chemical, palynological and biological (phytoplankton) studies on the water and sediment samples will be carried out through the fall and winter of 1980-81.

Preliminary Results

At this time, limited water chemistry is available for the 20 lakes. Data for surface (0 to maximum 5.0 m depth) water pH, alkalinity (total inflection point), calcium (Ca), and sulphate (SO_4) are presented in Figure 1.

The data confirm the presence of a pH gradient along the sampling strip, with lakes at the southwest end (lakes A to D) abnormally acid (pH < 6.0). Alkalinity (as $CaCO_3$, the principal buffering agent in lake waters) and Ca show the same trends as pH, while SO_4 shows evidence of a reverse gradient, with values decreasing from southwest to northeast. However, the gradients are not smooth. Rather, they show perturbations related to geology.

The most acid lakes (A to D) occur over granitic rocks in the southwest. The pH increases rapidly, with associated peaks in alkalinity, Ca and SO_4, in lakes F and G, which are located in 'greenstone' terrain. The gradient is poorly developed between lakes H and N, which are underlain by granite. The pH, alkalinity, Ca and, most distinctively, SO_4 rise again in lakes O, P and Q, which are underlain by 'greenstone' rocks. In the far northeast, pH rises dramatically, as does alkalinity and Ca, while SO_4 falls in lakes developed in calcareous drift overlying granitic bedrock.

The SO_4 pattern is considered most significant. The overall trend of decreasing SO_4 values from southwest to northeast is thought to reflect the introduction of SO_4 as H_2SO_4 in polluted rain brought in by the prevailing wind. The increase in SO_4 in lakes F, G, O, P and Q is considered to reflect, at least in part, natural input from the 'greenstone' rocks, which have a higher SO_4 content than the granite. Similarly, the rise in alkalinity and Ca in these lakes reflects natural input from rocks richer in these materials. The patterns observed along the traverse reflect the interaction between natural and anthropogenic sources.

In evaluating the data, the following points are also significant:

(1) Lakes A to D have pH values below 6.0 and are thus, by common definition, acid lakes.

(2) Many of the lakes have alkalinity values below 15.0 mg/l $CaCO_3$. These lakes have very little buffering capacity to mineral acid and hence a high susceptibility to acidification. This is the case in lakes A to D, where the alkalinity is abnormally low (1.5 to 6.1 mg/l $CaCO_3$) and shows evidence of a loss of buffering capacity due to acidification.

(3) In the northeast, lakes S and T have abnormally high alkalinity and elevated pH values. These lakes are exceptionally well buffered.

The relationship between pH and alkalinity is further displayed in Figure 2. It can be seen that the acid lakes (A to D) have low alkalinity and lie in a separate field on the plot. The neutral lakes show evidence of a weak, positive, linear relationship between alkalinity and pH. Of particular interest are lakes E, I, J and N, which lie off the main trend and display slightly depressed alkalinity and pH. These lakes appear delicately poised with minimal

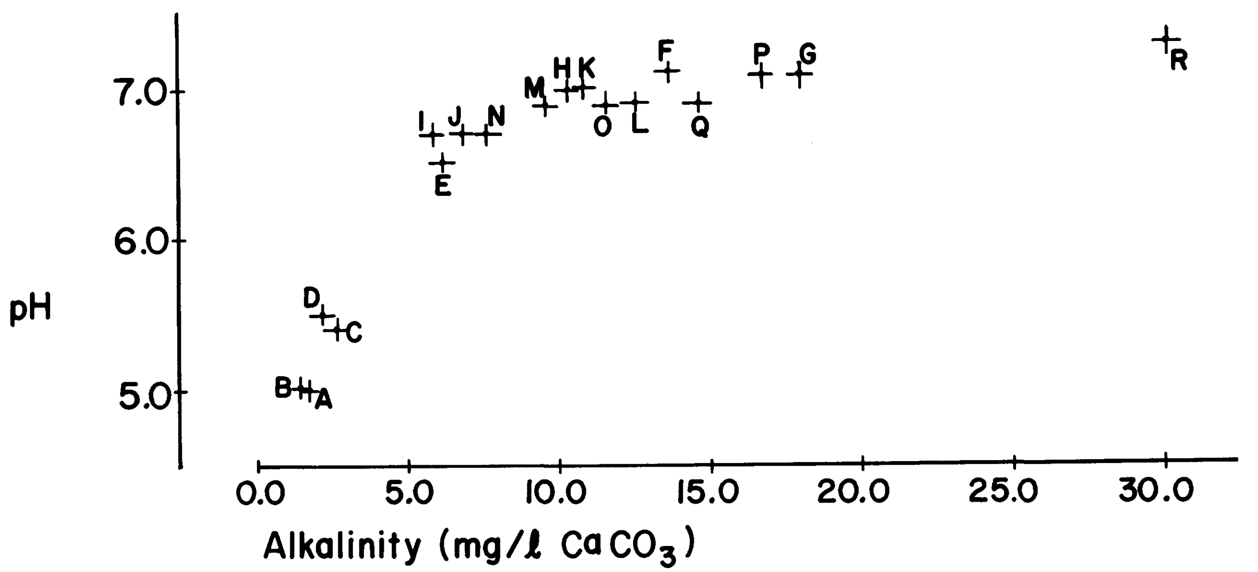


Figure 2—Relationship between pH and alkalinity (total inflection point) in surface waters of lakes, Wawa lake traverse.

buffering capacity. Further input of acid precipitation will almost certainly lead to rapid acidification of these lakes.

Early evaluation of the phytoplankton fauna from the study lakes (M.J. Dickman, personal communication) suggests a broad positive correlation between the number of species present and water pH. (Interestingly, the relationship also appears to be qualified by the geology of the lake catchment areas.) This pattern augments local Ministry of Natural Resources surveys, which show that fish stocks have become depleted within the area of acid lakes over the last 5 to 10 years. Indeed, recent studies (1979-80), prompted by release of the regional geochemical maps, have found that a number of acidified lakes are 'dead' in that they no longer contain fish (S. Kerr, personal communication).

Preliminary Conclusions

West of Wawa, acid precipitation derived from the long-range transport of polluted air masses is causing the acidification of lakes and a loss of biological (phytoplankton and fish) productivity. The effects of acid precipitation are, however, modified by the bedrock and surficial geology in the catchment areas of individual lakes. These two factors control the primary chemistry of the lakes and, hence, their buffering capacity.

The data show that, in addition to lakes which have already become acid, a very large area underlain by granitic rocks is characterized by lakes with low buffering capacity. Many of these are probably very delicately poised, in the manner of study lakes E, I, J and N, and are thus likely to become rapidly acidified if exposed to further acid precipitation.

Complete results from this study will be published in 1981.

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No. 22 Gamma Ray Mapping of Alteration Zones Associated with Gold-Bearing Horizons: Orientation Studies at the Kerr Addison Mine, Virginiatown, District of Timiskaming

Ian Thomson[1]

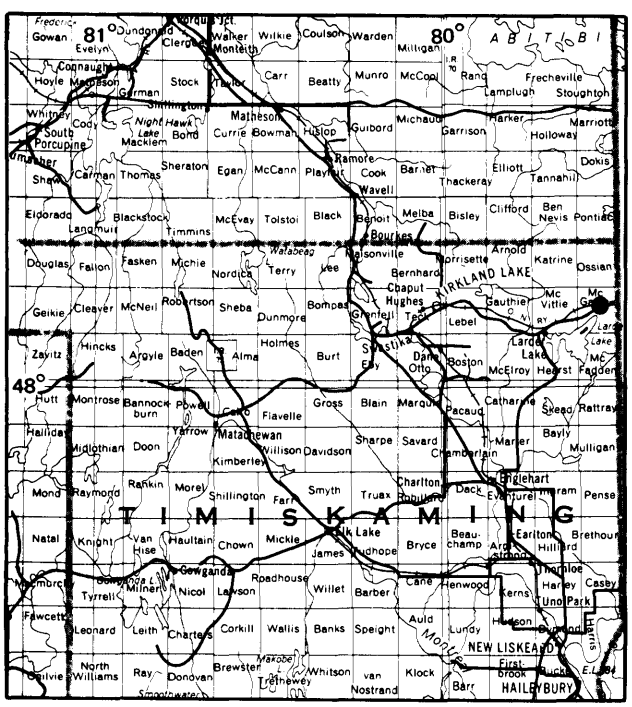
Introduction

Recent geological mapping by Downes (1979, 1980) and Jensen (1979) has established that the Kerr Addison Mine lies within mixed Archean mafic-ultramafic volcanic, volcaniclastic and sedimentary rocks of the Larder Lake Group. At the mine, gold mineralization occurs within an extensive zone of carbonate alteration which is in turn controlled by both lithology and structure.

Three types of gold ore are recognized at the mine:

1) Flow ore which, according to Downes (1979), includes several lithologic types, the only common denominator being that they are all pyritic and possibly silicified tuffs interbedded with mafic pillowed flows. It is suspected that the gold, which is hosted by the pyrite, is primary exhalative in origin.

[1]Goechemist, Geophysics/Geochemistry Section, Ontario Geological Survey, Toronto.



LOCATION MAP

Scale: 1:1,584,000
or 1 inch to 25 miles

2) Carbonate ore which occurs in sericite- and fuchsite-bearing dolomitized ultramafic volcanics. Downes (1979, 1980) notes that the gold occurs as free gold in quartz veins related to late stage silicic and potassic metasomatism.

3) Dike ore, a low grade ore occurring in albitite dikes which postdate both the carbonate and potassic alteration.

The observation by Downes (1979, 1980) that the carbonate ore is related to potassic metasomatism led the author to speculate as to the possibility of using a differential gamma ray spectrometer to map the character and extent of the potassic alteration. Rapid geochemical mapping by this procedure could yield further data of consequence to an understanding of the controls on gold mineralization. If successful, the technique might be of value in appraising areas with Kerr-type alteration, and hence gold potential, elsewhere in the Larder Lake district.

Acknowledgments

The present work was completed in February and July 1980 and is presented as an orientation study. The gamma ray data are supplemented by limited whole rock chemistry and unpublished underground mapping by M.J. Downes and Kerr Addison Mine geologists.

The writer wishes to thank the management of Kerr Addison Mines Limited for permission to carry out work in the mine, and in particular, D.M. Hendrick, J.K. Teal, and John Merhar for their personal interest and assistance with the study. In addition, M.J. Downes provided stimulating discussion on the work and permitted the writer to examine detailed maps of the 3850 level of the mine, as well as whole rock geochemical data.

Methodology

Systematic traversing was undertaken on the 1150, 1900, 3250 and 3850 levels of the mine using a Scintrex GAD-6 spectrometer with a GAS-3 (348 cm^3 crystal) sensor. All accessible development drives, drifts and crosscuts were traversed. In addition, detailed traverses were made within carbonate ore stopes on the 3250 level. A total of 482 sample points were established and readings taken.

Readings were taken at 7.5 m intervals (closer in areas of particular interest) in the centre of the underground developments. Within the stopes, readings were taken at close intervals on the rock face. The relationship between rock surface and sensor was relatively constant, since all development drives are of approximately the same cross section. Rock surface/sensor geometry changes were noted in timbered ground close to old stopes and at the junction of underground headings. These differences appear to be minor and are not believed to have a significant effect on the gamma ray patterns observed.

At each station, a 100-second integration time was used, and K (as ^{40}K), U (as ^{214}Bi), Th (as ^{208}Th), and total count were recorded in counts per second. The spectrometer was deployed in the differential mode, responding to all gamma ray energies within specified energy windows.

Standardization and Control of the Gamma Ray Data

The gamma ray environment within the mine was found to be very quiet and stable, characterized by low gamma counts which, although often extremely low, are also eminently reproducible. The spectrometer was checked daily using a thorium standard. In addition, selected locations within the mine were re-established repeatedly to check for instrument drift and/or changes in gamma emissivity.

No formal calibration procedures were employed to determine equivalent radio-element concentrations for a given count rate due to the inherent problem of calibrating within a slightly variable, modified 4π geometry. An estimate of instrument response characteristics is possible, however, by comparing gamma counts for K (^{40}K) with K_2O whole rock analysis of rock samples from the same location. A strong positive correlation ($r = 0.9819$) exists between the two, reflecting a linear change in instrument response with absolute abundance of K. The limited variability observed is readily ascribed to the difference between point source information from whole rock analysis of a discrete sample and the modified 4π geometric source of gamma emission from all rock surfaces surrounding the sensor in an underground working.

The control and simple calibration procedures described above are considered adequate for a rapid orientation study. They show that the data is reproducible and the responses roughly linear. The distribution patterns recorded by traversing through the mine are thus regarded as accurate and precise within the limits of the method employed.

Data Synthesis

Using the data obtained from traverses on four levels of the mine (Figure 1 is a representative traverse), it is possible to build up a composite picture of the potassic alteration and its relationship to gold mineralization. For this, the U data is discarded and attention given to the distribution of K, Th, and the K/Th ratio. Figure 2 is an idealized cross-section north-south through the mine. A bilaterally symmetrical, possibly zoned pattern is considered to exist, centred on the potassic alteration, of which the fuschite-bearing green carbonate is the most visible expression. The flanking K and K/Th lows lie within the zone of carbonate alteration and are, in turn, flanked by increases in K and K/Th ratio which occur towards the outer limits of pervasive carbonate alteration.

In the horizontal plane, the central K/Th ratio high is elongate east-west and terminates within carbonate alteration due to both falling K values and an increase in Th. The K/Th high is flanked by a low ratio zone which continues east and west beyond the limit of the ground covered by the present survey.

Gold mineralization in the carbonate ore zones, as defined by the cut-off grade for mining, appears to be localized on the flanks of the K/Th ratio high, in or close to strong gradients in the abundance of K. Gold orebodies seem to be best developed where the potassic alteration (as shown by absolute K and K/Th ratios) is strongest and widest. Certainly on the 3850 level, below the principal carbonate ore zones, both absolute K values and the K/Th ratio are generally lower than on upper levels around high grade gold orebodies.

In summary, therefore, the carbonate gold orebodies are believed to lie on the flanks of an elongate, pipelike, alteration zone marked by increased K with or without associated Th depletion. This lies within a broader zone of carbonate alteration, marked by low K and Th, which is elongated east-west, parallel with the Larder Lake Break. Within the mine sequence, the area of pervasive carbonate alteration is flanked on the north and south by unaltered or weakly carbonatized rocks having more normal K and Th contents.

These patterns transgress the Larder Lake Fault and the major structural discordance within the mine noted by Downes (1980). They also crosscut lithologies and overprint the flow ore zones. The patterns are, in turn, cut by the albitite dikes. These relationships suggest the following sequence of events:

1) Deposition of volcanic and sedimentary rocks of the Larder Lake Group, with associated exhalative activity giving rise to auriferous pyrite of the flow ores.
2) Structural deformation - folding and faulting.
3) Carbonate alteration with associated leaching of some elements.
4) Potassic and silicic metasomatism localized within a central elongate conduit. Deposition of gold in quartz veins on the flanks of the conduit where the associated potassic metasomatism is strongest.
5) Emplacement of the auriferous albitite dikes. It is interesting to note that these are assymetrical with respect to the earlier carbonate and potassic alteration. The dikes occur north of the axis of symmetry of the potassic metasomatism.

Multiple phases of hydrothermal/metasomatic activity, possibly related to deep circulation of waters along the

Larder Lake 'Break', are thought to be indicated by this sequence of events. Downes (1980) notes that the carbonatization (and also potassic metasomatism) is closely related to komatiitic flows in a tectonically thickened hinge zone that is also spatially related to the 'Break'. The juxtaposition of structures may have favoured the formation of the conduit along which potassic metasomatism is localized.

Conclusions

The following preliminary conclusions are drawn from the present work:

1) The gamma ray spectrometer can be used to map potassic alteration and the distribution of characteristic rock types within the Kerr Addison Mine.

2) The present survey has demonstrated that potassic alteration within the mine is bilaterally symmetrical, is probably zoned, and transgresses mapped rock types and structures. It is characterized by a gross increase in K with associated low values of Th, thus giving rise to anomalously high K/Th ratios.

3) The potassic alteration occurs as a pipelike body elongated with the plane of the ore zones parallel to the Larder Lake Fault. The alteration postdates the more extensive carbonate alteration and lies roughly centred within the carbonatized zone. The potassic metasomatism is, in turn, cut by later albitite dikes.

4) The carbonate gold ore zones occur where potassic alteration is strongest and most extensive. Individual ore bodies appear to be localized on the flanks of the potassic alteration pipe within or close to steep gradients in K concentration.

5) Gamma ray mapping could be used to examine other areas of carbonate alteration in the Larder Lake area. It represents a rapid technique for identifying and localizing potassic alteration which, in turn, appears to have a spatial control on the deposition of carbonate gold ore of

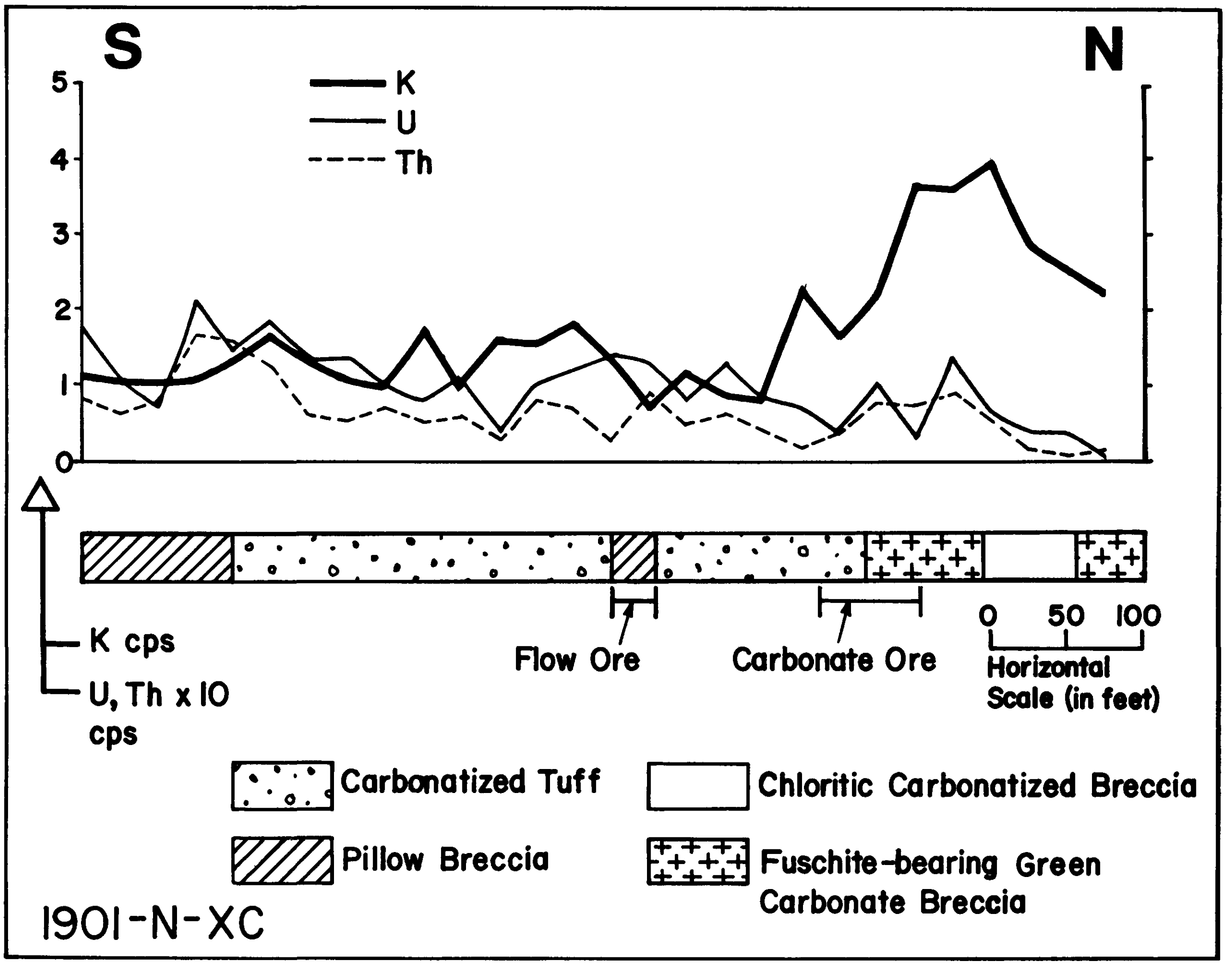


Figure 1 — Gamma ray profiles along the 1901-N crosscut, 1900 level, Kerr Addison Mine. Geology by Kerr Addison Mine Staff with modifications.

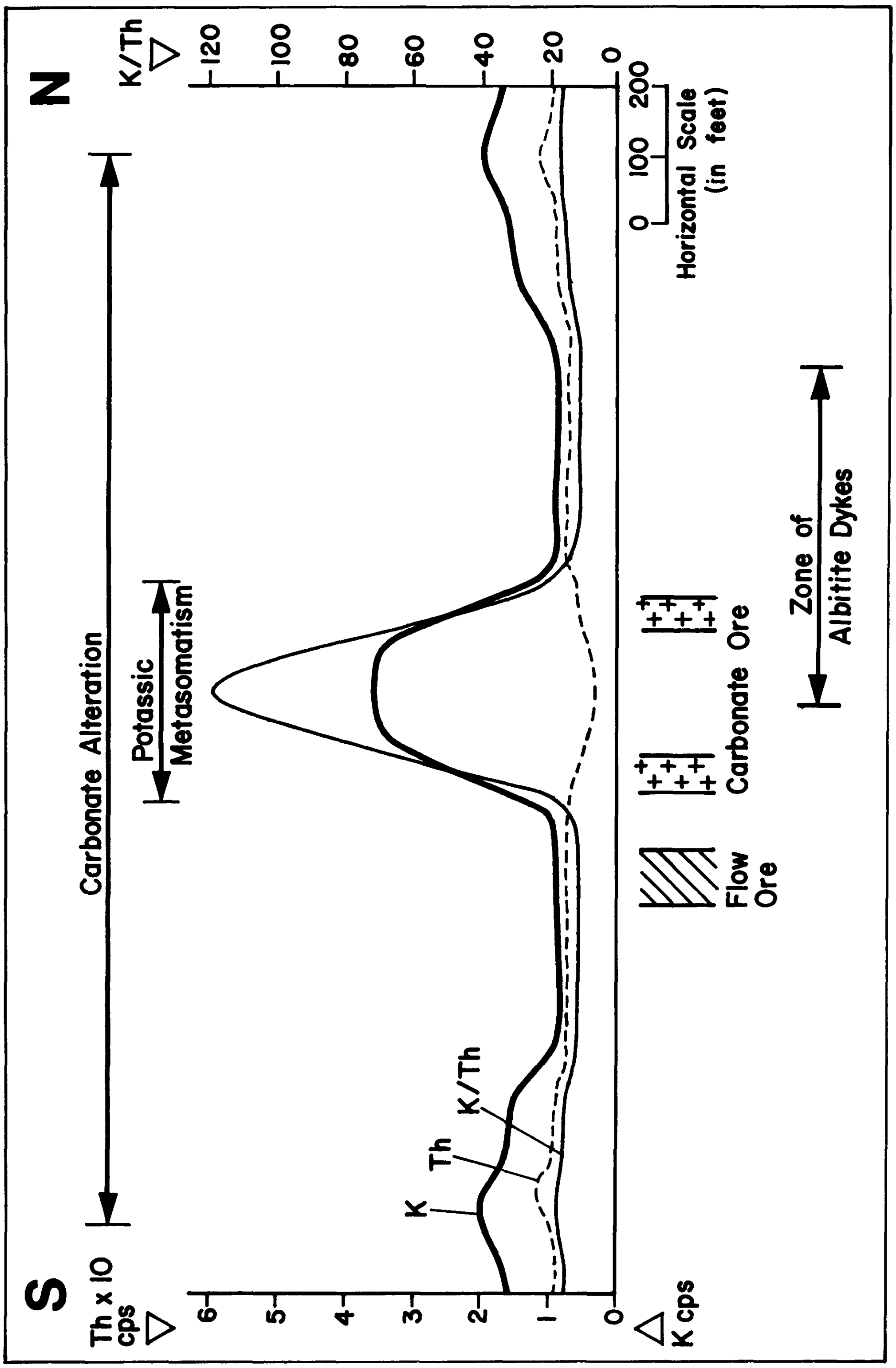


Figure 2 — Schematic section across the Kerr Addison Mine showing gamma ray profiles, alteration patterns and the disposition of gold orebodies.

the Kerr type. Rapid recognition of the form and symmetry of alteration zones could aid in locating new gold ore bodies on the flanks of alteration pipes.
6) Because of the very low count rates, this approach can only be employed underground in an environment free of background cosmic radiation. It is thus confined to mapping boreholes and underground development drives.

These conclusions are based on an orientation study and require further work on improving calibration and measurement procedure. Additional studies are planned, including extensive chemical analysis of rock samples and possibly some borehole gamma ray work in existing drill holes.

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GEOPHYSICS — SPECIAL PROJECTS

No. S19 Airborne Electromagnetic-Magnetic Surveys

D.R. Wadge[1]

THIS PROJECT WAS FUNDED BY THE ONTARIO MINISTRY OF NORTHERN AFFAIRS THROUGH THE NORTHERN ONTARIO GEOLOGICAL SURVEY (NOGS) PROGRAM.

Four airborne electromagnetic-magnetic surveys were flown for the Ontario Government during the winter of 1979-80. These surveys, part of a joint program of the Ministry of Northern Affairs and the Ministry of Natural Resources to enhance the overall geoscience data base in selected areas of the province which have mineral exploration potential, were planned and co-ordinated by staff of the Geophysics/Geochemistry Section. All four selected AEM Systems will respond to conductive overburden and near-surface horizontal conducting layers in addition to bedrock conductors.

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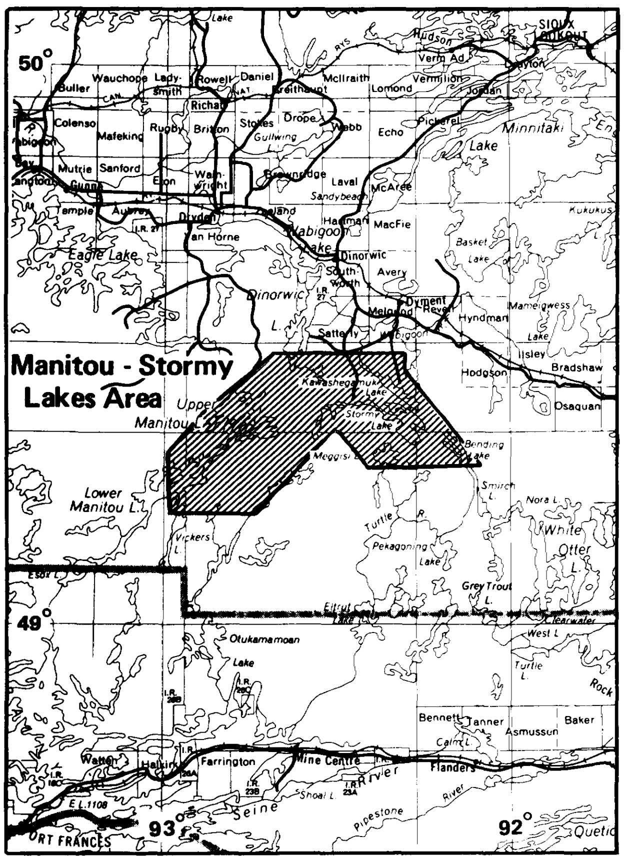


LOCATION MAP **Scale: 1: 1 584 000 or 1 inch to 25 miles**

Manitou-Stormy Lakes Area

This area was surveyed by Kenting Earth Sciences Limited using a Canso aircraft equipped with the Scintrex/Kenting Tridem[R] Electromagnetic System which measures in-phase and quadrature components at three frequencies (500 Hz, 2000 Hz and 8000 Hz). A Gulf MK V fluxgate magnetometer is included with the Tridem System. Mean flight line spacing was 200 m with a mean flight altitude of 50 m above terrain. Discrimination of conductors is based on the ratio of in-phase to quadrature responses, variation of response with frequency, magnetic correlation and the anomaly shape, together with conductor pattern and topography. A total of 9721 line km of data was collected in November and December 1979. Twenty-two photomosaic-based maps, at a scale of 1:20 000, were prepared to present the information collected.

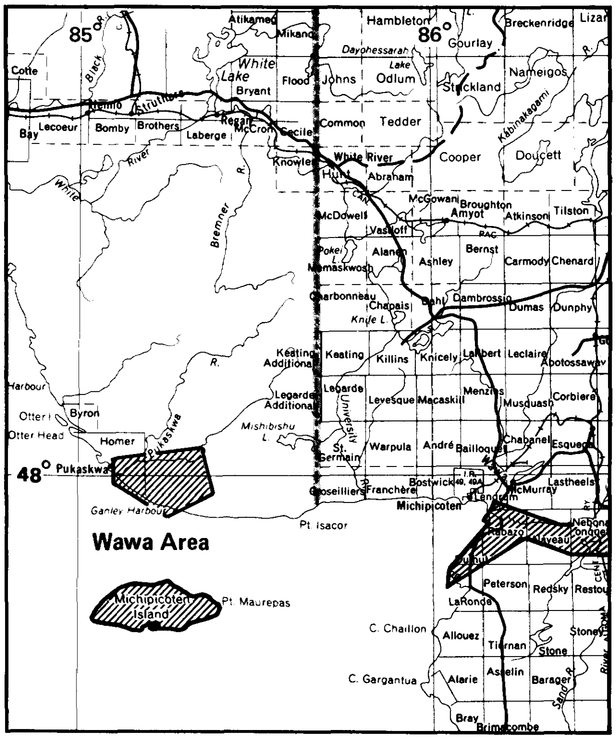
Wawa Area (Homer Township Area, Michipicoten River Area, Michipicoten Island Area)

This area was surveyed by Scintrex Limited using a Bell 206B helicopter equipped with the Scintrex HEM-802 Electromagnetic System which measures in-phase and quadrature components at two frequencies (735 Hz and 3220 Hz). A Scintrex MAP-4 Proton Precession Magnetometer is included in this system. Line flying was done at an average sensor elevation of 30 m above terrain with a nominal line spacing of 200 m. Discrimination of conductors is based on the ratio of in-phase to quadrature responses, variation of response with frequency, magnetic correlation and the anomaly shape, together with conductor pattern and topography. Approximately 4100 line km were flown in November and December 1979 and January 1980. Seven photomosaic-based maps, at a scale of 1:20 000, were prepared to present the information collected.

[R]Registered Trade Mark of Scintrex Limited.

D.R. WADGE

Atikokan-Mine Centre Area

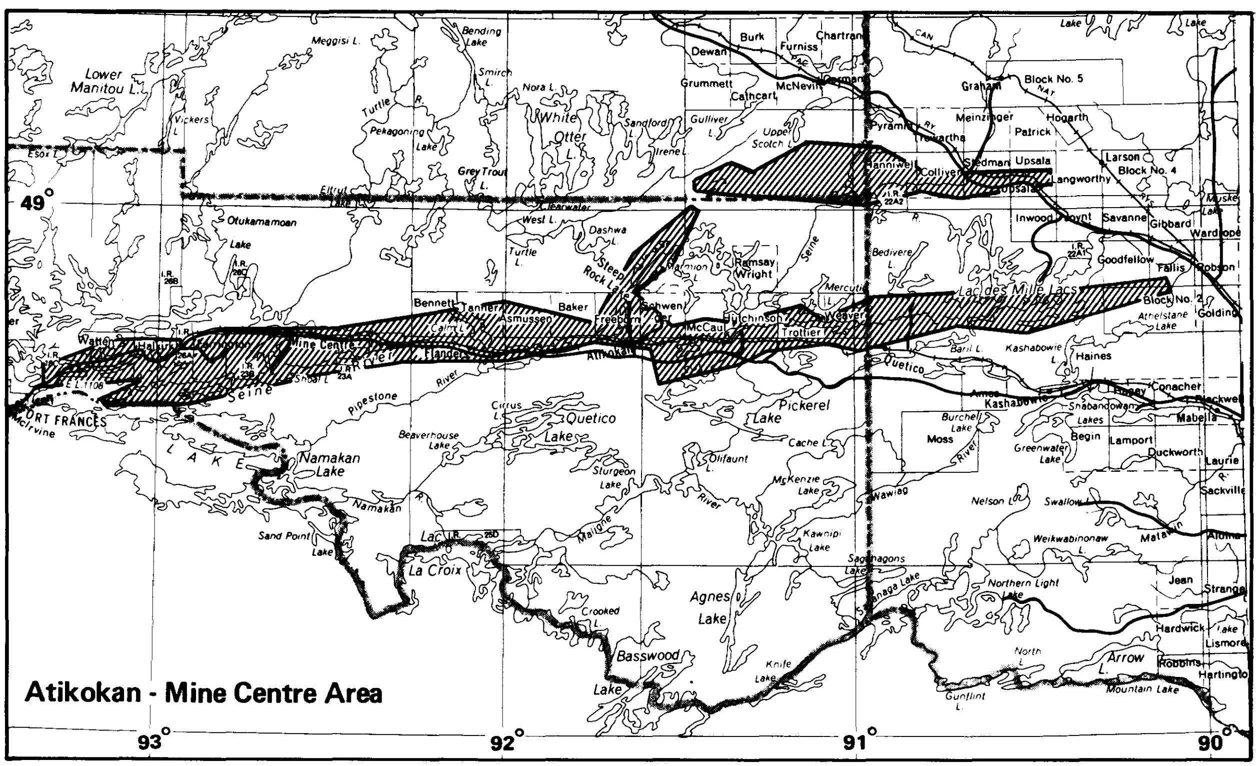


LOCATION MAP

Scale: 1: 1 584 000
or 1 inch to 25 miles

This area was surveyed by Questor Surveys Limited using a Trislander aircraft equipped with the Barringer/ Questor Mark VI INPUT[R] airborne EM System and the Sonotek PMH 5010 Proton Precession Magnetometer. Discrimination of conductors is based on the rate of transient decay, magnetic correlation and the anomaly shape, together with the conductor pattern and topography. A total of 14 166 line km of data was collected at a terrain clearance of 120 m and a line separation of 200 m, during December 1979 and January and February 1980. Forty-one photomosaic-based maps, at a scale of 1:20 000, were prepared to present the information compiled from the data collected.

[R]Registered Trade Mark of Barringer Research Limited.

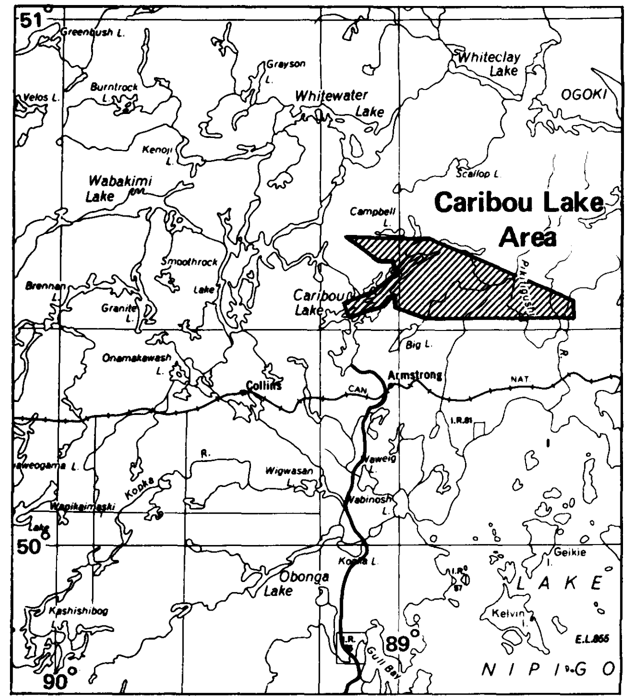


LOCATION MAP

Scale: 1:1,584,000 or 1 inch to 25 miles

Caribou Lake Area

This area was surveyed by Aerodat Limited using a Bell 206B helicopter equipped with the Aerodat HEM Electromagnetic System which measures in-phase and quadrature components at two frequencies (945 Hz and 4175 Hz). A Barringer AM-104 Proton Precession Magnetometer is included in this system. Mean flight line spacing was 200 m and terrain clearance of the sensor was 30 m. Discrimination of conductors is based on the ratio of in-phase to quadrature responses, variation of response with frequency, magnetic correlation and the anomaly shape, together with conductor pattern and topography. Approximately 3080 line km were flown in January 1980. Seven photomosaic-based maps, at a scale of 1:20 000, were prepared to present the data collected.



LOCATION MAP

Scale: 1: 1 584 000 or 1 inch to 25 miles

No. S20 Reconnaissance Basal Till Surveys and Related Detailed Geochemical Research in the Kirkland Lake Area, District of Timiskaming

Ian Thomson[1] and D.R. Wadge[2]

THE WORK REPORTED HERE IS PART OF THE KIRKLAND LAKE AREA GEOSCIENTIFIC SURVEYS. IT IS EQUALLY FUNDED BY THE FEDERAL DEPARTMENT OF REGIONAL ECONOMIC EXPANSION AND THE ONTARIO MINISTRY OF NORTHERN AFFAIRS UNDER THE COMMUNITY AND RURAL RESOURCE DEVELOPMENT SUBSIDIARY AGREEMENT.

Introduction

During the 1980 summer field season, the Geophysics/-Geochemistry Section continued an active program of applied geochemical studies in the Kirkland Lake area. This work forms part of the Kirkland Lake Incentives Program (KLIP), a joint Federal-Provincial project managed by the Ontario Geological Survey, which is designed to provide a comprehensive geoscientific data base for the area.

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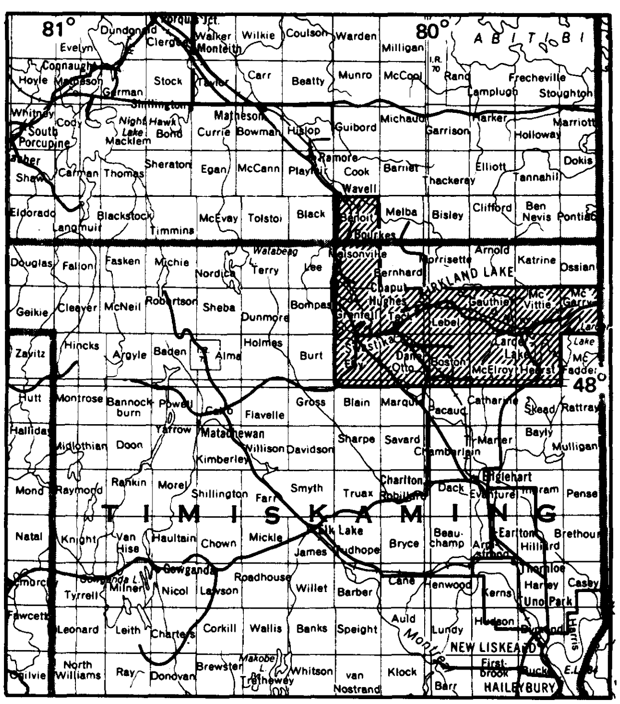

LOCATION MAP

Scale: 1: 1 584 000
or 1 inch to 25 miles

This year's work comprised a balanced program of systematic reconnaissance geochemical surveys and detailed geochemical investigations. The reconnaissance survey is a continuation of the work begun in 1979, and comprises deep overburden drilling and sampling in areas of glacial overburden. The detailed studies include rock, till and soil sampling designed to examine geochemical dispersion characteristics in both the primary (rock) and secondary (overburden and soil) environments.

The area of investigation lies between the Little Clay Belt and the greater Abitibi Clay Belt, and was the site of a major lake basin during the retreat stage of the Pleistocene glaciation. In areas such as that around Kirkland Lake, where there are extensive deposits of glaciolacustrine clay and/or glaciofluvial sediments covering the bedrock, conventional geochemical techniques of soil and silt sampling are inapplicable. In this area of complex glacial overburden, specialized geochemical techniques are required.

Acknowledgements

Unless otherwise indicated, the work described below was designed and completed by the authors, with the aid of Ken Steele and Robert Sutherland, summer student assistants, and David Guindon, contract geological assistant.

The authors wish to acknowledge the support given by individuals and companies who provided access to properties and, in some cases, maps and reports. In particular, Falconbridge Copper Limited, Kerr Addison Mines Limited, Sudbury Contact Mines Limited, Macassa Division of Wilroy Mines Limited, Davey Lowe and R.J. MacGreggor are thanked for permitting detailed orientation studies on their ground.

Reconnaissance Survey Program

This year's work was carried out in two phases. Systematic reconnaissance sampling in areas of deep overburden was completed through portions of seven townships using reverse circulation rotary drilling equipment. In addition, reconnaissance sampling was undertaken through Teck and Lebel Townships, using a back-hoe to excavate pits in areas of shallow overburden.

Practical experience has shown that, in areas such as the Kirkland Lake district, glacial till of essentially local derivation is preserved beneath the cover of exotic sediments. Drilling or pitting through this cover and sampling of the till beneath is a proven method of evaluating the mineral potential of such areas (Thompson 1979).

Reverse Circulation Rotary Drilling

This year's one-month field program marked the second part of a project that will ultimately cover most of the deep overburden terrain in the KLIP area. The work is a continuation of the project initiated in 1979 and employed the same equipment and techniques described by Thomson and Guindon (1979).

The work comprises drilling at a reconnaissance density (modified 3 km grid) in areas of deep overburden, continuous profile sampling of the unconsolidated overburden, and sampling of the bedrock beneath. Chemical and mineralogical studies will be undertaken on the samples obtained, paying particular attention to the composition of the till sheet, with a view to obtaining information of value in assessing the mineral potential of the drift-covered areas.

During the current work period, 53 drill holes were completed for a total of 1053 m of drilling. The holes are situated in areas of deep overburden on a 3 km grid, modified to account for access and overburden/outcrop relationships. Drilling was undertaken by Heath and Sherwood Drilling, Kirkland Lake, using an Acker reverse circulation rig mounted on a Timber-Jack. Management of the program was provided by Derry, Michener and Booth, Toronto, who had a team of three people (two geologists and an assistant) on site for supervision, logging and sampling of the drill holes.

Drilling was completed through parts of Benoit, Maisonville, Grenfell, Eby, Otto, Boston and McElroy Townships. In the north (Benoit and Maisonville), a complex glaciofluvial and glaciolacustrine sequence was encountered, with esker and open delta sediments interdigitating with glaciolacustrine silts and clay east of Highway 11 and north of the present Arctic watershed. Till was encountered in most holes away from the esker. In the vicinity of the esker, the bedrock appears to be swept clean of till material.

South of the height of land, the Quaternary stratigraphy appears to be less complex, with thick glaciolacustrine clay sequences over a thin (± 0.3 m), discontinuous till sheet. Glaciofluvial sands and gravels were encountered close to eskers where the bedrock appears to have been washed clean; till, where present, is very sandy and probably reworked.

Organic material (fragments of wood and twigs), which was encountered in glaciofluvial sediments in Benoit Township, will be submitted for identification and ^{14}C age dating.

During the fall and winter of 1980, chemical and mineralogical studies will be undertaken on the samples collected. The geochemical, mineralogical and geological data, together with all stratigraphic information, will be published in 1981.

Back-Hoe Pit Sampling

Much of the central part of the KLIP survey area was a positive topographic feature during the retreat stage of the Pleistocene glaciation and stood close to or above the level of glacial Lake Barlow-Ojibway. Lodgment till is present at surface in many parts of the area or covered by a thin and discontinuous mantle of glaciolacustrine and glaciofluvial sediments. This condition is most extensively developed along the present height of land where bedrock outcrops are common and lodgment till occurs at surface. The area is, however, traversed by north-trending esker ridges and associated flanking sand plains. Lodgment till is rarely encountered in the vicinity of the eskers, even at depth beneath the sand cover, since the bedrock was swept clean prior to deposition of the fluvial sediments. When preserved, till material close to eskers is invariably very sandy and shows frequent evidence of reworking by water.

In these areas of thin overburden, drilling with the large, expensive, reverse circulation rotary equipment is not justified. On a reconnaissance basis, sampling may be achieved by pitting at carefully selected locations and collecting fresh lodgment till where it is close enough to surface to be intersected in the pit.

For the 1980 project, lodgment till samples were collected at approximately 1 km intervals along all passable roads, tracks and trails through Teck and Lebel Townships. Till samples were collected at 57 sites using a back-hoe mounted on a Timber-Jack to excavate shallow pits into the overburden. Lodgment till was not encountered everywhere. Indeed, a total of 77 sites were visited and more than 100 pits excavated to obtain the 57 samples.

Lodgment till occurs discontinuously through the area, being preferentially deposited on the stoss (up-ice) side of outcrops. Till also occurs in hollows and on the lee (down-ice) side of outcrops; in such cases, it may not be true lodgment till but is, nevertheless, derived from the basal portion of the ice mass and thus of essentially local origin. This lodgment or basal till is recognized in the field by its tough, dense, compact character, fissility, poor sorting with angular clasts and moderate silt content. The presence of "armoured" clasts, with a partial sheath of silt or sand material on the upper, up-ice faces of the clast, is also diagnostic, as is the presence of ice-smoothed and ice-striated cobbles at the base of the till. The till is further characterized by a preponderence of clasts of local derivation and by its typical position, immediately above the bedrock.

The discontinuous nature of the till is largely a primary feature related to lodgment on the pre-existing bedrock topography, locally modified by washing of the bedrock in a fluvial or lacustrine environment close to eskers and in glacial Lake Barlow-Ojibway.

For the present program, aerial photographs were used to identify locations with shallow overburden where till might be found near the surface. On site, the Timber-Jack was maneuvered onto the stoss (up-ice) side of an outcrop and a pit excavated, following the outcrop down until till was encountered or the safe working limit (given local conditions) of the back-hoe reached.

On the basis of this season's work, it is concluded that, in the immediate vicinity of Kirkland Lake, till is usually encountered 1) at a depth of 1 to 2 m, and 2) as a thin 0.02 to 0.20 m lodgment plastered onto the stoss side of outcrops beneath a layer of sandy reworked till which is, in turn, overlain by glaciofluvial and/or glaciolacustrine sediments and talus derived from the adjacent outcrop. The lodgment till is typically a sandy silt with numerous pebbles and cobbles and, where fresh, is invariably tough, fissile and very compact.

Samples comprised 4.0 litres (6 to 8 kg) of the freshest material available, collected as a composite from the full till section. These samples will be subject to the same sample preparation and chemical and mineralogical studies as the reverse circulation drill samples, to permit integration of the data.

On the basis of this season's field work, it is concluded that the Timber-Jack-mounted back-hoe is the ideal equipment for till sampling in areas of shallow overburden. The Timber-Jack is versatile and maneuverable in the bush, yet capable of rapid progress along roads and tracks between sites. The back-hoe rapidly excavates a shallow pit in which the full character of the overburden is clearly visible. Lodgment till may be confidently identified, and the full till section down to bedrock excavated, examined in detail, logged and bulk sampled. Fresh till can be easily obtained; this is an important consideration when, as is the case with the present survey, examination of readily weathered indicator minerals, such as sulphides and carbonates, is to be undertaken.

For the reconnaissance survey a total of 91.5 machine hours were used, an average of 1.60 hours per sample. However, as noted above, more than 100 pits were excavated at 77 sites, and some 20 percent of the total time was accounted for in moving between sites. In practice, a pit 1.5 m deep could be excavated, logged in detail, sampled and backfilled in approximately 40 minutes.

The main practical limitation to the use of the back-hoe is the discontinuous nature of the till and, consequently, the frequent need to excavate several pits before a satisfactory sample is obtained. However, it was noted that as the survey progressed, the geologist on site became more knowledgeable of the factors controlling the local occurrence of till, and the number of barren holes decreased accordingly.

Following examination of the chemical, mineralogical and geological data obtained from this project, a more complete report will be published.

Detailed Investigations

During the course of the summer field season, a series of detailed geochemical studies were initiated. These are intended to provide data on the character and extent of mineralogical and geochemical dispersion patterns developed from various types of mineralization. These will aid the interpretation of the reconnaissance surveys and also establish criteria for geochemical surveys aimed at locating individual bodies of mineralization.

The detailed studies comprise:

1) deep overburden sampling around known occurences of sulphide mineralization using a man-portable percussion drilling unit;

2) till sampling around known occurrences of gold mineralization using a back-hoe to obtain bulk samples beneath shallow cover; and

3) a program of soil and rock sampling, in collaboration with the Applied Geochemistry Research Group, Imperial College, London, England, to investigate the role of tellurium, bismuth, antimony and selenium as pathfinder elements for gold mineralization.

Deep Overburden Sampling

Deep overburden sampling was completed over a cut grid 425 m by 220 m located 2 km west of Larder Lake, using a man-portable percussion drilling unit. The equipment employed, which is fully described by Thomson and Guindon (1979), comprises a Wacker gasoline-powered jack hammer which is used to drive a Holman flow-through bit sampler into the overburden to sample the till at depth.

Within the grid area, 65 holes were drilled for a total of 597.5 m. Minimum and maximum depths reached were 1.0 and 25.0 m. Drill penetration rates, working conditions, sample characteristics, and equipment specifications are as described by Thomson and Guindon (1979). In the present program, till was encountered in 31 holes, fluvial sand over thin till or bedrock in 32 holes, and two holes were abandoned at shallow depth (1 to 5 m) when the bit bound in well-sorted sands.

Although it is not known exactly where the drill stopped in the overburden, it is possible to draw maps showing 'apparent depth of overburden' and 'apparent bedrock topography', which are largely substantiated by depth of overburden as indicated by length of casing in diamond drill holes. These results revealed a very rugged bedrock topography, with a local relief of 24.1 m over a horizontal distance of 180.0 m, beneath a gently rolling sand plain.

The area of investigation is located on the flanks of an esker where fluvial sands interdigitate with lacustrine clays above a thin and discontinuous till. The grid covers a well-defined electromagnetic conductor that has been tested by several diamond-drill holes (Resident Geologist's files, Ontario Ministry of Natural Resources, Kirkland Lake). The conductor is principally graphite with irregular (possibly lenticular) bodies of massive and disseminated sulphides consisting of pyrrhotite with sphalerite, chalcopyrite and galena. The present drilling is designed to:

1) determine the form of the glacial dispersion train in till down-ice from known mineralization and

2) assess the effectiveness of the man-portable drilling equipment for deep sampling in areas of complex glacial overburden.

The geochemical data is not yet available. Comment is thus confined to physical parameters observed in the drilling.

Sulphide debris was observed in till samples collected over and immediately (up to 60 m) down-ice from the conductor. Sulphides were observed in the till at a greater distance (120 m) along the flanks of a major bedrock high. This suggests preferential development of a dispersion train as a result of diversion of the ice around a bedrock ridge.

The presence of a thin, discontinuous till is consistent with observations from surface mapping and pitting in areas of shallow overburden. In the grid area, till appears to be present over approximately 50 percent of the bedrock surface, being preferentially developed as lodgment on the stoss (up-ice) side of bedrock ridges and in hollows.

Field experience has shown that, to be fully effective, a number of percussion holes (minimum of five) should be drilled to confidently establish overburden thickness, distribution of till, and the character of the bedrock feature under evaluation. In the examination of electromagnetic conductors, the orientation of the conductor with respect to ice movement is, however, an important qualification as to how the sampling pattern should be arranged across the conductor.

In the present study, the elucidation of apparent bedrock topography and the extent of lacustrine clay lenses has also greatly influenced the interpretation of geophysical data. The use of deep overburden sampling is thus recommended, not only to obtain mineralogical and geochemical information on bedrock features, but also to provide qualifying data for the interpretation of geophysical surveys and as an aid in selecting sites for diamond-drilling.

The samples collected will be subjected to mineralogical and chemical tests to further define the character and extent of geochemical dispersion in the till. This data will be compiled and published at a later date.

Back-Hoe Sampling

Bulk samples of fresh lodgment till were collected at 27 locations around the Fernland and Cheminis gold zones in McVittie Township, east of Larder Lake. The gold in these two zones occurs with disseminated sulphides within carbonatized ultramafic rocks of the Larder Lake Group. The mineralized zones contain abundant fuschite which gives rise to the 'green carbonate' rock common to many gold zones in the Larder Lake camp.

The area has moderate topography with local surface relief of 10 to 15 m and numerous bedrock outcrops. The overburden is locally complex. Lacustrine clay and sands are found extensively at surface. Beneath these a thin lodgment till is irregularly developed, occurring most frequently as a remnant on ledges and bedrock irregularities low down on the stoss (up-ice) side of outcrops. For the most part, the till appears to have been washed from the rock surface by the action of the lake and redeposited as sand and gravel lenses beneath and within the lacustrine sediments. As a result, the intended sampling pattern, based on 30 m and 60 m spacing, was abandoned in favour of a pattern based on access and availability of fresh till. For this a back-hoe mounted on a Timber-Jack was employed to excavate shallow pits on the stoss side of outcrops. Some 50 pits were excavated at 45 locations to yield 27 samples from 26 locations. Field procedures were identical with those of the reconnaissance program described above.

Bulk samples of 4.0 litres (6 to 8 kg) were collected as composites of the full till section from each location. These will be subjected to extensive mineralogical and chemical investigation to determine the character and extent of dispersion of gold, other elements, and indicator minerals of gold mineralization in the till. Early examination of the heavy mineral fraction of the till has confirmed the presence of free gold in the overburden about the Fernland zone. Peak concentrations are recorded 75.0 m down-ice from the subcrop of the gold ore.

A full account of this study will prepared when chemical and mineralogical tests are completed.

Pathfinder Elements for Gold Mineralization

Telluride minerals are a common consituent of the gold ores in the Kirkland Lake camp (Thomson *et al.* 1948), and both bismuth and selenium are reported from ore concentrates (Todd 1928). Antimony, although not reported, may be present in trace quantities. These elements, and in particular tellurium, are thus positive indicator elements for new ore in the Kirkland Lake district.

Tellurium is of note for two reasons. First, it is usually present in trace quantities within the host rock to the gold deposits for some distance beyond the limits of gold mineralization. Tellurium halos in the host rocks might thus define a much larger target for exploration than gold alone. Similarly, gradients in the tellurium halo may help locate blind or hidden ore bodies. Secondly, tellurium is mobile in the secondary (surface) environment and might be expected to define broad anomalous areas. These would provide large targets in the surface exploration for new areas of gold mineralization, including blind or buried deposits.

The Applied Geochemistry Research Group of Imperial College, London, England, has successfully developed rapid techniques for the simultaneous determination of tellurium, selenium, bismuth and antimony at ultratrace levels in geological materials. The group has also developed a variety of techniques for the speciation of tellurium compounds that greatly aid interpretation of geochemical patterns and enhance the probability of correctly identifying the location of mineralization.

In June 1980, a collaborative program was initiated whereby soil and rock material collected in the Kirkland Lake area will be analyzed in London. The resulting data will be evaluated jointly by the Applied Geochemistry Research Group and the Geophysics/Geochemistry Section of the Ontario Geological Survey. Particular attention will be given to the geochemistry of tellurium as an indicator for gold.

For the present study, samples of soil, till and rock were collected along traverses west of the Macassa Mine and close to the McIvor Mine, west of Kirkland Lake. Care was taken to sample undisturbed and uncontaminated material, a difficult task within the Kirkland Lake camp where many areas have been repeatedly stripped, trenched or partially developed. Analytical work will continue through the fall and winter prior to the preparation of a report for release in 1981.

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Mineral Deposits Programs

Summary of Activities, Mineral Deposits Section, 1980

J.A. Robertson[1] and A.C. Colvine[2]

The Mineral Deposits Section continued its research on the nature and genesis of the mineral deposits of Ontario. The base program of the section involved major projects directed towards geological areas, such as the eastern Southern Province and the Grenville Province, and several commodity-based projects. Other projects, typically directed towards specific mining communities and designed to supplement the main base program areas, were funded by the Ontario Ministry of Northern Affairs or jointly by the Ontario Ministry of Northern Affairs and the Federal Department of Regional Economic Expansion. The sources of funding for these special projects are acknowledged in the individual project summaries.

The Southern Province metallogenic studies, which commenced in 1979 under the direction of A.C. Colvine, are continuing and, within the past year, have involved several public presentations and the addition of specific related projects. These include detailed studies of the environment of mineralization in the Cobalt area (Dillon- Leitch, No. S25, this volume) and uranium deposits of the Wanapitei watershed (Meyn and Matthews, No. S26, this volume).

The laboratory studies for the latter project have made extensive use of autoradiographs in an effort to relate the distribution of uranium mineralization to detailed lithologic and sedimentary features and to identify areas for X-ray and electron probe studies to identify the uranium minerals present. In addition, A.J. Andrews started a three-year project to investigate Early Precambrian (Archean) volcanism and its relationship to mineralization in and around the Cobalt Embayment. These studies were closely co-ordinated with the work of the Precambrian Section (John Wood, No. 14, this volume).

The manuscript reports arising from Operation Pembroke (Ontario Ministry of Treasury and Economics-Federal Department of Economic Expansion) have been completed and placed on open file (Gordon and Masson 1980). Processing of final maps and report is underway.

T.R. Carter (No. 24, this volume) continued his investigation of the mineral deposits of the Grenville Supergroup, as part of a three-year base program study, emphasizing gold mineralization in the southern part of this area. This work is to be supplemented by funding from the Ontario Ministry of Treasury and Economics and the Federal Department of Regional Economic Expansion.

S.L. Masson (No. 25, this volume) completed the mapping of an area in the Bancroft camp. This ties the previous detailed mapping in the vicinity of the Faraday Granite and the Madawaska Mine with the regional mapping undertaken by E.G. Bright (1980). Some emphasis was placed on uraniferous calc-silicates and the role of syenitic rocks in the genesis of uranium deposits.

The Northern Industrial Minerals Survey (NIMS) program, initiated in 1979, continued under the general supervision of M.A. Vos, assisted by T. Abolins. An interim report by Ulrich and Dianne Kretschmar on talc and magnesite deposits in the Kirkland Lake-Timmins area has been placed on open file (Ulrich and Dianne Kretschmar 1980) and follow up work is continuing. A map showing the distribution of lithium and related elements as revealed by centre-lake bottom sediment samples collected in the Thunder Bay area for the Federal-Provincial Uranium Reconnaissance Program is in press. The Sectoral Inventory of Industrial Minerals is in the final stage of preparation.

New investigations this year include a re-examination of nepheline-bearing rocks near Rutter (M.A. Vos, No. S22, this volume) and studies on the industrial minerals in selected carbonatite or alkalic complexes in northern Ontario (M.A. Vos, No. S21, this volume).

Other work completed and published on open file this year includes Chromite Deposits in Ontario (Whittaker 1980) and Gold Deposits of the Atikokan Area (Wilkinson 1980).

A.J. Fyon completed his M.Sc. Thesis at McMaster University based on field work sponsored by the Mineral Deposits Section. This thesis has been placed on file in the Ontario Geological Survey library and in the Resident Geologist's Office, Ontario Ministry of

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[2]Geologist, Mineral Deposits Section, Ontario Geological Survey, Toronto.

Natural Resources, Timmins. A summary paper is in preparation.

F.R. Ploeger (No. S24, this volume) began a two-year study on the relationship between gold mineralization and syenitic rocks in the Kirkland Lake area.

K.H. Poulsen (No. 23, this volume) began a multi-year study on the metallic mineral deposits of the Fort Frances-Mine Centre area.

The work begun in 1977 by A.C. Colvine to examine mineralization associated with Early Precambrian (Archean) granitoid stocks as possible porphyry coppers was continued by Soussan Marmont. Limited field work was carried out to assess the need for further investigation of several areas, including the Mink Lake molybdenum-gold-copper deposit east of Red Lake and the Chester Township gold-copper deposits southwest of Timmins. Work to date has demonstrated that many intrusions play a role in reconcentration of gold into vein systems around the margin of the intrusion. While there have been no examples of true porphyry-style systems identified as yet in this project, many features have some analogies with more recent systems and can be used to better assess the nature and extent of mineralization in these deposits. A compilation of data on these deposits will be placed on open file during 1981.

Work continued on mineral deposit classification, mineral potential assessment, reserve/ resource analysis and province-wide inventories of various mineral commodities.

J.A. Robertson continued special studies related to uranium and acted as liaison with the Uranium Resources Appraisal Group of Energy, Mines and Resources, Canada. The report for 1979 has not yet been released. However, the data released by the Royal Commission on Electric Power Planning (Porter 1980) gives a reasonably recent picture of Ontario Reserves and Resources. This can be compared with Canadian data from Energy Mines and Resources, Canada and international data from the Organization for Economic Co-operation and Development (1979). It is clear that only minor changes have taken place in Ontario's resources but that the Province's share of Canadian and world resources (Gordon *et al*, in press) continues to decline. The continued expansion of facilities and infrastructure at Elliot Lake, the cessation of mining operations at Agnew Lake (leaching of broken ore continues), and the continuing operation at the Madawaska Mine are documented in the annual reports of the companies concerned.

Rare Earth Resources Limited has undertaken limited underground work at the Halo property in Cardiff Township and is investigating the feasibility of radiometric sorters as a means of upgrading ore prior to transportation to a mill.

Staff members participated as leaders in workshops and scientific or technical field trips related to Cobalt metallogenesis, Grenville Province mineral deposits, the potential for porphyry-type deposits in Early Precambrian (Archean) rocks, and classification and setting of uranium deposits.

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No. 23 The Geological Setting of Mineralization in the Mine Centre – Fort Frances Area, District of Rainy River

K.H. Poulsen[1]

Location and Access

During the 1978 field season selected mapping was carried out in an area bounded by Latitudes 48°35′ and 48°50′N and Longitudes 92°30′ to 93°20′W. This work constitutes the first field season of a three-year project initiated to relate the numerous occurrences of mineralization to the stratigraphic, structural and metamorphic setting of the region. All of the area has been mapped previously (Lawson 1913; Tanton 1936; Harris 1974; Wood *et al.* 1980). Access to the area is excellent: by road via Highway 11; by water via Rainy Lake and its tributaries; and by air via float-equipped aircraft from Fort Frances. This report discusses preliminary results obtained during the past field season, in light of the author's continuing work in this area (Poulsen 1980).

Mineral Exploration

The Rainy Lake area has a long history of mineral exploration and exploitation since the discovery of gold at Mine Centre in 1893. At that time three deposits, the Olive, Golden Star and Foley, were worked and, coupled with renewed activity during the 1930s, a total production of approximately 485 kg of Au and 20 kg of Ag was realized (Beard and Garratt 1976).

The noted similarity of iron formations at Nickel Lake with those at Michipicoten led to exploration around the turn of the century. Diamond-drill programs in 1920 and 1955 defined a minimum of 2 million tonnes of magnetite-ilmenite mineralization hosted by anorthosite and gabbro north of Seine Bay (Rose 1969).

Since the mid-1950s exploration in the region has largely been focused on the search for base metals. The discovery of copper in gabbro at Grassy Portage Bay in 1958 led to the development of a 70 m two-compartment shaft and a 200 m drift through the mineralization by Northrock Mines Limited in 1973. Recent exploration programs have investigated zinc-copper mineralization hosted by metavolcanics. Numerous occurrences have been evaluated by diamond-drilling and geophysical methods but, to date, no economically viable deposits have been outlined.

During the 1980 season, exploration for gold and base metals continued in the region. The partnership of Armstrong and Hupchuk of Fort Frances carried out delineation drilling of the low-grade zinc deposit at Wind Bay. Sherritt-Gordon Mines Limited and Corporate Oil and

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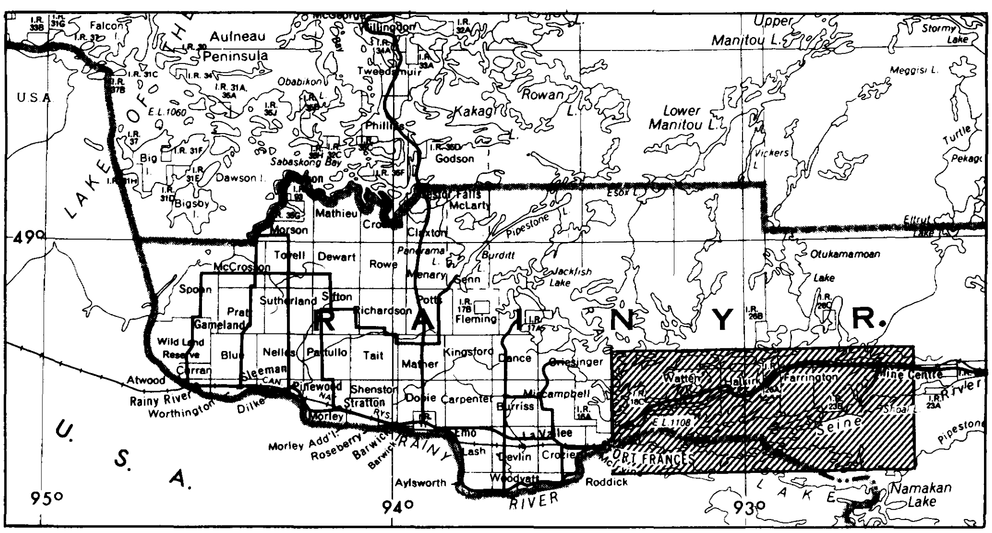

LOCATION MAP

Scale: 1:1,584,000 or 1 inch to 25 miles

Gas Limited began drill programs to evaluate gold mineralization near Mine Centre. The high world gold prices encouraged additional exploration by many prospectors in the area.

Structure and Metamorphism

During 1980 the results of recent structural and metamorphic studies at Rice Bay (Poulsen 1980; Poulsen *et al.* 1980) were supplemented by additional mapping over the entire study area.

Two regional faults are exposed within the map-area. In the north, the Quetico Fault is represented by a 700 m wide fault zone which includes mylonites, blastomylonites and, locally, ultramylonites and pseudotachylite. The mylonitic fabric strikes east and parallels the fault zone. The mylonites are commonly offset by small dextral faults and, locally, small folds are superimposed on the mylonite. Rocks of the Wabigoon Subprovince are exposed north of the fault.

In the south, the Seine River-Rainy Lake Fault is expressed as a phyllitic shear zone which strikes easterly. The rocks to the south of this fault are largely metasedimentary biotite schists of the Quetico Subprovince.

At least three fold sets may be recognized in the area between the faults. The youngest of these consists of small folds, F_3, which have northwesterly striking axial surfaces. These folds are commonly metre-sized and possess an axial planar crenulation cleavage. Kink bands are also common in this fold set. Ductile shear zones, particularly well developed in coarse-grained rocks, also tend to strike northwesterly and may be genetically related to the F_3 fold set.

F_3 folds may be observed superimposed on the cleavage and minor folds of an older set. These F_2 folds plunge northeasterly and southwesterly and vary in wavelength from a few centimeters to a few kilometres. Axial surfaces dip steeply and are commonly coplanar with a strong penetrative cleavage. The F_2 folds and cleavage are dominant in defining the structural grain of the region and strongly influence the distribution of lithologic units. Prominent F_2 structures include the Rice Bay Dome and a synform at Nickel Lake (Figure 1).

Of importance is the fact that F_2 folds in the Rice Bay-Bear Pass area face downward. Observations of stratigraphic tops, based on graded beds and pillow lavas, contradict the structural order so that antiformal features such as the Rice Bay dome are stratigraphic synclines. Overturned beds with dips as low as 45 degrees have been observed. The entire significance of the downward facing is undetermined, but it is clear that an earlier deformation must have taken place in order to invert the stratigraphic sequence (Poulsen *et al.* 1980). It is proposed that large, possibly recumbent, F_1 folds are important to an understanding of the distribution of lithologic units.

Systematic variations in metamorphic grade across the map-area are evidenced by different mineral assemblages in rocks of similar bulk composition. Biotite schists from the northwestern part of the area commonly contain porphyroblasts of garnet with staurolite or sillimanite on muscovite. Altered andalusite and cordierite are common near the margins of late granitic plutons. The above amphibolite facies rocks are separated from those of the greenschist facies to the southeast by a knotty schist isograd which extends northeastward through Swell Bay (Figure 1).

Stratigraphy

The stratigraphy of Archean rocks at Rainy Lake has long proved a source of controversy. The mapping of A.C. Lawson (1913) established a stratigraphic nomenclature which included the dominantly metavolcanic Keewatin Group, metasedimentary biotite schists of the Coutchiching Group and the conglomerate-bearing Seine Group. Using the principles of structural superposition, Lawson interpreted the Coutchiching Group to be the oldest, followed in turn by the Keewatin Group and the Seine Group. With the exception of disagreement by Grout and his coworkers (Grout *et al.* 1951), this stratigraphic interpretation has prevailed until recently (Poulsen 1980; Wood *et al.* 1980). Unfortunately, previous interpretations were based on observations around the Rice Bay dome where it can be shown that structural superposition is not a valid stratigraphic tool. As a result, a revised stratigraphic column (Table 1) is based upon data gathered during the past field season coupled with other recent mapping by the Ontario Geological Survey (Wood *et al.* 1980). The classical terminology of Lawson has been included due to its historical significance. The spatial distribution of the units is shown in Figure 1.

Mineralization

Table 2 shows a provisional classification of mineralization in the Mine Centre-Fort Frances area. The subdivision is based upon the examination of properties, private company reports, assessment files and diamond-drill core. Locations of typical occurrences of each deposit group are shown in Figure 1 and those referred to in the text are numbered.

Type 1: Stratabound Mineralization

Subtype 1A

Sphalerite and chalcopyrite are present in numerous occurrences, hosted by a unit of felsic and intermediate metavolcanics extending from Sandpoint Island northeastward through Mine Centre for a distance exceeding 30 km (Figure 1). Mineralization occurs at two specific horizons, one near the middle of the sequence, the other at the top. The latter type is present 1 km south of Gagné Lake, while the former is typified by mineralization at Wind Bay.

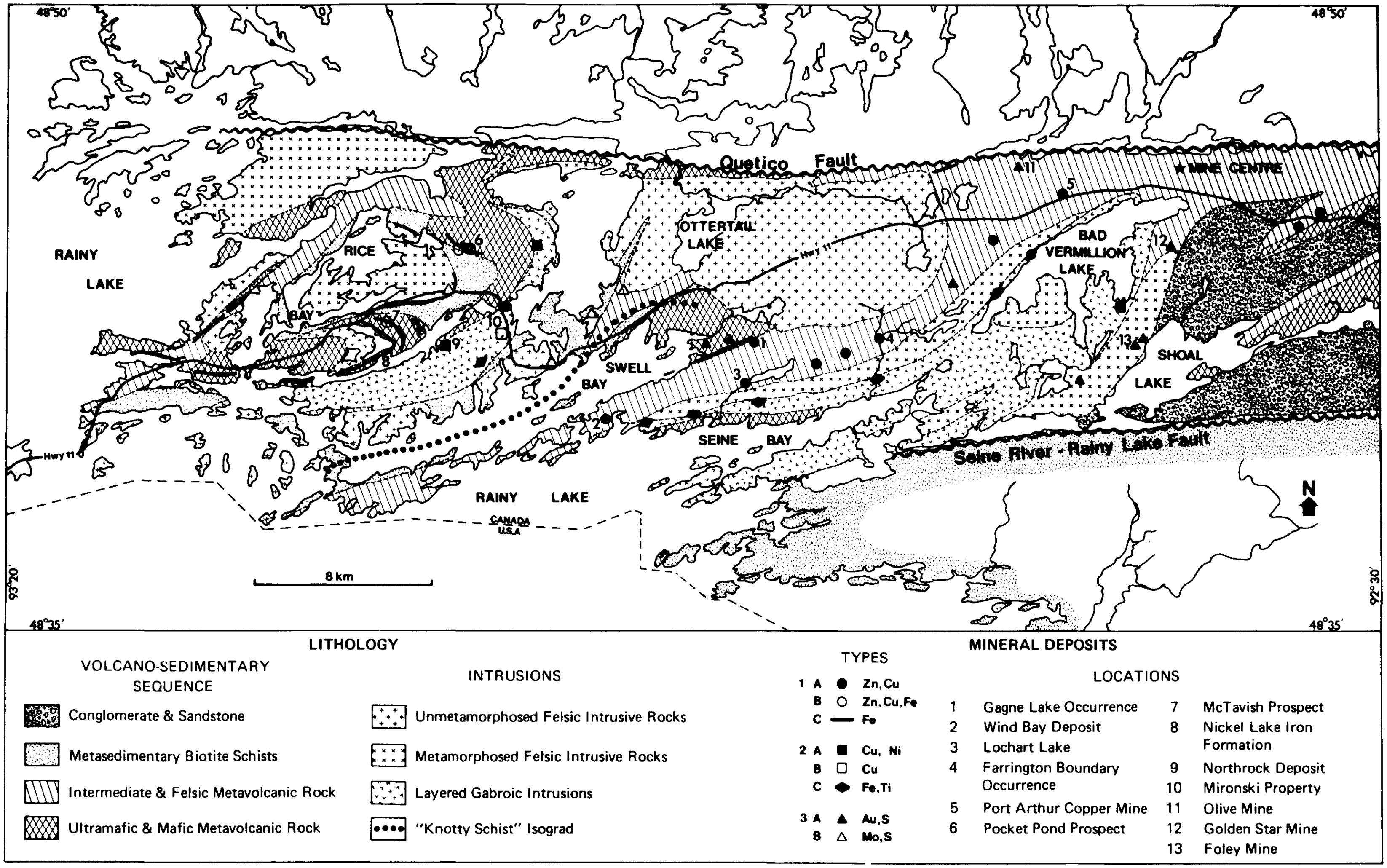

Figure 1—Generalized geology and mineral deposits of the Mine Centre-Fort Frances area.

At Gagné Lake, the mineralization consists of lenses of massive sphalerite and galena, up to 20 cm wide, which parallel similar overlying pyritic layers. Rocks of the footwall to the south of the mineralized zone consist dominantly of rhyolitic lapillistone which locally contains a distinctive spotted alteration of chlorite and centimetre-sized porphyroblasts of pinnitized cordierite. The hanging wall rocks consist of fine-grained siltstone and chert which locally form a coarse breccia with clasts ranging up to 50 cm in diameter. On strike with the mineralization, the breccia contains clasts of massive pyrite. While drilling to date by Armstrong-Hupchuk has shown the mineralization to be very thin, the geologic setting and alteration show a resemblance to many volcanogenic massive sulphide deposits (Sangster 1972).

At Wind Bay, a 4000 m diamond-drill program by Armstrong-Hupchuk has resulted in the preliminary definition of a large low-grade zinc deposit hosted by quartz-chlorite schists of volcanic origin. The drilling to date indicates a length in excess of 650 m, with a minimum depth extent of 150 m. Sphalerite, pyrrhotite, chalcopyrite, pyrite and minor galena occur in lenticular seams 1 mm to 5 cm wide. The seams parallel schistosity and occur in clusters which give rise to a series of consecutive mineralized zones separated by barren chlorite schist. Although extensive assay data are lacking, a typical drill section through 50 m of tuffaceous chlorite schist yielded two mineralized zones, 7 m and 8.6 m in true width, which averaged 1.5 percent Zn and 0.2 percent Cu, and 1.1 percent Zn and 0.09 percent Cu, respectively (George Armstrong, personal communication, 1980). Where the quartz-chlorite schist is only weakly deformed, primary features such as angular fragments and amygdules are recognizable, suggesting a derivation from volcanic flows and tuffs. The distinctive chlorite schist unit is underlain to the south by rhyolite lappilistone and tuff which, near the mutual contact, contains alteration consisting of abundant pyrite and pyrrhotite blebs with minor chalcopyrite. The chlorite schists are overlain by relatively unaltered quartz-eye rhyolite tuffs. The stratigraphic succession, and locally the mineralized zones, are dissected by three laterally extensive mafic sills which are slightly discordant to the strike of metavolcanic rocks.

Several other occurrences of the Wind Bay type were investigated and include mineralization at Lochart Lake (Selco Exploration Company Limited, 1967), on the Farrington Township boundary (Selco Exploration Company Limited, 1967; International Nickel Company of Canada Limited, 1977), near Barber Lake (Noranda Mines Limited, 1970; Armstrong-Hupchuk, 1978) and at the Port Arthur Copper Mine where a small amount of copper was mined in 1916. In each of these cases, the mineralization occurs near siliceous pyroclastic rocks in quartz-chlorite schist and metamorphosed amygdaloidal intermediate to mafic flows.

Subtype 1B

At Pocket Pond and Nickel Lake (Figure 1), significant quantities of sphalerite and chalcopyrite are associated with iron formation which is dominantly composed of chert-magnetite and sulphide-bearing carbonates. The base metals are hosted by a pyritic, black shale to siltstone unit which immediately underlies stratigraphically the iron formation. A single drill intersection through this mineralization yielded assays averaging 1.73 percent Zn and 0.09 percent Cu over a true width of 10 m (George Armstrong, personal communication, 1980). Chip sampling across a similar zone by Noranda Mines at the McTavish Option, Nickel Lake, yielded average assays of 0.3 percent Zn and 0.1 percent Cu (Resident Geologist's Files, Ontario Ministry of Natural Resources, Kenora). The host rocks to the iron formation at both localities are amphibolites, presumably derived from mafic volcanic flows and related intrusions.

Subtype 1C

Iron formations, which contain minor quantities of base metals, are commonly associated with amphibolite, particularly in the western portion of the map-area (Figure 1). Layered chert magnetite is abundant and commonly is associated with concordant zones of massive pyrite and pyrrhotite. Little iron formation is associated with felsic metavolcanics and, at Gagné Lake, the iron formation overlies the uppermost rhyolites of the metavolcanic succession.

Type 2: Gabbro-Hosted Mineralization

Two extensive tabular bodies of gabbro to anorthosite composition are present in the map-area, at Grassy Portage Bay and extending from Seine Bay through Bad Vermilion Lake (Figure 1). These layered intrusions possess an internal stratigraphy which is similar to that reported for the Doré Lake Complex, Québec (Allard 1970). Gabbros, leucogabbros and anorthosites give way upward to oxide-rich gabbros, iron-titanium oxide accumulations, quartz gabbros and tonalites. Distinctive types of mineralization are related to stratigraphic position within the intrusions.

Subtype 2A

Copper mineralization is common along the northwestern margin of the Grassy Portage Intrusion and at a few localities in the Seine Bay-Bad Vermilion Intrusion. The best example of this type occurs at the Northrock deposit, where 300 000 tonnes of material grading 1.89 percent Cu have been outlined. The mineralization is hosted by gabbro, metagabbro and leucogabbro near the base of the Grassy Portage Intrusion at the contact with pillow lava and pillow breccia. Mineralization consists of heavy disseminations of chalcopyrite and pyrrhotite with minor pentlandite and pyrite. Ilmenite, apatite and molybdenite are present locally. Texturally the sulphide minerals are

TABLE 1: TABLE OF LITHOLOGIC UNITS FOR THE MINE CENTRE-FORT FRANCES AREA.

Lithostratigraphic Unit	Classical Designation	Description
Unmetamorphosed Felsic Intrusive Rocks	Algoman Granites	mainly quartz monzonite and granodiorite; minor quartz diorite
	Intrusive Contact	
Metamorphosed Conglomerate and Sandstone	Seine Group	polymict conglomerate and cross bedded sandstone; some pebbly sandstone and siltstone
	Unconformity	
Metamorphosed Felsic Intrusive Rocks	Laurentian Granite	mainly tonalite and trondhjemite and their metamorphic equivalents; includes leucocratic gneisses in the core of Rice Bay dome
	Intrusive Contact	
Layered Gabbroic Intrusive Rocks		mainly gabbro, leucogabbro and anorthosite, and their metamorphic equivalents; includes some metagabbro, quartz diorite, tonalite and Fe-Ti oxide cumulates
	Intrusive Contact	
Metasedimentary Biotite Schists	Coutchiching Group	metamorphosed turbidites, sandstones and mudstones; includes abundant "knotty" schist
Intermediate and Felsic Metavolcanics	Keewatin Group	mainly metamorphosed rhyolitic to dacitic flows and tuffs; includes chloritic tuffs and quartz chlorite schists, some mafic volcanic rocks, metasedimentary rocks and mafic sills
Ultamafic and Mafic Metavolcanics		mainly metamorphosed mafic flow rocks and tuffs; includes pillow lavas, iron formation and ultrabasic units, as well as some felsic and intermediate rocks and mafic sills

TABLE 2: MINERAL DEPOSIT CLASSIFICATION, MINE CENTRE–FORT FRANCES AREA

TYPE 1 – Stratabound mineralization hosted by metavolcanics

- A: Sphalerite – chalcopyrite associated with siliceous volcanic rocks
- B: Sphalerite – chalcopyrite associated with iron formation
- C: Lean iron formation – mainly chert-magnetite and massive pyrite-pyrrhotite

TYPE 2 – Mineralization hosted by layered gabbroic intrusions

- A: Chalcopyrite associated with gabbro and leucogabbro near the base of the intrusions
- B: Disseminated chalcopyrite associated with felsic phases of intrusions
- C: Ilmenite – magnetite-apatite-rutile segregations in the upper portions of intrusions

TYPE 3 – Vein Mineralization

- A: Quartz-gold-sulphide veins in ductile shear zones
- B: Quartz-molybdenite-pyrite veins in tension fractures associated with unmetamorphosed granites

commonly interstitial to silicates, with considerable evidence of remobilization into fractures. The deposit consists of three *en echelon* lenses, each approximately 50 m long and 10 m wide. Several other occurrences of similar type are exposed along strike from the deposit for 8 km to the northeast.

Subtype 2B

A zone of disseminated pyrrhotite and chalcopyrite mineralization, hosted by a biotitic quartzo-feldspathic rock, is exposed along Highway 11 near Grassy Portage Bay. Known as the Mironski showing, this occurrence was drilled by Phelps Dodge Corporation of Canada Limited in 1966 and again by Belacoma Mines Limited in 1978. Approximately 300 000 tonnes of material grading 0.8 percent Cu is present (Harris 1974). The quartzo-feldspathic host has been previously interpreted as an inclusion of metasedimentary country rock, but an observed increase in modal quartz in the gabbroic rocks immediately below this zone suggests that this may represent a tonalitic differentiate.

Subtype 2C

Substantial accumulations of magnetite and ilmenite are present in both intrusions. They consist of lenticular bodies which occupy a similar stratigraphic position near the tops of the intrusions. Rutile and apatite were observed associated with this type of mineralization in the South Grassy Intrusion. These deposits were once considered to be Canada's largest potential source of titanium (Rose 1969).

Type 3: Vein Mineralization

All past gold production in the Mine Centre area was from quartz veins hosted by ductile shear zones. The veins are developed in most rock types, principally in tonalite, gabbro and metavolcanics. The veins and shear zones hosted by the Bad Vermilion Intrusion are particularly well exposed and possess a systematic geometric pattern which is consistent over much of the area. The gold-bearing quartz occurs in principal veins which occupy the centres of shear zones. Both the vein and shear zone possess a common northwesterly strike and dip steeply. Foliation in the shear zone is oblique to the principal vein, commonly at 45 degrees, and strikes northerly; it results from the preferred dimensional orientation of phyllosilicates and, locally, porphyroclasts of quartz. Narrow, second-order tensional veins are found normal to this foliation and are locally sigmoidal. Third-order veins which parallel the foliation are rare and tend to be less than 1 cm wide.

The principal veins range from 10 cm to 2 m in width and are composed primarily of quartz with minor carbonate and locally tourmaline. Visible gold and electrum were identified in a few veins, and sulphide minerals are present in substantial quantities. Pyrite, sphalerite, galena, chalcopyrite, arsenopyrite and argentite are common. Scheelite has been reported from gabbro-hosted quartz veins near Swell Bay (Harris 1974).

Gold content of veins is variable, but a study of available assay data suggests that grades of up to 15 ppm Au may be realistically sought over widths of approximately 1 m. This represents the approximate average grade of the two most successful past-producers, the Olive and Golden Star Mines (Beard and Garratt 1976). All gold-bearing veins appear to be restricted to rocks of greenschist facies metamorphism.

Subtype 3B

Molybdenite occurrences are largely restricted to the northwestern part of the map-area, in quartz veins related to intrusions of unmetamorphosed quartz monzonite and granodiorite. The best occurrence is located on Highway 11 at Bear Pass, where molybdenite and pyrite are abundant in tensional quartz veins in the Bear Pass Pluton (Figure 1). The veins strike northerly and westerly and, in general, are not related to shear zones. The best mineralization is located in veins near the pluton margins. A number of other quartz-pyrite-molybdenite occurrences are related to dikes and sills of granodiorite well removed from the main plutons. The majority of molybdenite occurrences are restricted to areas of amphibolite facies metamorphism.

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No. 24 Metallic Mineral Deposits of the Grenville Province, Southeastern Ontario

T.R. Carter[1]

Introduction

This year's field studies are a continuation of mineral deposit studies started in 1977 (Colvine *et al.* 1977; Carter and Colvine 1978, 1979; Carter *et al.* 1980). The purpose of the work is to establish the geological setting of metallic mineralization in the Grenville Province in southeastern Ontario (Figure 1) and hence establish metallogenetic relationships in order to help delineate areas of greatest economic interest.

During 1980 forty deposits were examined by the author. Detailed mapping of individual deposits was completed, where necessary, and approximately eighty assay samples were collected in order to provide estimates of metal contents and to substantiate previously reported assays. The deposits examined are listed and classified in Table 1 according to metal contents and lithologic associations. Short descriptions of the principal deposit types follow. Emphasis is placed on those types for which new information is available or those which have been inadequately assessed in previous work.

Description of Deposits

Stratiform Volcanic/Volcaniclastic-Hosted Pyrite Deposits

The three pyrite deposits that were examined are located a few kilometres north of Madoc. They occur as stratiform lenses within intercalated volcaniclastic metasediments and felsic to intermediate metavolcanics at the top of a thick succession of mafic volcanic rocks. Coarse felsic pyroclastic rocks are abundant near the Blakely and Canadian Sulphur Ore deposits. Mineralization consists of disseminated to massive pyrite; disseminated to massive sphalerite and arsenopyrite are locally abundant at the Blakely deposit. The geological association, form, and mineralogy of the deposits is similar to Archean volcanogenic massive sulphide deposits. Although these deposits are largely pyritic, the presence of some base-metal sulphides indicates possible economic potential.

Significant amounts of base and precious metals are associated with two similar deposits to the north (described previously by Carter *et al.* 1980). At the Simon deposit, which is located about 90 km north of Madoc, 253 000 tons averaging 1.09 percent Cu and minor Zn have been outlined by diamond-drilling to a depth of 350 feet (Carter et al. 1980). The New Calumet deposit is located on Calumet Island in the Ottawa River in Quebec. Approximately 3.5 million tons of zinc-lead-silver ore was mined from the deposit between 1943 and 1969 (Sangster 1970).

Stratabound Skarn-Hosted Magnetite Deposits

The three magnetite deposits examined are located in the southwestern part of the area. These deposits occur as lenses of disseminated to massive magnetite contained in diopside-amphibole-epidote skarns. The St. Charles and Marmoraton deposits occur within marbles immediately adjacent to the contacts of felsic intrusions. No bedrock is exposed in the vicinity of the Ledyard iron deposit; however, it occurs adjacent to the contact of a large gabbroic intrusion. The deposits are believed to be contact metasomatic in origin.

Similar deposits within marbles adjacent to intrusive contacts are common in southeastern Ontario; however, the Marmoraton deposit is the only one to achieve significant production. Approximately 500 000 tons of iron pellets were produced annually between 1955 and the mine's closure in 1979.

Significant production was also attained from the Hilton (or Bristol) Iron Deposit in southwestern Quebec. It produced approximately 800 000 tons of iron pellets annually between 1959 and 1977. At the Calabogie deposit, located 70 km south of Renfrew, approximately 27.2 million tons grading 22.28 percent Fe and mineable by open-pit methods, has been outlined (company files, Algoma Steel Corporation Limited, 1972). The origins of these two deposits are uncertain.

Intrusion-Hosted Iron – Titanium Deposits

The Orton deposit consists of lens-like bodies and discontinuous layers of disseminated ilmenite, ilmenomagnetite and magnetite contained within massive gabbro. Similar deposits are common within gabbroic and syenitic intrusions in the Grenville Province. The deposits are probably magmatic in origin.

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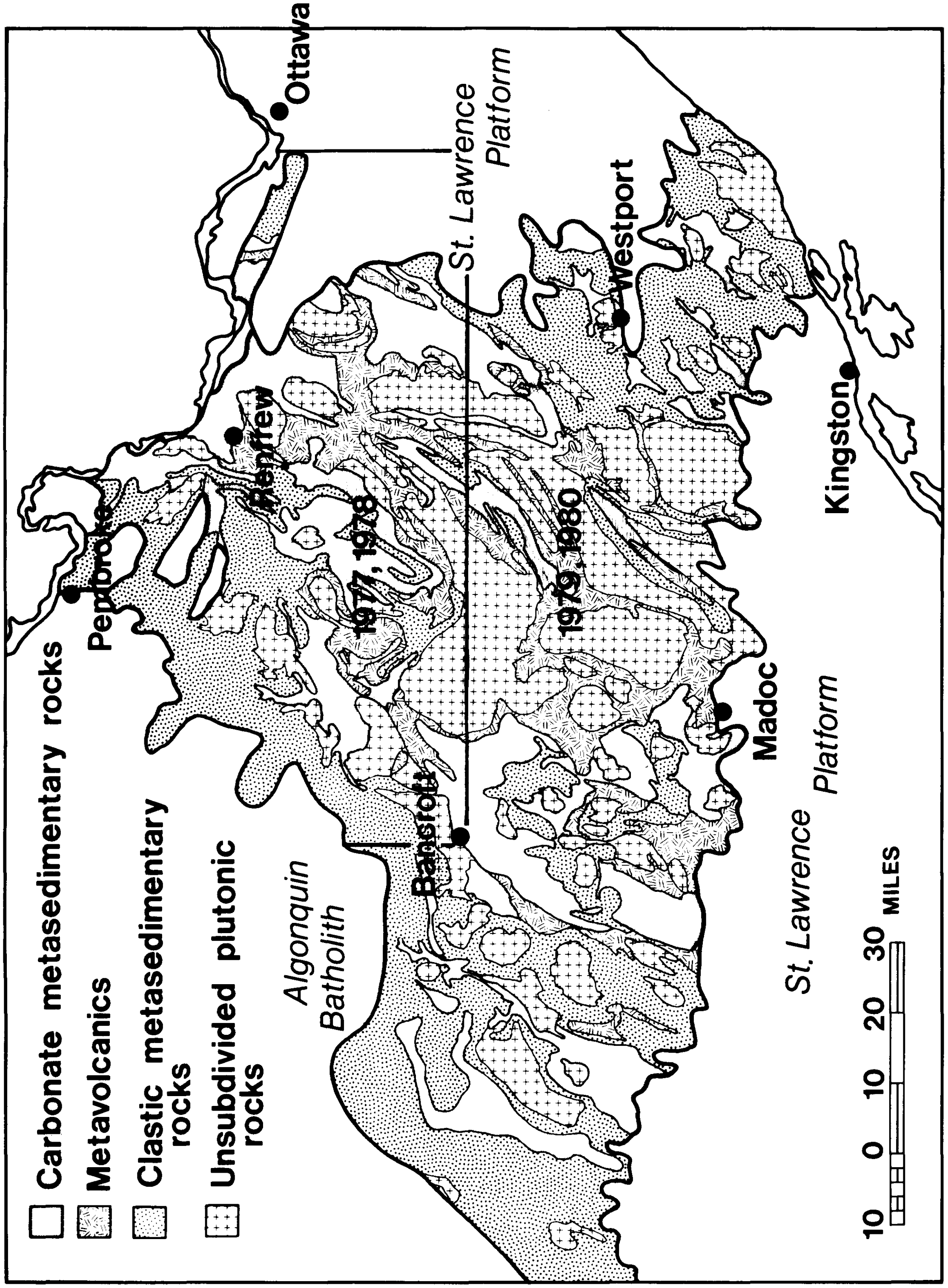

Figure 1 Location of study area. Geology from Freeman (1978).

Stratiform Marble-Hosted Zinc Deposits

The general geological relationships of zinc deposits in the Grenville Province of southeastern Ontario have been outlined previously (Carter and Colvine 1979). The present discussion is limited to the deposits visited in 1980.

The Slave Lake and Long Lake deposits consist of stratiform lenses, pods and layers of disseminated to massive sphalerite (with minor pyrite and pyrrhotite) contained in calcitic marble. Minor amounts of galena also occur at the Long Lake deposit. In both cases, the host marble is contained as xenoliths within igneous intrusions.

The Slave Lake deposit is contained within a large granitic intrusion about 40 km northwest of Kingston. Preliminary mapping of the deposit indicates more complex relationships than previously indicated (Sangster 1970). At least five layers of calcitic marble, separated by lineated to foliated granite, and one layer of pelitic metaclastic rocks containing large plagioclase porphyroblasts, are indicated by the mapping. Zinc mineralization is hosted by three of the marble layers. Additional mapping

TABLE 1 MINERAL DEPOSITS EXAMINED, 1980

IRON AND IRON-TITANIUM DEPOSITS	
Stratiform, volcanic/volcaniclastic-hosted pyrite	
Bannockburn	Madoc Tp.
Blakely	Madoc Tp.
Canadian Sulphur Ore	Madoc Tp.
Stratabound, skarn-hosted, magnetite	
Ledyard (Belmont)	Belmont Tp.
Marmoraton	Marmora Tp.
St. Charles	Tudor Tp.
Intrusion-hosted iron-titanium	
COPPER-NICKEL-LEAD-LEAD-ZINC DEPOSITS	
Stratiform, marble-hosted, zinc	
Long Lake	Olden Tp.
Slave Lake	Sheffield Tp.
Spry	Kaladar Tp.
Stratiform, clastic-hosted, copper-zinc-silver (rusty schist)	
Caverly	Marmora Tp.
Deer Lake	Belmont Tp.
Myers	Marmora Tp.
Intrusion-hosted copper-nickel	
Macassa	Limerick Tp.
GOLD DEPOSITS	
Unconformable, quartz (±ankerite) vein-hosted, gold-silver ±arsenic	
Ackerman	Marmora Tp.
Addington (Golden Fleece)	Kaladar Tp.
Bannockburn	Madoc Tp.
Big Dipper	Barrie Tp.
Boerth	Clarendon Tp.
Cook	Marmora Tp.
Cordova	Belmont Tp.
Craig	Tudor Tp.
Deloro	Marmora Tp.
Gilmour	Grimsthorpe Tp.
Gold Base	Kennebec Tp.
Gough	Barrie Tp.
Helena	Barrie Tp.
Ledyard	Belmont Tp.
O'Donnell I, II and III	Anglesea Tp.
Ore Chimney	Barrie Tp.
Sophia (Diamond)	Madoc Tp.
Sovereign	Barrie Tp.
Star	Barrie Tp.
Stratabound, quartz-dolomite vein-hosted, gold-copper-zinc-lead-antimony	
Barrie Syndicate	Barrie Tp.
Mazinaw Base Metals	Barrie Tp.
CALCITE-GALENA DEPOSITS	
Unconformable, calcite vein-hosted, lead	
Chrysler	Limerick Tp.
Hollandia	Madoc Tp.
Ramsay	Tudor Tp.

is necessary to clarify the structural and stratigraphic relationships of the marble and metaclastic horizons. The Long Lake deposit was visited only for purposes of sample collection; hence, no new information is available.

The Spry deposit is located approximately 40 km northeast of Madoc within the central portion of the Clare River synform. It is hosted by siliceous dolomitic marble within a succession of intercalated calcitic marble, dolomitic marble, siliceous dolomitic marble, and sandstone. The units strike north-northeast and dip at about 50 degrees to the east. Two mineralized zones were examined by the author. The main zone consists of stratiform layers of disseminated sphalerite with very minor pyrite within well-layered siliceous dolomitic marble. Mineralization occurs over widths of up to 5 m and has been traced along strike for at least 500 m. A representative chip sample taken by the author across 5 m of the zone contained 3.88 percent Zn,10 ppm Pb and trace amounts of Ag. A grab sample taken from the best mineralized layer contained 19.8 percent Zn, 78 ppm Pb, 186 ppm Cu, 840 ppm Cd and trace Ag.

The second mineralized zone is located approximately 700 m to the south within dolomitic marble. Mineralization consists of a narrow (3-10 cm) stratiform layer of disseminated, dark grey sulfosalt grains which are probably zinkenite. Very thin layers of disseminated sphalerite up to a few centimetres wide are also present. A grab sample of well-mineralized marble collected by the author contained 0.60 ounce of Ag per ton, 9 600 ppm Pb, 9 000 ppm Zn and 5 000 ppm Sb.

The deposits are similar to marble-hosted stratiform zinc deposits that occur elsewhere in southeastern Ontario (Carter and Colvine 1979; Carter *et al.* 1980), in southwestern Quebec (Gauthier 1978) and in the Balmat-Edwards area of New York (Lea and Dill 1968). The mineralogy and geological setting of the deposits are similar to Mississippi Valley type deposits (Brown 1976). However, the consistently stratiform nature of the mineralization, with lack of crosscutting or open-space-filling features, suggests a synsedimentary origin similar to that proposed by Lea and Dill (1968) for the Balmat-Edwards deposits. Metals may have been supplied to the carbonate depositional environment as a result of distal volcanic exhalative activity or local diagenetic processes.

Stratiform Clastic – Hosted, Copper – Zinc – Silver (Rusty Schist) Deposits

Concordant zones of rusty-weathering schist are common within supracrustal rocks throughout most of the Grenville Supergroup. The schists generally consist of beds of fine-grained siliceous metaclastic rocks that contain abundant disseminated pyrite and pyrrhotite, locally abundant graphite and rare sphalerite and chalcopyrite. Total sulphide content generally ranges from about 5 to 20 percent.

The Caverly, Deer Lake and Myers deposits are located adjacent to each other near the boundary between Marmora and Belmont Townships, about 20 km northwest of Madoc. The deposits all occur at approximately the same stratigraphic level within an extensive sequence of thinly bedded argillite, siltstones, and sandstones at the top of a thick succession of mafic metavolcanics. There are minor interbeds of marble within the sequence. Mineralization at the deposits consists of disseminated pyrite, pyrrhotite and minor sphalerite and chalcopyrite.

Significant amounts of copper-zinc-silver mineralization have been outlined at the Deer Lake and Caverly deposits. The mineralized zone at the Deer Lake deposit is located near the nose of a syncline within vertical to steeply dipping metasediments. The zone is approximately 600 m long and up to 200 m wide. According to records obtained from C. R. Young of Havelock, a total of eight diamond-drill holes ranging from less than 100 to 865 feet in length have been completed on the deposit. Mineralization was encountered over the entire length of all eight drill holes, with values ranging from 0.01 to 0.1 percent Cu, 0.04 to 1.13 percent Zn and trace to 0.5 ounce of Ag per ton. The average metal content is approximately 0.05 percent Cu, 0.5 percent Zn and 0.2 ounce of Ag per ton. In addition, a random representative grab sample of rusty schist collected by the author from a surface outcrop at the southern edge of the deposit contained 0.02 ounce of Au per ton, 2.47 ounces of Ag per ton, 0.67 percent Cu and 0.14 percent Zn.

The mineralized zone at the Caverly deposit is at least 200 to 300 m in length and about 100 m wide. It strikes east and dips vertically. Four diamond-drill holes totalling 1273 feet have been completed, one by C.R. Young and three by Coniagas Mines Limited. Mineralization, which was encountered over the entire length of all four drill holes, yielded values of: 0.01 to 0.16 percent Cu, 0.10 to 1.69 percent Zn, trace to 0.33 ounce of Ag per ton. Average metal contents are similar to those for the Deer Lake deposit.

The Myers deposit forms a horseshoe-shaped layer about 350 m long and 30 to 50 m wide. Assay results on samples collected by the author are not yet available.

The deposits contain significant amounts of copper, zinc and silver but are probably uneconomic at present price levels due to their low grades. However, to date, insufficient work has been completed to properly evaluate the Myers and Caverly deposits, and none of the deposits have been properly sampled to determine their gold content. Additional exploration might also reveal high-grade zones in the deposits, as suggested by the assay results obtained by the author from the Deer Lake Deposit. However, the most significant aspect of this part of the project is that the existence of these deposits establishes the potential for large-tonnage, low-grade, open-pit-mineable copper-zinc-silver ± gold deposits in the Grenville Province. They also form important local stratigraphic marker horizons due to their characteristic appearance and continuity along strike.

Intrusion-Hosted Copper – Nickel Deposits

The Macassa copper-nickel deposit is located just west of Highway 62, about 20 km south of Bancroft. Mineralization at the deposit consists of disseminated to massive pyrrhotite, pentlandite, pyrite and chalcopyrite. The sulphides form concordant layers or lenses that are confined to an irregular lensoid mass of pyroxenite within a gabbroic intrusion. The mineralized zones are irregularly distributed within the pyroxenite and commonly pinch and swell both along strike and down dip. Branching is not uncommon (Lumbers 1969). Approximately 1.8 million tons grading 0.91 percent Ni, 0.26 percent Cu and 0.06 percent Co have been outlined to a depth of 1200 feet as a result of a diamond-drilling program completed by Macassa Gold Mines Limited (Northern Miner, May 27 1971).

Similar deposits are contained in gabbroic intrusions elsewhere in the Grenville Province in southeastern Ontario. They are believed to be magmatic in origin.

Unconformable Quartz (±Ankerite) Vein-Hosted Gold – Silver ±Arsenic Deposits

Twenty-one gold deposits were examined by the author in 1980. Numerous other deposits also occur in the area, generally confined to an area of greenschist facies metamorphoic rocks centered on Madoc and Marmora Townships, north of Madoc. Outside this area, the prevalent metamorphic grade is amphibolite facies and attains granulite facies in places.

The deposits have variable characteristics, but in all cases mineralization is contained within quartz or quartz-ankerite veins. The veins occupy shear zones in gabbroic (Cordova, Ledyard) and granitic intrusions (Ackerman, Bannockburn, Big Dipper, Cook, Deloro, Sovereign) and in mafic volcanic rocks (Craig, Gilmour, Gold Base, O'-Donnell I, II and III, Sophia), and crosscutting fractures in marble and metaclastic rocks (Boerth, Gough, Star, Helena). They can also form discordant to concordant lenses along the basal unconformity of the Flinton Group (Addington, Ore Chimney). Mineralization at the deposits is erratic and varied in nature. Pyrite and arsenopyrite are most common and widespread, with galena, sphalerite, chalcopyrite, pyrrhotite, jamesonite, boulangerite, tetrahedrite, tourmaline and actinolite also being common at some deposits. Generally, base-metal sulphides are most commonly associated with deposits hosted by mafic volcanic rocks, whereas sulfosalts are most abundant in marble-hosted deposits. Rare native gold is reported from some deposits, but none was observed by the author.

The epigenetic nature of the deposits is demonstrated by their crosscutting relationships, the structural and metamorphic control on localization, and their occurrence within different lithologies. Derivation of the mineralizing fluid by dehydration during regional metamorphism would account for the metamorphic control. However, geological relationships at some of the deposits, notably the Helena and Sovereign deposits, indicate that gold deposition may also be related to intrusive activity.

Production statistics for gold deposits in southeastern Ontario are summarized in Table 2.

TABLE 2 PRODUCTION STATISTICS OF GOLD MINES IN SOUTHEASTERN ONTARIO[1]

Mine	Year	Tonnage Milled	Au (ounces)	Ag (ounces)	Recovered Grade (ounce of Au per ton)
Big Dipper	1907, 1909	52	17	-	0.33
Cook	1901, 1902, 1904	1,483	389	-	0.26
Cordova	1892-93, 1898-1903, 1912-1915, 1917 1939-40	22,774	687		0.19
Craig	1905, 1906	1,850	248	-	0.13
Dean and Williams	1870	1,000	500	-	0.5
Deloro	1897-1902	39,143	10,360	-	0.26
Gatling Five Acre	1900, 1902-03	6,114	2,353	-	0.38
Gilmour	1909-1910	550	172	-	0.31
Golden Fleece (Addington)	1919, 1922	-	65	26	-
Ledyard	1893-34	55	13	-	0.24
Pearce	1893, 1908	238	302	60	1.26
Sophia	1940-1941	1,800	110	7	0.06
Sovereign	1891-92, 1900	1,962	370	-	0.19
Star	1905, 1907	976	134	-	0.14

[1]Data summarized from Gordon, J.B. Lovell, H.L., de Gris, Jan. and Davie, R.F., 1979, Gold Deposits of Ontario, Part 2; Ontario Geological Survey, Mineral Deposits Circular 18, 253 p.

Remaining reserves at the Cordova deposit are reported to average 0.12 ounce of Au per ton, with 46 000 tons proven, 50 000 tons probable and 100 000 tons possible ore outlined (company files, Cominco Limited). In addition, there is an estimated 10 000 to 15 000 tons of broken ore contained in a large pile on the surface, and a similar quantity of tailings from the old milling operations. A representative chip sample of broken ore collected from the dump by the author contained 0.25 ounce of Au per ton. Assays of the tailings graded 0.11 to 0.69 ounce of Au per ton and trace to 0.14 ounce of Ag per ton. The deposit is presently being developed by a small company called Laser.

Reserves remaining at the Addington (Golden Fleece) deposit amount to approximately 250 000 tons averaging about 0.l ounce of Au per ton. The deposit is currently being evaluated by E & B Explorations Limited of Vancouver who have optioned the property from Cominco.

No reserve figures are available for the other gold deposits in southeastern Ontario. However, from some of these deposits, gold assays of up to 1.96 ounces per ton have been obtained from samples taken by the author from surface exposures and dumps. A complete list of currently available assay results and their locations can be obtained from the author on request.

Re-evaluation of known gold deposits in southeastern Ontario appears to be warranted at current high price levels. Exploration for additional mineralization is also warranted and should be directed to areas of greenschist facies metamorphic rocks.

Stratabound Quartz-Dolomite Vein-Hosted, Gold – Copper – Zinc – Lead – Antimony Deposits

These deposits occur within rocks of the Flinton Group about 55 km northeast of Madoc. Their geological relationships have been outlined previously (Carter and Colvine 1979).

Unconformable Calcite Vein-Hosted Lead Deposits

The three lead deposits examined are located in the southwestern part of the area. They are hosted by calcite veins occupying late fractures cutting carbonate and metaclastic rocks of the Grenville Supergroup. Mineralization consists of lenses, layers and scattered grains of coarse-grained galena. Their metallogenetic and regional geological relationships have been described previously (Carter and Colvine 1979).

Recommendations for Exploration

General exploration guidelines for metallic mineral deposits in the Grenville Province of southeastern Ontario are outlined in Carter and Colvine (1979). The 1980 field work has indicated the potential for large, low-grade, open-pit-mineable copper-zinc-silver (±gold) deposits in the Grenville Supergroup. Any rusty-weathering pyritic schists are potential hosts, particularly when they overlie thick successions of volcanic rocks. Electromagnetic, magnetic and soil geochemical methods are effective exploration techniques. The field work has also indicated the potential for small, high-grade copper-nickel deposits within gabbroic intrusions in the area. Magnetic and electromagnetic methods may be useful.

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No. 25 Uranium Mineralization and its Controls in the Bancroft Area, Southern Ontario

S.L. Masson[1] and J.B. Gordon[2]

Introduction

Detailed mapping of parts of Dungannon, Faraday and Monteagle townships, initiated in August 1978, was completed during May and June 1980. The new map sheet covers an area of 168 km^2. Emphasis in this study was placed on the roles of stratigraphy and structure as controls on uranium mineralization. In 1980, areas of uranium mineralization, especially those involving calc-silicate deposits, were studied in further detail.

General Discussion

Although there is a relationship between major stratigraphic units and the presence or absence of uranium mineralization (Masson and Gordon 1980), the effects of numerous intrusions and the complexity of structural deformation in the region have made recognition of detailed stratigraphic control difficult. However, detailed mapping has shown that certain lithologies exercise control on uranium deposition indirectly through their influence on structure. Also, graphitic and pyritic metasedimentary lithologies cause reducing environments favourable to the precipitation of uranium. Alkalic rocks also exercise geochemical control on the mobilization of uranium. The alkalic granites and syenites of the syenite belt are rich in F, P and CO_2, all capable of mobilizing uranium. Anatectic melting of siliceous sediments and granitic rocks during high rank regional metamorphism produced the pegmatitic melts and much of the metasomatic fluids. Uranium, F, P and CO_2 were derived from the alkalic rocks. Uranium, CO_2, and important amounts of H_2O were derived from metamorphic dehydration of the metasedimentary sequence. Uranium, therefore, was probably derived from these two sources, whereas the source of the fluorine was the fluorine-rich alkalic rocks.

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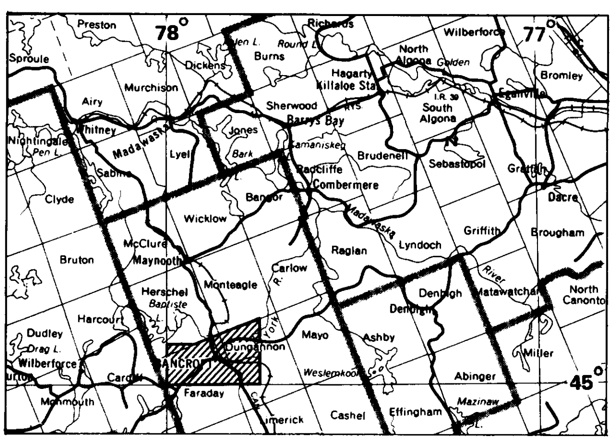

LOCATION MAP

Scale: 1: 1 584 000 or 1 inch to 25 miles

Metallogenic Controls in Pegmatite Deposits

In addition to a favourable geochemical environment, favourable structures were necessary to localize and channel uraniferous solutions. Regional structures on the flanks of the larger granitic bodies (e.g. the Faraday Granite) include intense gneissic layering, a well-developed foliation, and the development of penetrative fracturing subparallel to or along the foliation planes, as well as shear and thrust faulting, flowage and recumbent isoclinal folding. Individually or more commonly in combination, these structures controlled pegmatite emplacement, as well as channelling of mineralizing and metasomatic fluids. The intersection of planar features such as bedding, gneissic layering, foliation planes, joints and shear zones formed well-developed, commonly steeping dipping linear structures. Late movement along one or more of these planes, after pegmatite emplacement, caused the development of irregular pipe-like deformation in the pegmatites. Differences in competency between pegmatite and wall rock resulted in the localization of deformation in the contact area of the pegmatite bodies. Uranium was deposited from late stage metasomatic-hydrothermal mineralizing fluids introduced into the cataclastic irregular pipe-like structures in the pegmatite. The development of these irregular, branching, pipe-like structures explains the continuity of ore with depth in contrast to the characteristic irregular lateral discontinuity of the mineralized zones. Structure is therefore one of the main controls in the concentration of uranium in pegmatites.

Wall rock lithology is also an important control on mineralization. At pegmatite contacts, oxidizing hydrothermal solutions alter iron-rich minerals of mafic country rocks to magnetite and hematite. Formation of iron oxides, especially hematite, reduces the hydrothermal solutions and uranium is precipitated. This would explain the brick-red colour characteristic of mineralized pegmatite and adjacent wall rocks.

Metallogenetic Controls in Calc-silicate Deposits

Masson and Gordon (1979) tentatively suggested that in contrast to the mineralized pegmatites, some marble and calc-silicate hosted 'skarn-type' uranium occurrences do not appear to be structurally controlled. Field work in 1980, particularly on the South State deposit, indicates that this preliminary conclusion is incorrect.

Genetic Modelling and the South State Occurrence

The South State (North) deposit (Masson and Gordon 1980) located southwest of the village of Musclow in Monteagle Township is a structurally controlled skarn (Masson, in preparation) situated along a northeast-trending fault (Figure 1).

The stratabound uranium mineralization is in a silicated marble unit, which is separated from the underlying granitic gneiss (meta-arkose) by a proposed paleofault zone, the evidence for which is obscured by alteration and recrystallization. The two main lithologies show evidence of increasing strain towards the fault zone. However, in the immediate area of the fault plane, the rocks have undergone subsequent recrystallization and are unstrained. As the original fault trace is approached, the granitic gneiss shows increased flattening of quartz, development of local layers of augen gneiss, and an increase in the number of biotitic shear planes. The highly strained gneiss grades into well-foliated biotite hornblende syenite, which passes into less-strained pyroxene syenite near the fault contact (Figure 1). Near the fault zone, small pegmatite sills (less than 20 cm wide) in the granitic gneiss have been subjected to cataclasis and are radioactive.

On the other side of the fault, the main marble unit, a calcite-pyrite-phlogopite rock, becomes graphitic and more pyritic towards the fault zone. It is postulated that the graphite was derived from the carbonate under increased shear stress conditions; the pyrite was remobilized in the marble and concentrated towards the fault zone. The marble adjacent to the fault was enriched in silicates, principally green diopside, as well as an orange-pink calcite. Approaching the contact with the pyroxene syenite, the mineralized silicated marble grades into biotite-pyroxene metasomatite. The metasomatic silicated marble and pyroxene metasomatite are unstrained, and the pyroxene syenite is only slightly foliated. A few peg-

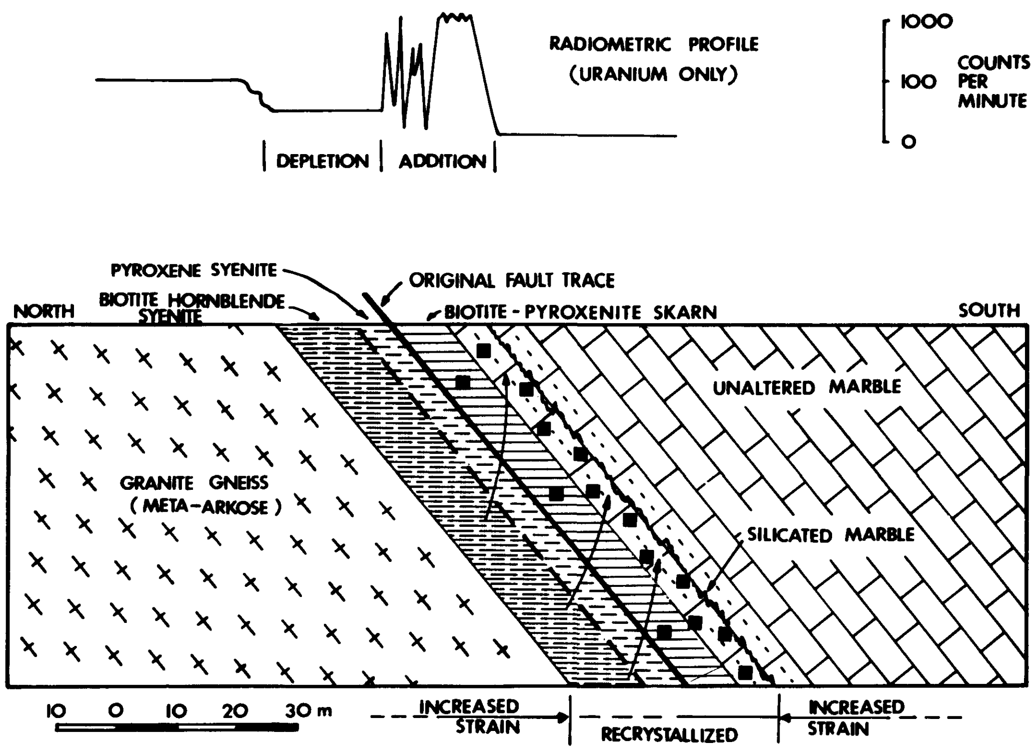

Figure 1 — Composite section of the South State deposit.

matites (up to 2 m wide) which intrude the marble are unmineralized and show no spatial relationship to the mineralization. One pegmatite which cuts both the silicated marble and the metapyroxenite terminates abruptly at the syenite contact (original fault trace). Where this pegmatite cuts the pyroxene metasomatite it has been extensively syenitized by replacement of quartz with pyroxene.

The South State uranium occurrence has many similarities to pyroxene-carbonate veins which cut granitic rocks in the Bancroft area. Essentially, both show a metasomatic zonal transition from granite, through syenite and pyroxenite, to carbonate. Granitic rocks intruded by veins show extensive wall-rock metasomatism (Figure 2). Quartz and plagioclase in the granitic wall rock are replaced by sodic pyroxene (aegerine augite), making the wall rock adjacent to the vein a pyroxene syenite. The alteration (syenitization) is commonly 4 to 6 times as wide as the vein. Similar reaction zoning exists on a much larger scale in the South State deposit (see Figure 1). Although genetically distinct, the zoning in both cases appears to involve a reaction between siliceous and carbonate components under hydrous conditions. Unlike the veins, in which CO_2-rich hydrous fluids were channelled up fractures in granitic rocks, metasomatic fluids at the South State deposit were channelled up the sheared contact between granitic rocks and marble. Intermixing of the different lithologic components under hydrous metamorphic conditions caused desilication of the granite gneiss to produce pyroxene syenite and silication of the marble to produce pyroxene skarn and silicated marble.

The degree of uranium enrichment in many of the pyroxene-carbonate veins in the Bancroft area commonly has a direct relationship with the uranium content of the wall rocks they intrude (Masson and Gordon 1980), i.e. veins in granitic rocks have the highest uranium concentrations.

Hence, it appears that uranium in these veins was mobilized from granitic rocks during syenitization of the wall rock and deposited as uranothorite and, to a lesser extent, as uraninite within clusters of biotite in the pyroxene-rich zone of the vein. A variation of this process appears to have operated in the formation of the South State occurrence. Uranium and thorium remobilized from desilicated granitic rock (syenite) were deposited in marble. On the opposite side of the fault zone, uranium and thorium were deposited in the reducing environment of the graphitic-pyritic silicated marble, and partially in the biotite-rich portions of the pyroxene skarn. A radiometric traverse across the property (Figure 1) shows a depletion of radioactivity in the syenite relative to the granitic gneiss, whereas the pyroxene skarn and especially the silicated marble are enriched relative to unaltered marble. The presence of pink (fine hematite) calcite and magnetite rimmed pyrite in the mineralized silicated marble suggests an interplay of oxidizing and reducing conditions which favoured uranium deposition. The high thorium content of the uraninite rules out the possibility that mineralization in the marble was either syngenetic or early epigenetic.

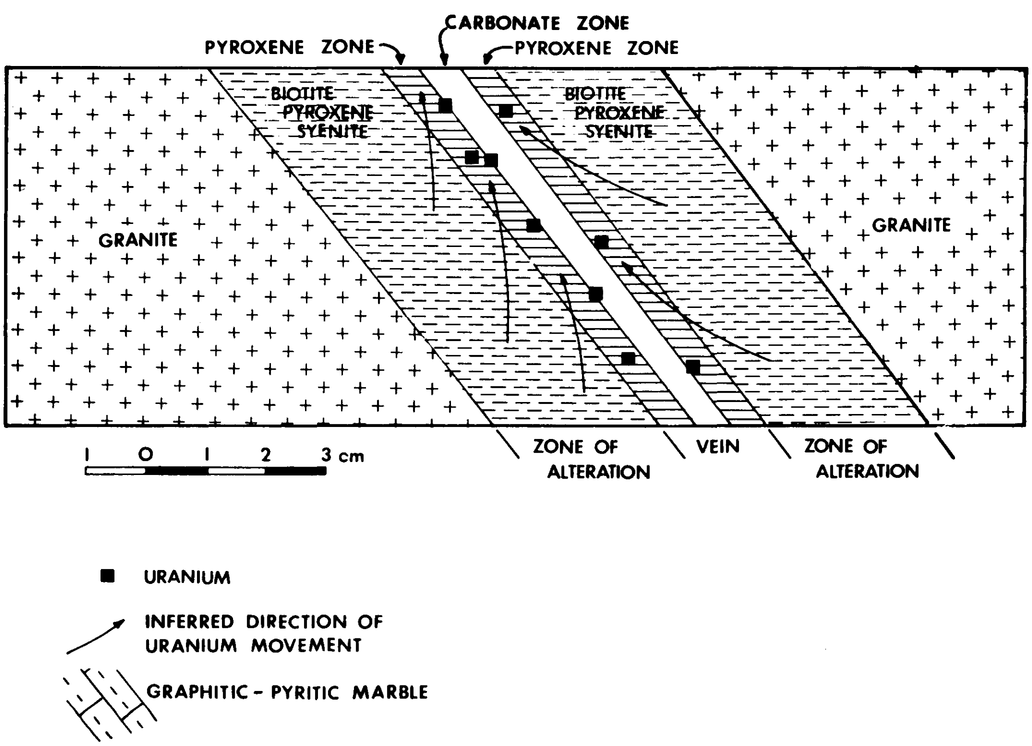

Figure 2 — Typical section of a calcite-pyroxene vein.

Summary and Conclusions

A late mineralizing metasomatic hypothesis, as suggested above, has important implications for the genesis and timing of uranium mineralization. There are several important metallogenetic controlls on uranium mineralization in the Bancroft area:

1) Structure is the main localizing control.

2) Elements released during wall rock reactions play an important role in the formation of these deposits. Structures which incorporate fluorine-rich country rock may contribute both mobilizers (e.g. fluorine) and uranium to the hydrothermal system through metasomatism under conditions of high-rank metamorphism. The fact that the majority of the uranium occurrences in the Bancroft area are spatially associated with the alkalic fluorine-rich rocks of the syenite belt supports this hypothesis.

3) The formation of mineralized skarns ('metapyroxenite' and silicated marble) post-date pegmatite intrusions. Similarly, in pegmatite deposits, uranium occurs in fine-grained cataclastic or recrystallized zones in otherwise undeformed medium- to coarse-grained, poorly mineralized pegmatites.

These observations suggest that the mineralizing event took place in the latest stages of pegmatite formation when anatectic melting had ceased and only late-stage hydrothermal metasomatism was active. Late hydrothermal activity is indicated by the prevalence of pyroxene veins cutting pegmatites but rarely the converse. Furthermore, Withers (1976), in his study of the Eagles Nest property, shows that these veins follow certain fracture sets which exercise no control in the emplacement of pegmatites, suggesting that perhaps there was an intervening structural event of short duration.

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No. S21 Industrial Minerals of the Alkalic Complexes

M.A. Vos[1]

THIS PROJECT IS FUNDED BY THE ONTARIO MINISTRY OF NORTHERN AFFAIRS THROUGH THE NORTHERN INDUSTRIAL MINERAL STUDIES (NIMS) PROGRAM.

Introduction

The location and mineral content of many alkalic complexes, with or without a carbonatite core, in Ontario are shown on Ontario Department of Mines, Preliminary Map P.452 by Satterly (1968)(see Figure 1).

The complexes represent potential sources of nepheline syenite, apatite, vermiculite, niobium and rare earths, as well as uranium, thorium, copper, nickel and iron. Some complexes have provided excellent building stone; dark, coarse-grained syenites of the Coldwell Complex have been extensively quarried near Marathon. Claims have been staked on many of the mineral deposits associated with alkalic complexes, and extensive drilling of some deposits has been undertaken (e.g. the phosphate deposits in Cargill Township, southwest of Kapuskasing).

A study of industrial minerals in alkalic complexes has been undertaken as part of the Northern Industrial Mineral Studies (NIMS) program. A better understanding of the geological processes leading to the lithologies and mineral deposits in these complexes will benefit the evaluation of potential for industrial minerals.

Previous Work

A survey of the alkaline rocks of Canada was completed by Currie (1976). Information on carbonatite-alkalic complexes of Ontario has been compiled by Satterly (1968). Recent studies by Sage (1974, 1975, 1976, 1977, 1979) have added considerably to the available literature on the subject. The complexes are interpreted as being eroded volcanic edifices associated with structural zones in the continental crust of the earth. The volcanic activity resulted in alteration of rocks adjacent to the volcanic centre and introduction of new rock types and mineralization near the core.

Object of Study

This study of alkalic complexes is aimed at improving the evaluation of industrial mineral potential through better understanding of the geology. The required detailed analyses of rock samples available in outcrop or stream valley deposits will add to the existing data base.

Methodology

The study of industrial minerals of the alkalic complexes is a three-year project. This summer's field work was spent assessing the type and quality of information to be gained from sampling bedrock outcrop and stream valley deposits in accessible complexes. The structures examined include Seabrook Lake, Firesand River, Coldwell, Lackner Lake, Cargill Township, Clay-Howells Townships and Callander Bay (Figure 1).

At Seabrook Lake it was found that the area of iron-rich rocks previously postulated from sparse outcrop in the core of the body could be considerably extended. New outlines will be presented on maps in preparation by R.P. Sage (Geologist, Precambrian Section, Ontario Geological Survey, Toronto). Flow structures in carbonaceous breccia matrix and an elliptical-shaped inclusion resembling a football-sized volcanic bomb were noted. These features will be investigated further.

The Firesand River Complex, which is deeply buried and heavily overgrown, has been well explored, initially for iron and later for niobium. The most recent attempt by Algoma Steel Corporation Limited, in 1970, was aimed at outlining calcium carbonate resources, for use in the company's sinter plant at Wawa (Sage 1977). International Minerals and Chemical Corporation, in an effort to duplicate the finding of residual apatite concentrates in Cargill Township, drilled three holes in areas of deeply buried bedrock in 1976 (Erdosh 1976). The drilling intersected thick deposits, up to 38.5 m, of calcareous sand and mud without apatite. Although it is suggested that separation of calcite and apatite has taken place, allowing for apatite concentration to occur elsewhere in the overlying deposits, the total amounts are estimated to be insufficient to warrant further drilling (Erdosh 1976).

Coldwell Complex syenites, from west of Redsucker Cove, have been tested for their potential as a source of ceramic raw material. In 1960, Denison Mines Limited found that, after routine magnetic separation, the iron content of the leucocratic fraction could still not be reduced consistently to below 0.08 percent; therefore, they

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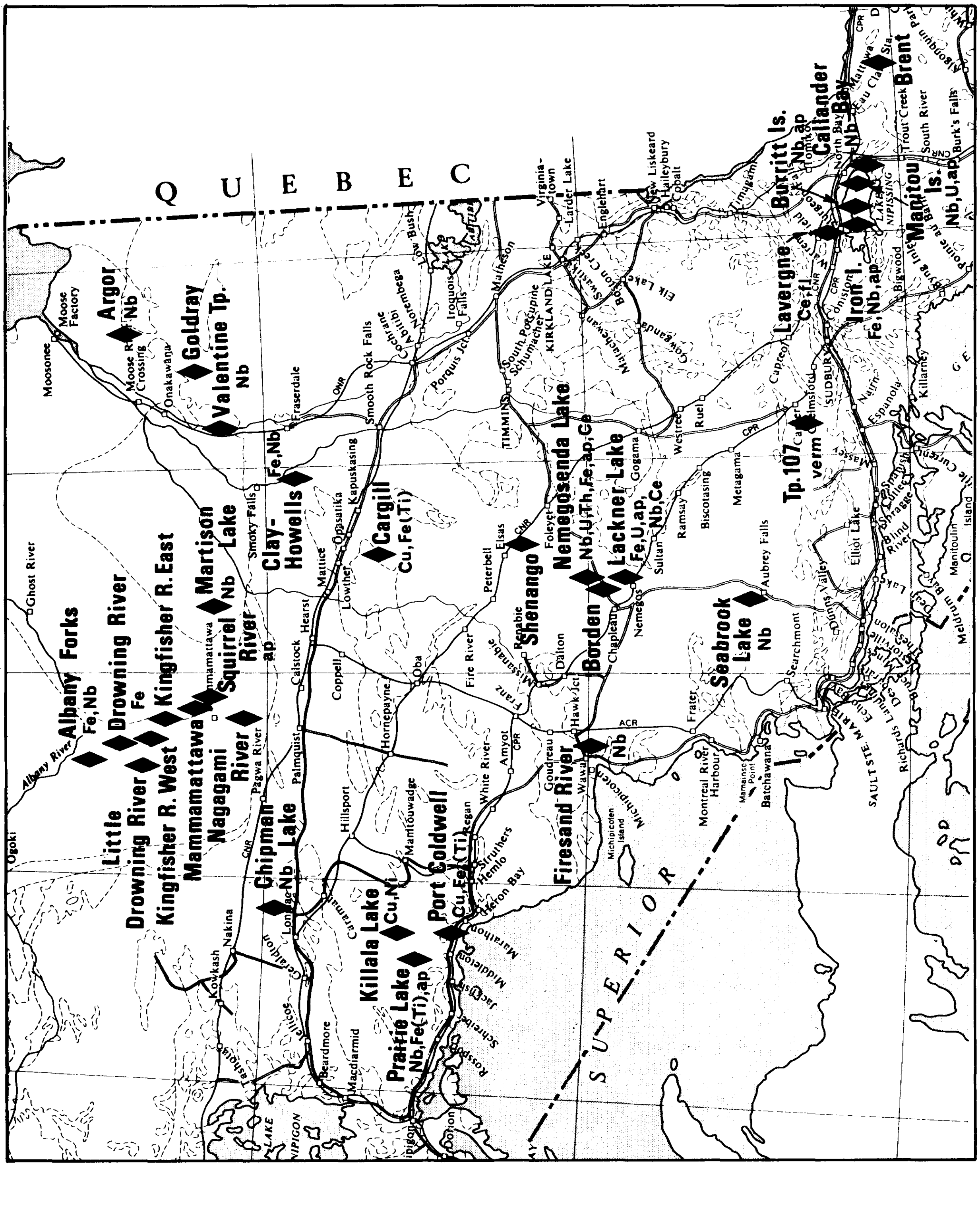

Figure 1 — Some carbonatite-alkalic complexes in Ontario.

discontinued development of these nepheline syenite occurrences (Puskas 1967). Alternative locations of higher quality syenite may be revealed by stream-bed sampling. Some samples have been collected for further tests.

The Lackner Lake Complex has been extensively drill-sampled and analysed, yet a lack of data still exists for an area of carbonatite, located by Parsons (1961) in the northeastern part of the complex on the strength of surface boulders.

The Cargill Township residual phosphate deposit is presently the most promising of the alkaline complex-derived deposits in terms of mine development. It is being investigated by Sherritt-Gordon Mines Limited under a three-year option agreement (Northern Miner, April 19 1979). Some samples of the 1975 drill program were made available to the author for additional testing. If developed, an effort should be made to utilize the overlying quartz sands and kaolin clays reported by Sandvik and Erdosh (1977). A deeply weathered outcrop of vermiculite is being excavated for use in road surface improvement.

The Clay-Howells Township Complex is large and only partly exposed. Drilling was restricted to the outlining of a magnetite deposit. Knowledge of the structure is very limited at the present time. This survey has not included some of the known but less accessible deposits. Exploratory drilling of magnetically anomalous areas of unknown origin may be required, provided that the anomaly occurs in the proper geological environment and has the characteristic magnetic signature.

A study of the Callander Bay Complex is included in an attempt to refine some of the results reported by Currie (1976). He showed that, based on a stable oxygen content, primarily Si, Na and Fe were subject to transportation in the zone of altered rocks surrounding the volcanic centre (fenitized zone). However, the distributions of Si and Fe in alkalic complexes are not always consistent with the concept of metasomatism issuing from the volcanic centre outward. Currie shows depletion of Fe in the outer fenitized zone compared to background Fe in the surrounding country rocks. Concentrations of Fe towards the centre are common in many complexes. The depletion of Si from the fenitized zone, if balanced at all, is frequently balanced by excessive Si occurring with carbonates in the centre of the carbonatite complexes (Heinrich 1966). At Callander Bay, samples were taken in two sections of the fenitized zone radiating outwards from the centre. Systematic analysis may indicate the direction in which transport of elements took place. If it is found that transport was directed towards the centre rather than outward, the possibility must be entertained that some transport was effected by circulating groundwater activated by excessive heat in the volcanic centre, as discussed by Andrews and Fyfe (1976). Such a concept has important implications for mineral potential of the complexes. If the surrounding country rocks are the primary source of some of the mineralization, then an estimate of maximum concentration can be derived from a knowledge of the geochemistry of these surrounding rocks and the volume affected by alteration. However, if all metasomatism and introduction of new rock types and mineralization progressed outward from a deep magmatic source, as is now believed by a majority of researchers, and would be indicated by isotope geology, then the expected mineral potential would be less predictable. Further study will be necessary to throw more light on these alternative interpretations.

Conclusions

The geology and mineralizing processes in carbonatite-alkalic complexes of Ontario are not well understood. Although all exposed complexes have been mapped by R.P. Sage (Geologist, Precambrian Section, Ontario Geological Survey, Toronto) or S.B. Lumbers (Geologist, Royal Ontario Museum, Toronto), detailed petrologic study or exploratory drilling is necessary to add to the existing data.

The only potential commercial apatite deposit is a residual deposit at Cargill. Elsewhere, apatite is considered as a potential by-product of carbonatite extraction. Rare earth elements are concentrated in apatite, making rare earth potential and apatite extraction inseparable (R.P. Sage, personal communication).

Further analysis is required of the following commodities:

1) vermiculite, quartz sand and kaolin in Cargill Township;
2) building stone and potential ceramic raw material at the Coldwell Complex; and
3) potential sources of lime at the Prairie Lake Complex.

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No. S22 Nepheline Syenite and Feldspar in Northern Ontario

M.A. Vos[1]

THIS PROJECT WAS FUNDED BY THE ONTARIO MINISTRY OF NORTHERN AFFAIRS UNDER THE NORTHERN INDUSTRIAL MINERAL STUDIES (NIMS) PROGRAM.

Introduction

The nepheline syenite deposit in Bigwood Township, 55 km southeast of Sudbury, has been re-examined as part of a review of nepheline syenite and feldspar deposits in Northern Ontario to assess possible resources of ceramic raw material. The project is part of the Northern Industrial Mineral Studies (NIMS) program.

The geology of Bigwood Township is shown in Figure 1. The nepheline syenite is located north of the French River and west of Highway 69 which, in the northern part of the township, runs parallel to and within 200 m of the axis of the Rutter Syncline.

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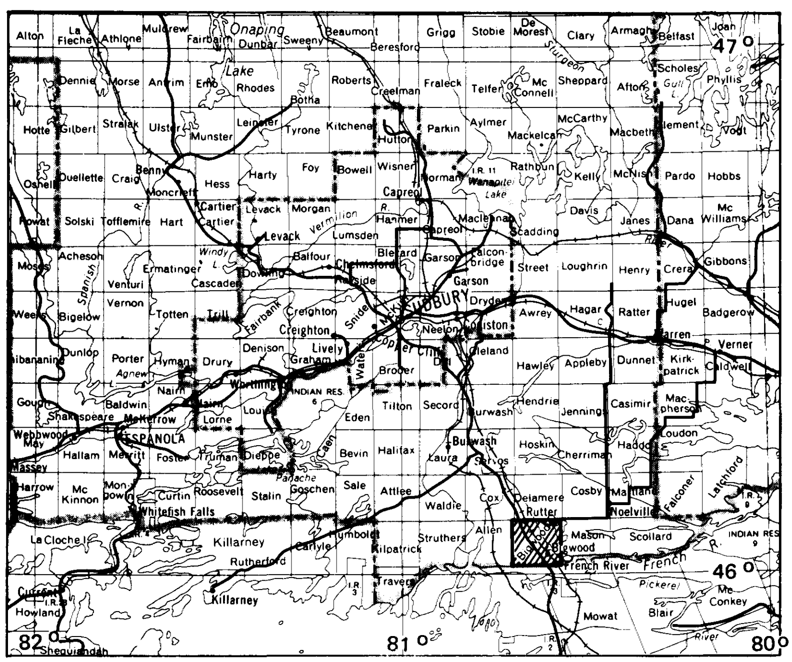
Previous Work

Nepheline syenite in Bigwood Township was first discovered by T.T. Quirke (1924, 1926) of the Geological Survey of Canada when he mapped the area in 1924 and 1925. The minerals in this deposit were the subject of a study by T.L. Walker and A.L. Parsons (1926). Hewitt (1960) re-examined the geologic formations and published several chemical and mineralogical analyses of the different rock types. He felt that the syenite intruded the sedimentary formations after folding had taken place, but was subsequently subjected to the potash metasomatism that was responsible for granitization of the country rock. Hewitt (1960, p.186) considers the generally low nepheline content of rocks in the syenite body, together with the high iron content of the pink nepheline, to be sufficiently detrimental as to place in doubt the economic viability of these deposits, when compared with the Blue Mountain deposits near Peterborough.



LOCATION MAP

Scale: 1:1,584,000 or 1 inch to 25 miles

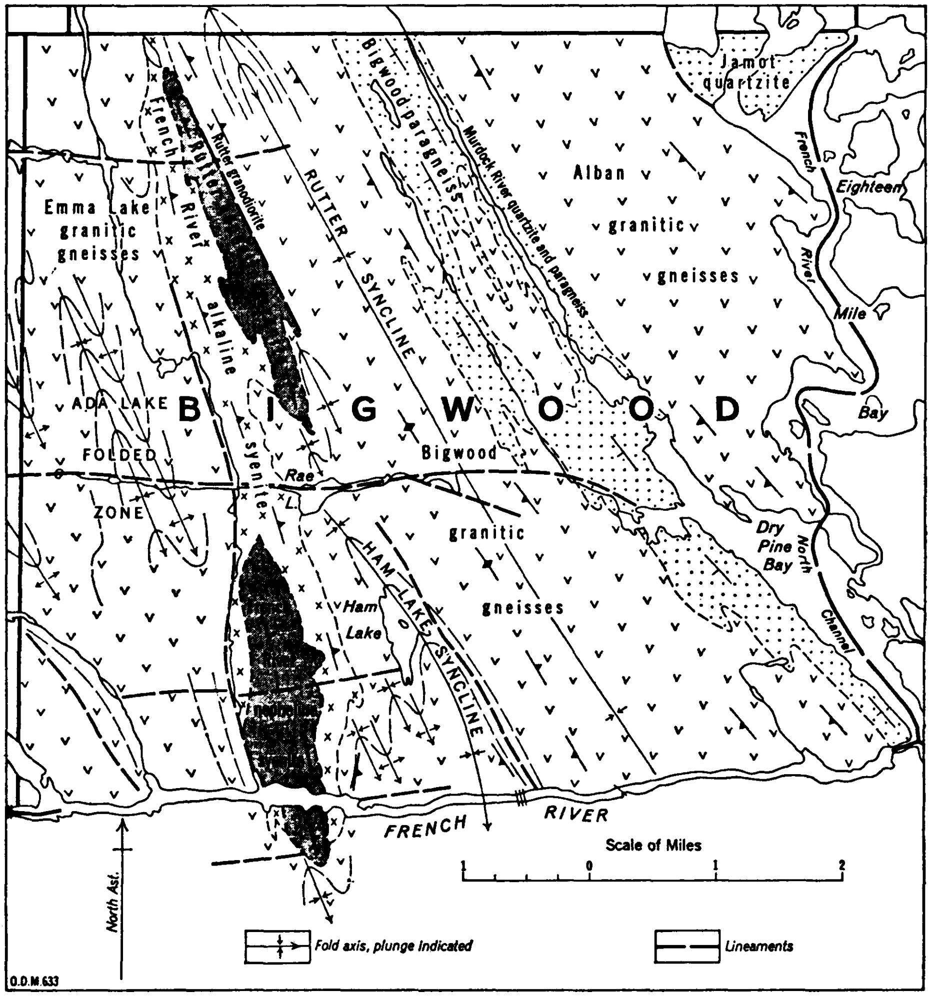


Figure 1 — Geological sketch map of Bigwood Township showing main structural features. (After Hewitt 1960).

Purpose of the Study

Re-examination of the deposit was undertaken to acquire more information on the genesis of nepheline syenite. It is hoped that the investigation will throw light on the character of the original rock. Understanding of the source rock and the process of alteration are required in order to make predictions concerning potential quality and quantity of material in unexposed parts of the syenite body.

Methodology

Systematic sampling of syenite and adjacent rocks across the strike of formations was carried out where outcrops permitted. Special attention was paid to structural features and foliation. It was noted that several of the faults delineating the syenite body on Ontario Department of Mines Map 1960f (Hewitt 1960) were absent in the field, or coincided with a topographic feature near the syenite contact rather than the contact itself. Nevertheless, close scrutiny of contact relationships in the field failed to produce evidence of the intrusive nature of the syenite body.

The foliation changes dramatically in orientation at the contact between the syenite and the adjacent gneiss. This change is particularly abrupt on the east side of the syenite body which, in the stratigraphic sequence, represents the top of formations in the synclinal structure. The foliation in gneisses overlying the syenite is parallel to the original bedding of the sediments and dips uniformly eastward at an angle of 50 to 70 degrees. In the syenite there is an abrupt change to near-horizontal foliation or to massive rock. Whether this difference signifies a change in character of the original rocks in the stratigraphic sequence or, as is argued by Hewitt (1960), a post-tectonic intrusion of massive syenite into the folded complex of sediments is difficult to establish. If a thorough process of potash metasomatism and granitization has affected all rocks in this part of the synclinal structure, including the syenite as is supposed by Hewitt, then there are two origins possible for the syenite body. The initial chemically different and massive character of the sediments in some locations may have led to alkalic syenites. Alternatively, a local tectonically introduced deviation in attitude of foliation towards the horizontal may have allowed more thorough syenitization of the rocks, eventually wiping out any evidence of sedimentary bedding by thorough recrystallization. The major change required in syenitization is depletion of silica and iron and, in some instances, introduction of sodium and potassium. However the suggestion that horizontal foliation may bring about a more thorough syenitization by initially blocking easy passage of the metasomatizing liquids or gases is purely hypothetical. It is important, nevertheless, for an evaluation of the potential grade and quantity of ceramic raw material at depth, to determine whether lack of foliation and sedimentary bedding in syenite is a characteristic of the original rock type, or merely due to locally deviating tectonic behaviour and/or recrystallization of the rock. A thin section study of collected rock samples should throw more light on this problem.

After study of the syenite and adjacent rock types in the west limb of the synclinal structure, and in view of the very symmetric character of the structure as indicated on the map and aerial photographs, and the observed absence of faults, it was decided to traverse the east limb of the syncline in an attempt to locate a possible equivalent of the syenite in the stratigraphic sequence. A traverse along the Rutter-Alban road near the nose of the Rutter syncline was chosen. All rocks observed on the traverse are shown on the existing geological map (see Figure 1), except for an approximately 85 m thick, thick-bedded to massive, feldspathic to arkosic sequence of sediments. This sequence stands out from the other metasediments because of its massive character. As it is located the same distance from the axial plane as the syenite (but in the opposite limb of the syncline), a further study of the chemistry and mineralogy of this rock will be made as part of the final report.

Conclusions

Renewed evaluation of the potential of the Bigwood Township nepheline syenite as a source of ceramic raw material is warranted because of improved beneficiation techniques, diminishing resources and improved understanding of the geology of these deposits. Evaluation of potential grade and quantity of material at depth will be facilitated by geologic interpretation of the Bigwood Township syenites. The rock samples collected will be analyzed for chemical composition and mineralogy with this purpose in mind.

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No. S23 Sources of Lime in Northern Ontario

J.K. Mason[1] and M.A. Vos[2]

THIS PROJECT IS FUNDED BY THE ONTARIO MINISTRY OF NORTHERN AFFAIRS UNDER THE NORTHERN INDUSTRIAL MINERAL STUDIES (NIMS) PROGRAM.

Introduction

During August and September 1980, a one-year lime study was initiated for the North Central Region, centred on the Thunder Bay area, with the remainder of the survey scheduled for completion in 1981. For each occurrence, a literature search was undertaken prior to a property examination and sampling program. Also a market study was begun for lime.

The area studied in 1980 is within a 130 km radius of Thunder Bay. Wilson (1910), Tanton (1931) and Franklin *et al.* (1980) did regional mapping in the Thunder Bay area and Goudge (1938) and Hewitt (1964) documented the carbonate showings that were known during their respective time periods.

Potential Lime Resources

Four geological environments are being investigated in the North Central Region for lime:

1) Marl – recent sediments
2) Carbonatite – Late Precambrian carbonatite-alkalic complexes
3) Limestone (dolomite) – Late Precambrian Sibley Group sedimentary rocks
4) Calcite (barite) veins – Middle Precambrian Rove and Gunflint Formations

Marl

Marl in the Thunder Bay area was initially documented by A.W.G. Wilson (1910) at Shillabeer Lake and Creek (Sucker Lake), 80 km northeast of Thunder Bay. The marl occurs as a dark grey to off-white, water-saturated, high-calcium mud in a shallow water environment. Thicknesses vary and the marl colour depends on the degree of contamination from overburden. Marl has been located in the Sioux Lookout area, and at two other locations in the Shillabeer Lake area (Fog Lake, Wolfpup Lake).

The properties will be investigated in 1981.

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[2]Geologist, Mineral Deposits Section, Ontario Geological Survey, Toronto.

Carbonatite-Alkalic Complexes

Carbonatite-alkalic complexes may prove attractive as potential sources of calcium carbonate. Four complexes occur northeast of Thunder Bay: the Prairie Lake Complex, the Chipman Lake Complex, the Killalla Lake Complex and the Coldwell Complex. The geology of these complexes is outlined in Sage (1975).

A relatively clean carbonate could possibly be extracted from portions of the Prairie Lake carbonatite-alkalic complex (D. Hume, President, New Insco Mines Limited, personal communication), but economic possibilities for the other complexes are poor.

Limestone-Dolomite

Limestone and dolomite occur within the Rossport Formation of the Sibley Group. The sedimentary rocks of the Sibley Group are Late Precambrian in age and are geographically situated northeast of Thunder Bay in the Nipigon Basin. The carbonate and associated mudstones are often overlain by Keweenawan diabase sills which have contact metamorphosed the members of the Sibley Group and which represent the regional topographic highs.

Three carbonate showings in the Eaglehead-Wabikon Lakes area (100 km north of Thunder Bay) have been investigated. A typical stratigraphic section encountered on any one property consists of, from top to bottom: diabase sill (30-60 m), mudstone, grey to white dolomite and/or white brucite limestone, and mudstone. Thickness of the carbonate unit at the three showings varies from 2.8 to 5.5 m. Typical range in mineralogy of the carbonate units is as follows: 55-65 percent calcite, 0-4 percent dolomite and 0-30 percent brucite.

Diamond-drilling in 1980 by Uranerz Exploration and Mining Limited in the Sibley Group rocks immediately southeast of Shillabeer Lake in Cockeram Township outlined 300 m of Rossport Formation, thus more than doubling the previously estimated thickness (Franklin *et al.* 1980, p.633). Although no pure limestone was located, the best potential source for economic carbonate deposits in the Sibley Group is the Rossport Formation.

Calcite (Barite) Veins

Calcite (barite) veins associated with the Rove Formation shales and wackes warrant investigation as a calcium carbonate source. The majority of these veins were worked for silver in the late 1800s and early 1900s. A large calcite vein, known as the Morehouse calcite vein and located in Devon Township, 50 km southwest of Thunder Bay, is a vertically dipping composite vein 70 m in length, striking N85E and having a width varying from 2.0 to 4.5 m. The vein is almost entirely free of sulphides. Chemical analysis of one sample yielded 96.76 percent calcium carbonate. Other large calcite (barite) veins to be investigated in 1981 are located on McKellar, Spar and Jarvis Islands, and at the Neepatyre, Silver Mountain and Shuniah Mines.

Summary

Exploration for lime is restricted to four geological environments:
1) Marl – recent sediments
2) Carbonatite-alkalic complexes
3) Limestone (dolomite) – Rossport Formation of the Sibley Group
4) Calcite (barite) veins

Chemical analyses during 1980-81 by the Geoscience Laboratories, Ontario Geological Survey, Toronto on selected samples will be followed up by field work in 1981 in all four geological environments. A market study for lime, mainly in the Thunder Bay area, will be completed.

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No. S24 Kirkland Lake Gold Study, District of Timiskaming

F.R. Ploeger[1]

THE WORK REPORTED HERE IS PART OF THE KIRKLAND LAKE GEOSCIENTIFIC SURVEYS. IT IS EQUALLY FUNDED BY THE FEDERAL DEPARTMENT OF REGIONAL ECONOMIC EXPANSION AND THE ONTARIO MINISTRY OF NORTHERN AFFAIRS UNDER THE COMMUNITY AND RURAL RESOURCE DEVELOPMENT SUBSIDIARY AGREEMENT.

Introduction

The major area of study comprises a narrow strip of predominantly alkalic rocks approximately 5.5 km long and 1.5 km wide which encompasses one present and six past-producing gold properties in Kirkland Lake. Additional areas within Teck and Lebel Townships containing various alkalic intrusive and extrusive rocks, particularly the Murdock Creek syenite stock in southeastern Teck Township, were also examined and sampled.

The objective of the study is to examine and sample, in detail, the productive alkalic suite of rocks at Kirkland Lake and to compare this assemblage with an alkalic assemblage that has proved unproductive so far. The comparison will attempt to determine 1) the distribution of gold (in ppb) in the various phases of both alkalic suites using neutron activation analysis, 2) the relationship of gold to structural features or stratigraphic units, 3) the rare earth element (REE) patterns of the alkalic assemblages, 4) the major and trace element geochemistry of the alkalic assemblages and 5) the existence of any alteration patterns or features within them. This study complements other studies recently completed or in progress and which relate the various gold deposits to specific aspects of regional geology (Downes 1979; Thomson and Guindon 1979).

The 1:2 400 (1 inch to 200 foot) scale base maps used in this study were derived from the original maps of Thomson (1948) and Thomson *et al.* (1948) and from the surface plans of many of the Kirkland Lake mines. Enlargements of 1:15 840 scale air photographs were utilized to update geographic features.

The writer appreciates the helpful information received from numerous local residents, many of whom had worked in the formerly producing mines. I would also like to acknowledge the cooperation and help of the geological staff of Willroy Mines Limited, Macassa Division, and the Town of Kirkland Lake Works Department. Advice and guidance were also provided by H. Lovell (Resident Geologist, Ontario Ministry of Natural Resources, Kirkland Lake), J.A. Robertson and J.B. Gordon (Mineral Deposits Section, Ontario Geological Survey, Toronto), and Dr. J. Crocket (Professor, Geology Department, McMaster University).

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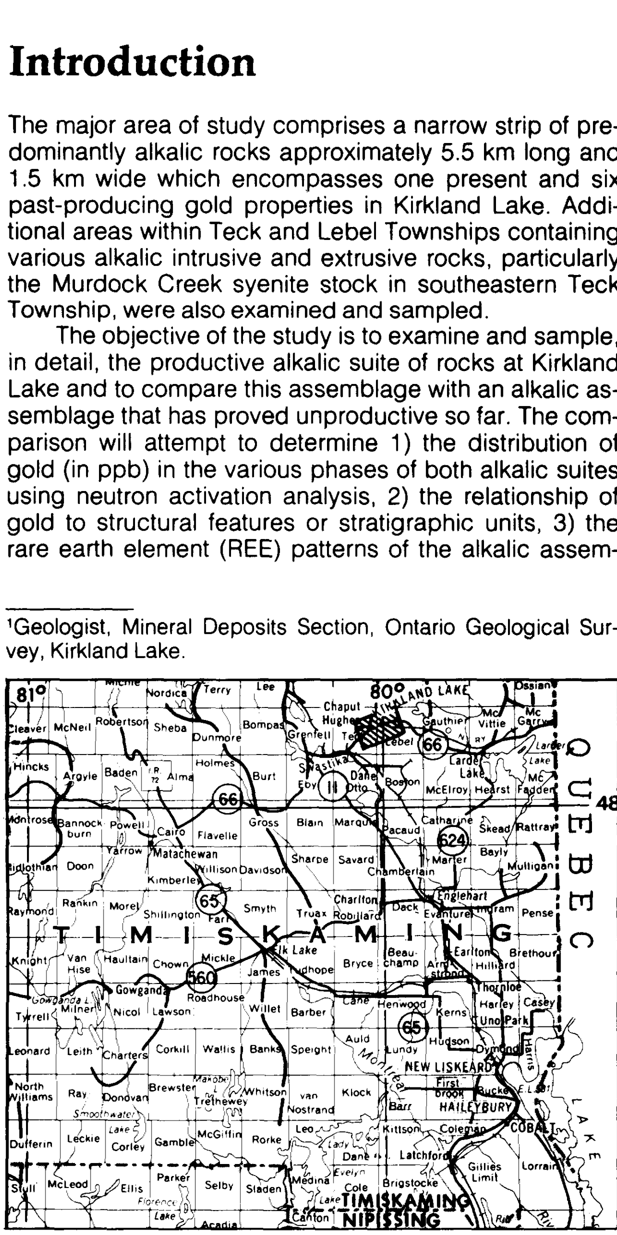

LOCATION MAP

Scale: 1:1 584 000 or 1 inch to 25 miles

General Geology

The rocks in the Kirkland Lake area are of Timiskaming age and consist mainly of wackes, conglomerates, trachytic flows, pyroclastics, and alkalic intrusives. Hewitt (1963) indicates that the Timiskaming Group rocks attain their greatest thickness, about 16,000 feet, in Lebel Township. Several writers (Thomson 1948; Hewitt 1963; Hyde 1978; Jensen 1978; Downes 1979) have observed that the Timiskaming Group unconformably overlies the Keewatin volcanic rocks, particularly along the northern contact. Recent work by Downes (1979) in McGarry and McVittie Townships, to the east of Kirkland Lake, has shown that much of what had formerly been classified as Timiskaming belongs to an older group of rocks.

Sedimentary Rocks

The Timiskaming sedimentary rocks have been described in great detail by Thomson (1948), MacLean (1956), Hewitt (1963) and Hyde (1978). The lowermost unit consists of a narrow section of basal grits, tuffs or pebbly wackes which rests unconformably on the underlying Keewatin volcanics. However, the bulk of the sedimentary rocks comprise a sequence of massive and interbedded units of boulder and pebble conglomerate and coarse- to fine-grained wackes. Pebbles within the conglomerates represent a wide variety of rock types, the most distinctive of which are red jasper. The wackes typically appear massive and medium- to fine-grained, although fine bedding and graded bedding are present locally.

Alkalic Extrusive Rocks

Trachytic flows, tuffs, breccias and agglomerates constitute the alkalic extrusive suite of the Timiskaming Group. MacLean (1956), Cooke (1966), Cooke and Moorhouse (1969) and Lovell (1976) have described the distinctive nature of the trachytic flows, particularly the leucitic varieties in Lebel Township. The tuffs, breccias and agglomerates make up the bulk of the alkalic extrusive rocks. The tuffs often exhibit sedimentary features such as graded bedding, scouring and cross-bedding, and therefore should be strictly classified as sediments.

Alkalic Intrusive Rocks

Thomson (1948) described three dominant alkalic intrusive rock types, augite syenite, syenite and syenite porphyry, which probably represent various phases of one magmatic intrusive event. The augite syenite was the earliest rock type intruded into the Timiskaming volcano-sedimentary sequence. It forms irregular dike-like bodies and is typically dark coloured and coarse textured, the dominant ferromagnesian mineral being augite or its alteration products.

The irregular pipe-like bodies of syenite represent contemporaneous or slightly later phases of intrusive activity. Thomson (1948) observed transitions from augite syenite to massive syenite as well as sharp contacts between the two phases in drill core. Recently this phenomenon has been observed underground and in drill core at the Macassa Mine (G. Nemsock, Mine Geologist, personal communication).

Syenite porphyry cuts the earlier sedimentary, extrusive and intrusive rocks. In the immediate vicinity of Kirkland Lake the syenite porphyry forms a central plug from which numerous dikes and irregular bodies of varying sizes emanate. The rock is distinctly porphyritic in texture and ranges from maroon to green-grey in colour. Coarse- and fine-grained mafic inclusions and, to a lesser extent, inclusions of a variety of other rock types commonly occur in the syenite porphyry.

Economic Geology

Since the beginning of mining in the Kirkland Lake camp in 1913, 23 million ounces of gold and 4.4 million ounces of silver have been produced. At present only one mine, Willroy Mines Limited, Macassa Division, is still in production in the camp. The other major past producers, from west to east, are the Kirkland Lake Gold, Teck-Hughes, Lake Shore, Wright-Hargreaves, Sylvanite and Toburn Mines. Most of the gold has been mined from a continuous major fault structure, the Kirkland Lake "Main Break", and from numerous branching and parallel satellite structures and veins. The gold occurs in various types of veins described by Thomson (1948, p. 93, 94) as follows:

". . . the single fissure vein is the most commonly found. There are all variations from this to intricately connected composite veins or lodes, sheeted zones, stockworks, and vein breccias. The vein-filling consists of quartz, inclusions of wall rock, some carbonate rocks, a small amount of sulphides, and a variety of other minerals in minor amounts, including tellurides and native gold."

Mineralized veins occur in all rock types at Kirkland Lake, including basic syenite, syenite porphyry, syenite (unsubdivided), trachyte tuff, conglomerate and wacke. Some gold occurs in conformable pyritic lenses and disseminations in trachytic pyroclastic rocks. The sulphide content of these lenses, and that in the mineralized veins, is generally less than 2 percent. During the period of underground operations, the average stope width was 5 to 6 feet (Thomson *et al.* 1948) although single, narrow, high-grade veins only several inches in width were mined in 3-foot stopes; stopes up to 70 feet wide were mined in zones of closely-spaced, parallel or branching vein structures.

Todd (1928), Hawley (1948) and Wark (1948) have described the mineralogy of the Kirkland Lake ores in some detail. The greater part of the gold occurs as native gold, gold-filled fractures and rims on pyrite grains, inclusions, or forming combinations with telluride minerals. According to Wark, altaite (PbTe) is the most abundant of the tellurides in the Kirkland Lake camp. However, the greater part of the gold from tellurides is obtained from calaverite ($AuTe_2$) or is found in association with coloradoite (HgTe). Other telluride minerals identified are: melonite ($NiTe_2$); petzite (Ag_3AuTe_2); tetradymite (Bi_2Te_2S); and joseite ($Bi_3Te(Se,S)$).

Alteration is most intense in the major structures, mineralized or unmineralized, in all the rocks of the alkalic assemblages in the Kirkland Lake camp. Carbonatization is ubiquitous in zones adjacent to most minor fractures and slips as far as 600 feet or more from ore-bearing structures, whereas zones of intense silicification and sericitization are generally confined to areas immediately adjacent to the veins.

At the Macassa Mine and various other parts of the camp the trachyte tuff, syenite and syenite porphyry, which normally appear light to dark pink, are altered to an intense brick red colour near vein structures. This makes these rocks virtually indistinguishable from one another. The basic syenite, typically dark grey to black, is bleached to a mottled pink. Thomson *et al.* (1948) attribute the reddish colouration to fine dusty particles of hematite, brown limonite and iron-bearing carbonates. Detailed rock geochemistry, which forms the basis of the Kirland Lake Incentive Program Gold Study, will better define alteration patterns and assemblages.

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No. S25 Alteration and Mineralization in Archean Volcanic Rocks of the Cobalt Area

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Introduction

During the 1980 field season, Archean volcanic rocks located in Coleman, Bucke and Lorrain Townships were investigated. This is the initial phase of a two-year project to study the pattern and history of alteration observed in these rocks and their relationship to base-metal and vein-type cobalt-silver mineralization characteristic of the area. Relevant structural and lithologic data have also been recorded to enhance the stratigraphic control of samples collected for whole rock analysis. As this work is in a preliminary stage, all observations and conclusions are somewhat tentative.

General Geology

As discussed by Patterson (1979), base-metal sulphide mineralization in the Keewatin rocks of the Cobalt area occurs primarily as pyrite, pyrrhotite, chalcopyrite and galena, and is located, for the most part, within interflow sedimentary units and pillow selvages of the basalts. Certain basal units of the overlying Huronian Coleman Formation contain sulphide mineralization in the form of detrital clasts which often exhibit textures indicative of local remobilization.

The volcanic sequence in this area has experienced intensive silicification which appears to have been overprinted by a regional greenschist facies metamorphism. Locally, there is intensive chloritic alteration, apparently related to the intrusion of Nipissing Diabase sills.

Early Precambrian Volcanic Sequence

The Early Precambrian (Archean) volcanic rock sequence ranges in composition from tholeiitic massive flows and pillow basalts to calc-alkaline rhyodacitic tuffs, flows and quartz-feldspar porphyries. The sequence is overlain by volcanogenic sediments. Individual massive flow-units vary from 10 to 150 m in thickness and generally exhibit pillowed upper portions, often accompanied by minor, discontinuous hyaloclastites and/or pillow breccias. Pillows range from 0.2 m spheroids to 2.0 to 4.0 m wide lava tubes, with average dimensions of less than 1.0 m by 0.3m. Deformation of pillows during folding has been negligible. Re-entrants are abundant in the larger pillows and tubes, indicating a rather fluid magma. Amygdules and vesicles tend to be rare in the basaltic rocks, possibly suggesting either a low volatile content (at the time of eruption) or submarine extrusion in very deep

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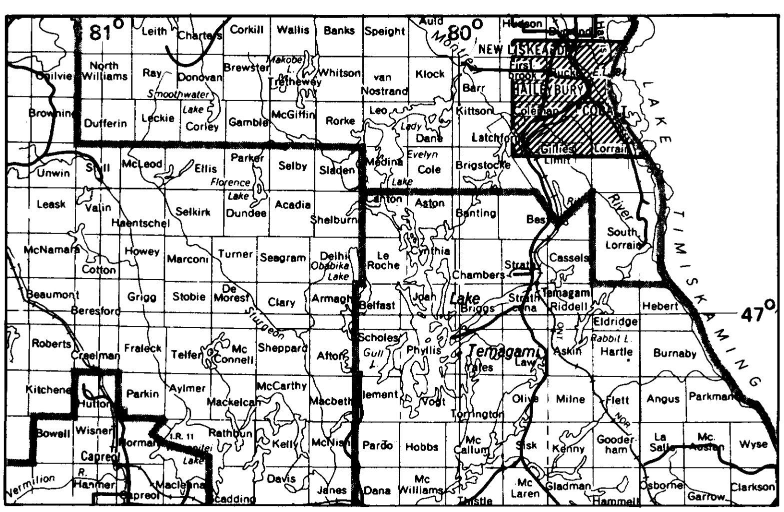

LOCATION MAP **Scale: 1: 1 584 000 or 1 inch to 25 miles** water. Selvages are chloritic, 0.5 to 1.5 cm in width, and occasionally exhibit interstitial hyaloclastite fillings.

Mafic tuffs and breccias are relatively scarce and frequently display a variable degree of silicification, with the result that many of them have been previously mapped as rhyolites. Examples of this occur in the Sasaginaga and Cobalt Lake areas (Figure 1). Felsic rocks occur as massive quartz-feldspar porphyry units (e.g., in the area northeast of Cross Lake) and fine-grained, thinly bedded, normally graded, siliceous tuffs.

Sedimentary interflow rocks exhibit a trend from a proximal facies (breccias, tuffs and graded wackes) near Cobalt Lake to a more distal facies (fine-grained, magnetite-rich siltstones and argillites) towards the Agnico Beaver Mine (Agnico-Eagle Mines Limited) at Cross Lake.

Mineralization

Sulphide mineralizations in the Keewatin basalts consist primarily of pyrrhotite and pyrite along with minor chalcopyrite and traces of galena and sphalerite. They occur at flow interfaces and within pillow breccia and pillow selvages located near the top of flow sequences. The upper few metres of mineralized flows are typically intensely silicified, suggesting an accompanying period of hydrothermal - exhalative activity (e.g., Nipissing Hill). Interflow breccias and tuffs contain pyrite and minor chalcopyrite often within a graphitic matrix. Interflow graphitic schists contain disseminated pyrite porphyroblasts (Patterson 1979) with finely-banded chalcopyrite, galena and sphalerite.

In discussing the nature and distribution of sulphide mineralization in the overlying Lower Huronian Coleman Formation, Patterson (1979, 1980) has presented evidence in support of local derivation from the Archean volcanic sequence.

Alteration

An early stage (possibly synvolcanic) alteration in the Early Precambrian (Archean) sequence is manifested predominantly as silicification, along with subordinate carbonitization. Individual flows, breccias, and epiclastic material have been silicified and mineralized to varying degrees. Examples of this occur in mafic breccias of the Sasaginaga Lake area (Patterson 1979, 1980) and amygdaloidal pillow basalts located on the southeastern shore of Clear Lake, where a silicified breccia is observed overlying a highly carbonitized flow.

A section exposed on the southern shore of Cobalt Lake consists of massive flows and pillow basalts capped by 50 m of bedded, normally graded, tuffaceous sediments. This sediment capping, which is in turn overlain by another sequence of pillow basalts, is moderately to highly silicified, and tuffaceous beds contain minor pyrite, chalcopyrite and intercalated graphitic horizons. Silicification and sulphide mineralization appear to be closely associated, with sulfides often preferentially located within a silica-rich matrix. The degree of silicification, together with the occurrence of local discontinuous quartz veins, indicates that a significant introduction of silica has taken place.

Felsic tuffs near the southwestern end of Cross Lake are pervasively silicified, imparting a rather cherty appearance to the rock. Many of these tuffs, which were originally described by Thomson (1961) as 'volcanic sediments', appear to consist of variably silicified, mafic volcanoclastic material, ranging in grain-size from fine ash to lapilli (Fisher 1966). Crosscutting networks of quartz veinlets (1 to 3 mm wide) with bleached aureoles (2 to 4 mm wide) occur in areas of pervasive silicification (e.g., Cross Lake). Chlorite is present in some of these veinlets, but it is not yet clear whether this mineral is contemporaneous with silicification or related to the later stage Nipissing Diabase metasomatism.

The mafic volcanic sequence which occurs between Cross Lake and Lake Timiskaming does not appear to have been silicified and mineralized to the same degree as those to the southwest. This may reflect either localization of hydrothermal-exhalative activity, or may be taken as evidence that this sequence represents a distinct and separate volcanic cycle (Lovell 1978).

As described by Jambor (1971), Archean rocks of the Cobalt area have been regionally metamorphosed to greenschist facies (albite-epidote subfacies). Epidote and albite occur mainly as blebs, filling vertical veinlets, pillow selvages and inter-pillow voids. Minor biotite and hornblende have been observed in Archean lamprophyre dikes and, more rarely, between pillow selvages.

Of the three phases of alteration tentatively recognized within the Cobalt area, the Nipissing Diabase-related chlorite spotting is the most obvious and widespread. According to D. Robinson of Canadaka Mines Limited (personal communication, 1980), the spotted chlorite alteration in the Bailey Mine closely follows the Huronian-Archean unconformity, becoming preferentially developed along paleofractures and topographic depressions in the Archean basement. This may be taken to reflect the movement of pore waters along specific zones of high permeability. In this respect, Jambor (1971) has noted that the distribution of chlorite spotting appears to be a function of the porosity and permeability characteristics of individual rock types. For example, chlorite spots are commonly observed along bedding planes in argillaceous beds and in the more coarsely-grained sandstones. Within the rare volcanic turbidites, located on the south side of Cobalt Lake, chlorite spotting has developed preferentially within pelitic layers.

Where Nipissing Diabase crosscuts the Archean volcanic rocks well below the unconformity (i.e. no Huronian sediments in the immediate vicinity), chlorite spotting is rare and epidote-rich crackle-breccias and veinlets become dominant (examples of this are observed in the Agnico Beaver and Canadaka Consil Mines). In this environment, the alteration is of limited extent (extending less than 30 m from the intrusive contact into the host basalt) and is sometimes accompanied by local silicification. Veinlets associated with the intrusive contact contain either epidote or an assemblage of albite-carbonate$\pm$quartz.

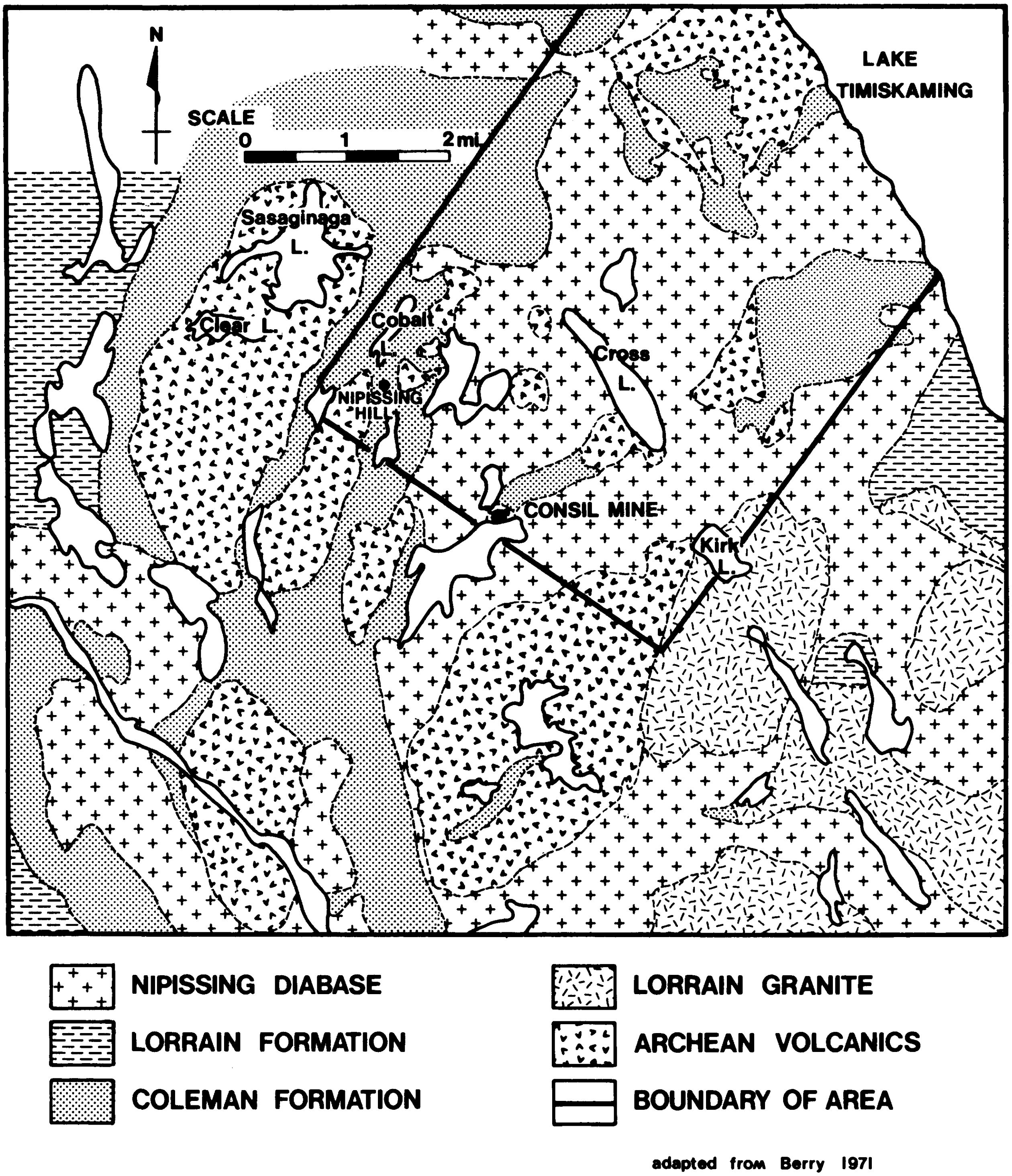

Figure 1 — General geology of the Cobalt area.

They are discontinuous, sub-horizontal, *en echelon* features which were generated as a result of the intrusion and provided dilatent zones facilitating the movement of hydrothermal fluids.

Discussion

Archean volcanic rocks of the Cobalt area exhibit three distinct types of alteration:
1) an early stage (possibly synvolcanic) silicification,
2) a later stage, regional, greenschist facies metamorphism, and
3) a late stage metasomatism (chlorite spotting) related to the intrusion of Nipissing Diabase.

Areas of silicification tend to occur in mafic rocks immediately beneath the contact with felsic units and are commonly accompanied by sulphide mineralization in the form of pyrrhotite>pyrite±chalcopyrite. There appears to be a zone of discontinuous silicification, located between Sasaginaga Lake and the Agnico Beaver Mine, which follows the broad, southeasterly trending structural and lithologic features characteristic of the area. It is worth noting that silver deposits located northeast of Cross Lake decrease rapidly in number and grade along a similar southeasterly trend (B. Thorniley, Agnico-Eagle Mines Limited, personal communication, 1980).

The areas of silicification are characterized by quartz vein networks, chlorite veining and associated bleached host rocks, and may reflect localized zones of synvolcanic(?), hydrothermal-exhalative activity. Chlorite spotting is a characteristic metasomatic feature resulting from the Nipissing Diabase intrusion. The distribution and intensity of this type of alteration appears to be a function of local permeability which, in turn, controlled the movement of pore fluids. In this respect, chlorite spotting is best developed within and in close proximity to Huronian sediments, which provided a readily available source of pore water.

Recommendations for Further Work

Petrographic-geochemical studies should be undertaken to:
1) identify volcanic cycles and their boundaries,
2) identify and characterize large- and small-scale alteration patterns within the area, and
3) better characterize the synvolcanic phase of alteration, particularly with respect to chlorite and carbonate generation.

A study should be undertaken to characterize the nature of mineralization within the Huronian Coleman Formation, and to assess the potential for large-scale, low-grade deposits. This is with particular reference to 1) disseminated Ag-Co wallrock mineralizations which occur in association with multiple vein systems and 2) stratabound and topographically controlled Cu,Zn and Pb occurrences.

Continuing work will include detailed petrographic studies of alteration types and geochemical characterization of altered suites. The 1981 field work will consist of a follow-up program of mapping and sampling in altered mineralized areas of particular interest and a re-examination of areas previously mapped as rhyolite or cherty sediments for the possible occurrence of silicified mafic volcanics. An attempt will be made to distinguish between multiple stages of chlorite development.

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No. S26 Uranium Deposits of the Cobalt Embayment

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Introduction

During the 1979 field season, the senior author began a two-year examination of the uranium occurrences in the southern portion of the Cobalt Embayment and the Southern Province northwest of Lake Wanapitei (Meyn 1979). This area is bounded by Latitudes 46°36′ and 47°15′ and Longitudes 80°00′ and 80°17′ W. Thompson (1960) published descriptions of the uranium occurrences in the area. The purpose of this project is to investigate the setting and origin of the mineralization.

The regional geological setting was described briefly by Robertson (1978). The geology of the southern portion of the Cobalt Embayment was mapped, in part, during the 1979 field season (Figure 1). In addition, detailed

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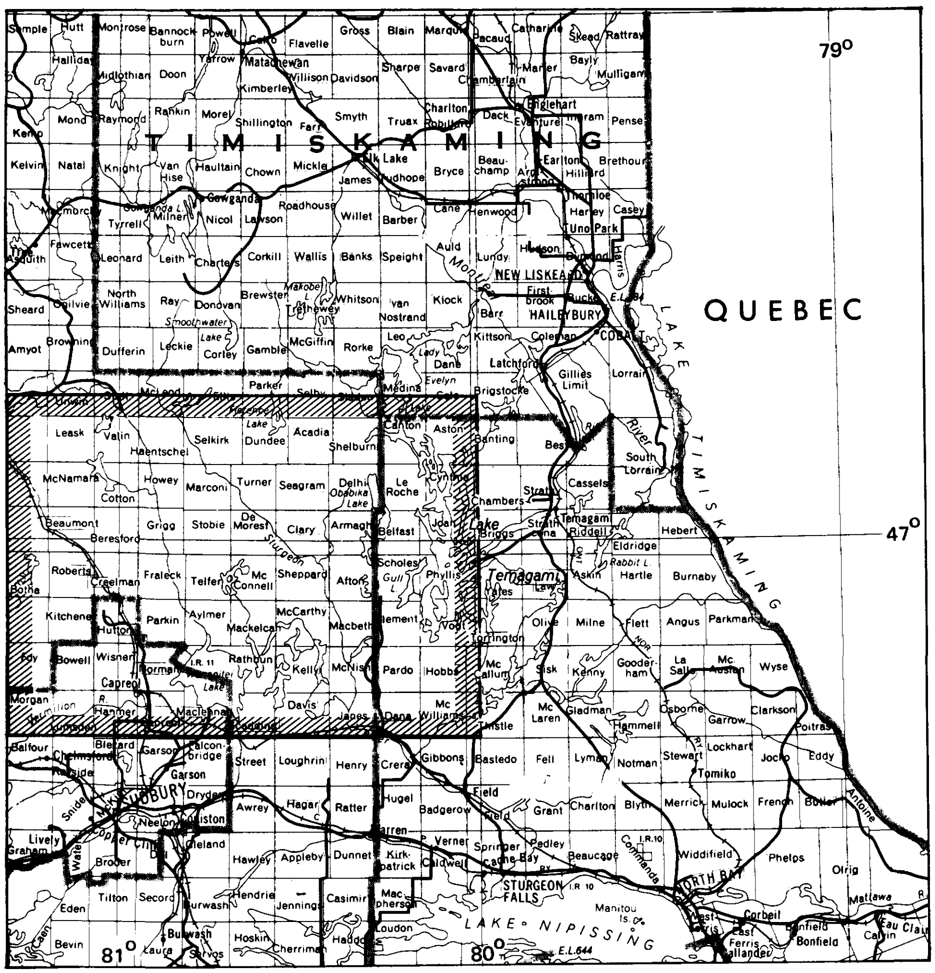

LOCATION MAP

Scale: 1:1 584 000 or 1 inch to 25 miles

mapping has been carried out in many of the townships in the area (Meyn 1970,1971,1972,1973).

Since completion and publication of the detailed mapping, exploration for uranium-gold occurrences has continued intermittently. Records of exploration carried out in this area are available at the Assessment Files Research Office, Ontario Geological Survey, Toronto. As part of the present study, more than 200 rock samples were selected for detailed examination, including autoradiographs, electron and x-ray probe analysis, chemical analysis, polished thin sections and computer analysis.

General Geology

The Mississagi Formation, hosting most of the known uranium deposits at or near its base, is present north of Lake Wanapitei (Figure 1). This formation apparently forms the basal part of the Huronian Supergroup. The geological compilation map for the area (Card and Lumbers 1976) shows that the Matinenda and McKim Formations of the Elliot Lake Group and the Ramsay Lake and Pecors Formations of the Hough Lake Group are present in Falconbridge and Street Townships.

Robertson (1978) has indicated briefly the distinctions between the sections of the Elliot Lake, Agnew Lake, and Cobalt Embayment deposits. Long (1976,p.52) stated:

The presence of uraniferous quartz-pebble conglomerates near the base of the sequence is equivalent to the Matinenda Formation in the Quirke Lake area. As the Ramsay Lake conglomerate has not been positively identified north of Wanapitei Lake, such a correlation can only be considered tentative.

As well, derived from Peters (1969), Long (1976,p.53) predicted that:

The thinly bedded argillaceous sequence may tentatively be correlated with the Pecors Formation, and the overlying sandstones, which are locally in contact with the basement, may be correlated with the Mississagi Formation, in the sense of Roscoe (1957) and Robertson, Card, and Frarey (1969). Units below this thinly bedded unit may be correlated in part with the Elliot Lake Group, and possibly with the Ramsay Lake Formation. The absence of conglomerates may be due to a facies change, or non-deposition of this formation.

Due to extensive faulting west of the Wanapitei River, the correlation of favourable mineralized beds is difficult.

Mineralization

During the present study, uranium mineralization was found in argillite, siltstone, sandstone and conglomerate. Thomson (1960,p.31) found the richest mineralization (0.31 percent U_3O_8) occurring in brown to black mudstones and siltstones similar to those at the Leslie showing (Number 3, Figure 1). Samples taken from the thirteen showings had U contents ranging from 1 to 8200 ppm and Au values ranging from 2 to 800 ppb. The highest U

TABLE 1 — RANGES OF URANIUM, THORIUM AND GOLD CONCENTRATIONS IN SAMPLES TAKEN FROM THE MAJOR SHOWINGS IN THE SOUTHERN COBALT EMBAYMENT

LOCATIONS	U(ppm) HIGH	U(ppm) LOW	Th(ppm) HIGH	Th(ppm) LOW	Au(ppm) HIGH	Au(ppm) LOW	NUMBER OF SAMPLES
A) Northern Roberts & Creelawn Townships							
1) Northern Creelawn	581.9	8.0	190.0	20.0	140.0	14.0	8
2) Roberts Lake Area	1516.0	5.0	780.0	30.0	600.0	4.0	10
3) Smith Lake Area	386.0	5.0	290.0	30.0	16.0	2.0	5
4) Proudfoot Lake Area	49.0	2.0	370.0	20.0	33.0	2.0	15
B) Central Roberts & Creelawn Townships							
1) Nordic Showing	8200.0	30.0	1640.0	20.0	800.0	8.0	33
2) Leslie Showing	3499.0	59.0	880.0	70.0	90.0	3.0	12
C) Central Hutton Township							
1) North of Moose Mountain	340.0	4.0	270.0	10.0	120.0	5.0	7
2) Central Hutton	1300.0	1.0	450.0	10.0	250.0	3.0	15
3) Bannagen Lake	1500.0	3.0	1380.0	20.0	120.0	3.0	10
C) Parkin Township							
1) Flesher Lake	30.0	3.0	100.0	10.0	80.0	3.0	8
2) Powerline Road	120.0	2.0	170.0	10.0	31.0	3.0	5.0
3) Bouma Showing	16.0	15.0	70.0	40.0	11.0	7.0	2
C) Grigg Township							
1) CJM	730.0	4.0	560.0	20.0	300.0	8.0	17

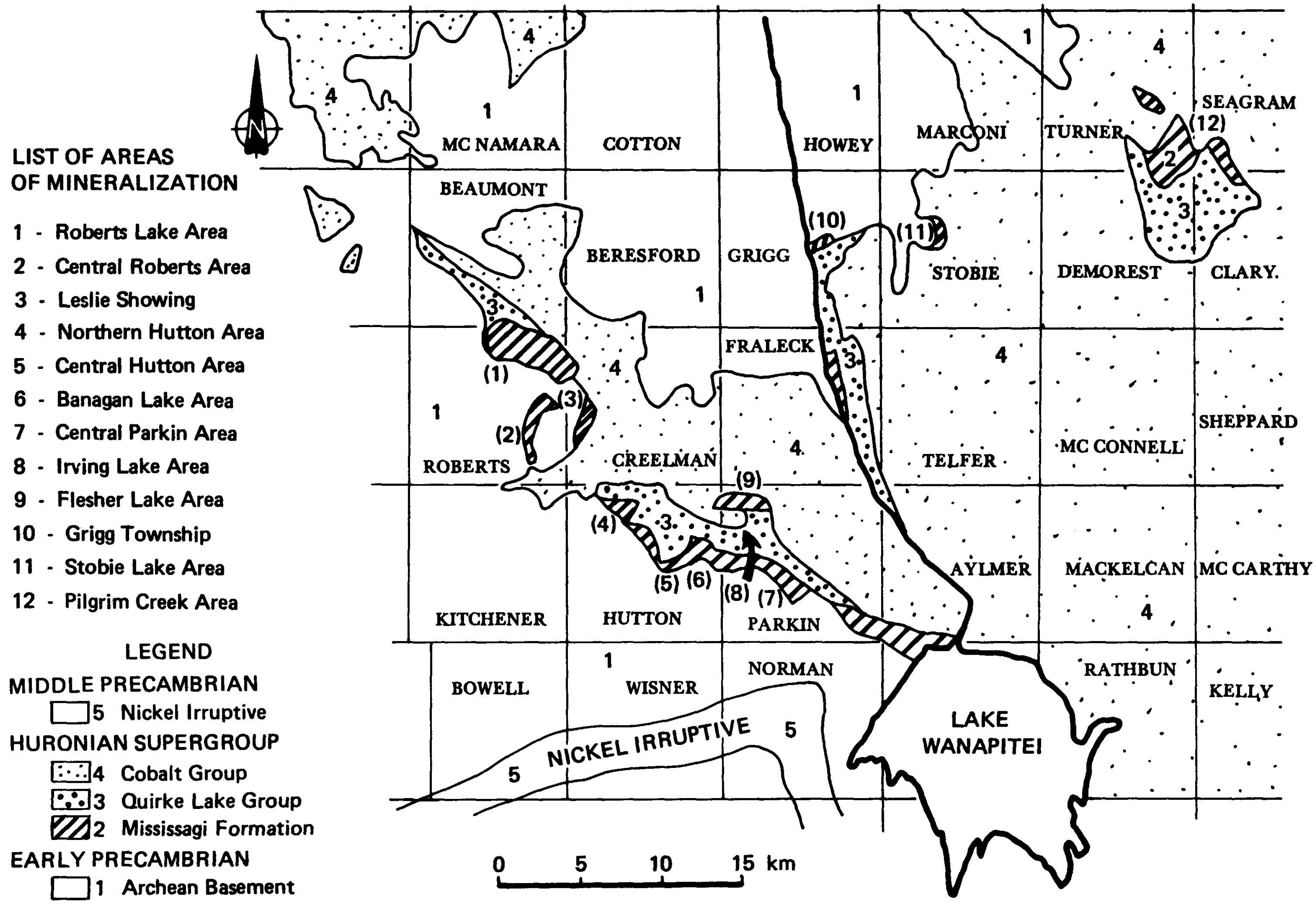

Figure 1 — General geology and detailed study area locations, Southern Cobalt Embayment.

value found in the study area (8200 ppm or 0.82 percent) was in a small selected hand specimen from the Nordic showing in central Roberts Township (Number 2, Figure 1). This showing appears to contain the richest and most extensive mineralization.

Several generalizations can be made from the work completed to date:

1) Pyrite is usually closely associated with uranium mineralization, but the converse is not true.

2) Uranium mineralization seems to be locally concentrated in specific beds or parts of a bed. Mineralized material is typically up to 30 cm thick (locally to 1 m) with strike extensions from 50 cm to 30 m. The down-dip extent of mineralization is not known.

3) The uranium-bearing conglomerates had been thought to resemble those in the Elliot Lake area, but there are significant differences. The conglomerates, particularly those northwest of Lake Wanapitei, are generally polymictic and commonly reflect the underlying basement lithology; clasts of diabase, volcanic rocks, iron formation, and felsic intrusive rocks were recognized. Both quartz and quartzite clasts occur, in contrast to the predominance of vein quartz at Elliot Lake. The matrix of the conglomerates ranges from fine-grained, chloritic, black-green mudstone to light grey, medium-grained sandstone.

During 1980, examination and sampling of several outcrops was completed in the Pilgrim Creek area (Number 12, Figure 1), Turner Township.

Also during 1980, autoradiographs were made of rock samples. These autoradiographs confirmed that radioactive areas coincided with a distinct heavy mineral suite. Polished thin section study, to date, has identified these minerals as magnetite, zircon, ilmenite, rutile and sulphides, of which polygenetic pyrite is the most abundant. This heavy mineral suite appears to be directly associated with uranium concentrations in silty micaceous beds, as well as in minor uranium-bearing conglomerates. Pyrite, minor chalcopyrite and pyrrhotite are also present in these micaceous beds, suggesting that they too are closely associated with the uranium mineralization. Examination of thin sections has revealed that the increased content of zircon and ilmenite - rutile in radioactive zones is directly proportional to the amount of uranium present. Electron probe studies have identified the uranium minerals as brannerite, uraninite and coffinite. Further study of these minerals is being carried out to determine their distribution and relationships.

To date, computer analysis has shown a relatively strong correlation of uranium with thorium, titanium oxide, cerium and yttrium and a moderate correlation of uranium with zirconium and chromium. Also found was a strong correlation between titanium oxide and chromium.

The sedimentary rocks which host the mineralization were deposited in a fluviatile sedimentary environment. The uranium-bearing minerals form part of a heavy mineral suite which was deposited as a result of the sedimentary processes in a fluviatile environment. In addition, some uranium may have been transported in solution and redeposited under favourable physico-chemical conditions. Subsequent redistribution of uranium during diagenesis and/or metamorphism may also have taken place (Theis 1979; Ferris and Rand 1971).

The anomalous gold content of these showings can also be attributed to a fluviatile, placer mode of concentration, in which the gold provenance is the Abitibi 'greenstone' belt to the north. In this respect, the showings are distinct from those of the Blind River area.

The basal portion of the Mississagi Formation in this area demonstrates that heavy mineral placers, including gold and uranium minerals, were deposited in a fluviatile, possibly braided stream environment. Further exploration in this area must therefore include comprehensive sedimentological studies in order to interpret favourable environments for placer concentration.

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