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Gupta, V.K.
Preface

In 1978 the name of the Geological Branch was changed to the Ontario Geological Survey, Mineral Resources Group, Ministry of Natural Resources and within the survey the Phanerozoic Geology Section was renamed the Engineering and Terrain Geology Section. During 1978 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 Ontario Centre for Remote Sensing (Ministry of Natural Resources), the Geological Survey of Canada, the Royal Ontario Museum and with private contract companies. Funding for a number of regional stimulation projects was provided by the Ministry of Northern Affairs and Ministry of Treasury, Economics and Intergovernmental Affairs. Project involvement is summarized in the section introductions which follow.

The locations of the areas investigated are shown on the map 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 mostly during the winter of 1978-1979. 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.
LOCATION OF FIELD PARTIES, 1978
ONTARIO GEOLOGICAL SURVEY

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<td>1 foot</td>
<td>= 0.304 8 m</td>
<td>metre</td>
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<td>1 mile</td>
<td>= 1.609 344 km</td>
<td>kilometre</td>
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<tr>
<td>1 pound (avoirdupois)</td>
<td>= 0.453 592 kg</td>
<td>kilogram</td>
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<tr>
<td>1 ounce (troy)</td>
<td>= 0.031 103 kg</td>
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<tr>
<td>1 troy ounce/short ton</td>
<td>= 34.285 71 ppm or g/t</td>
<td>parts per million grams per tonne</td>
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<tr>
<td>1 ton (short)</td>
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In all 24 projects were operated under the direction of the section during the 1978 field season. These ranged from detailed areal surveys to broad regional studies. Of these projects 19 comprise the ongoing program of the section coordinated to the objectives of stimulating exploration, and developing correlation of stratigraphy, structure and petrogenesis as a basis for resource prediction, initially in six major geologic belts and tectonic provinces. Of the remaining projects, two in the Renfrew area (Nos. 22 and 23) are funded by the Ministry of Treasury, Economics and Intergovernmental Affairs, and two, in the Cobalt and Cochrane areas (Nos. 20 and 12), are funded by the Ministry of Northern Affairs as part of the programs of these ministries to encourage regional development. Ground follow-up to airborne uranium reconnaissance surveys was directed by section staff during the 1978 field season in support of the West Patricia Land Use Plan.

Section staff directed 13 projects and 11 were operated by contract staff. In the ongoing program approximately 2900 km² were mapped at a detailed scale (1:31,680 or 1:12,000) and about the same total, 2900 km², at a reconnaissance scale (1:50,000 or 1:1,267,200). An additional 422 km² detailed scale and 770 km² reconnaissance scale mapping were completed in the other projects.

In the first stage of investigation of the Uchi Belt effort is being concentrated upon correlation and stratigraphic interpretation of the Eagle Lake — Red Lake — Birch Lake — Bamaji Lake western segment of the belt. In 1978 detailed mapping was continued in the Red Lake (No. 3) and Bamaji Lake (No. 1) areas, an interpretive compilation survey was completed in the Birch Lake area (No. 2) and a synoptic survey was started (No. 4) to integrate recently completed detailed mapping over the entire Red Lake camp. A study of the geochronology of the belt is proceeding concurrently (see Geophysics, Geochemistry, and Geochronology Surveys) in support of the stratigraphic and mineralization genesis interpretation.

In the Wabigoon Belt field work was completed on a special study of the western section of the Belt extending from Crow Lake to Savant Lake (No. 6). The objective of the study is to integrate the geologic data over this large area at a relatively detailed scale, in an effort to correlate between mineral producing areas, such as Sturgeon Lake and other sectors of the belt, and to interpret the evolution of this metavolcanic-metasedimentary belt and the mineral deposits it contains. A geochronology study has also been undertaken (see Geophysics, Geochemistry and Geochronology Surveys) in support of this project.

Much detailed mapping remains to be done in this belt but this study will provide an improved framework for the study of mineral deposits, mineral potential assessment and planning future surveys. In conjunction with the broader program, detailed mapping was undertaken in 1978 in the Zarn Lake area (No. 7) which is considered of interest for gold and base metals. In the eastern part of the Wabigoon Belt detailed mapping was completed over a 520 km² area lying northeast of Onaman Lake (No. 8) and covering the eastern extension of the mineralized Marshall Lake belt.

In 1978 field work was essentially completed on a special project examining the regional stratigraphy and structure of the Timmins-Kirkland Lake section of the Abitibi-Wawa Belt (Nos. 10 and 11). Several major lithological groups and supergroups have been delineated which indicate a strong relationship between mineralization type and specific groups and in particular appears to indicate a particular economic importance to the boundary between the two major supergroups. Detailed mapping in the Abitibi-Wawa Belt continued in the Hemlo area (No. 14), Matchinameagus area (No. 16, Wawa belt), Grey Owl Lake area (No. 15, Batchawana belt) and in the Cunningham-Garnet Townships area (No. 13, Swayze belt). In addition a synoptic survey in the Kirkland Lake — Larder Lake area (No. 10) was continued. Of these gold appears to be of principal interest in the Hemlo and Cunningham-Garnet Townships areas, radioactivity along the Montreal River in the Grey Owl Lake area, and the presence of previously unrecorded felsic metavolcanics in the Matchinameagus Lake area suggests that some investigation for base metals may be warranted. In the Wawa
Belt along the north shore of Lake Superior a reconnaissance examination of several isolated and scattered breccia features (No. 9) was undertaken to determine their origin and potential mineralization significance. It is concluded that some breccia bodies of carbonatic affinities contain radioactive mineralization of interest.

Work in the Southern tectonic province continued in the Penokean fold belt with compilation in 1978 of a regional examination of the volcanic rocks at the base of the Huronian Supergroup, between Sault Ste. Marie and Sudbury (No. 18). Chemical characterization and stratigraphic comparison provides a basis for correlative extrapolation between some of the isolated volcanic units. In the Cobalt Embayment detailed mapping was completed in the Wanapitei Lake area (No. 19) in which gold, copper, nickel-copper and uranium mineralization are of interest. Compilation mapping of the area between Cobalt and Timagami (No. 20) was undertaken to provide a preliminary outline of major rock units in this area as a basis for planning future detailed mapping and special projects to investigate the stratigraphy, sedimentology and mineral deposit environments of the embayment.

Two detailed mapping projects were completed in the southern Grenville tectonic province. In the west, mafic, and intermediate to felsic metavolcanics first reported in Cavendish Township (Bright 1975) have been traced through the centre of Harvey Township (No. 24) and represent an exploration target not previously tested for base metals. Mapping in the Long Lake area (No. 21) to the east has traced the Long Lake mine host rock and suggests that additional zinc mineralization might be located through detailed fold geometry study.

A detailed mapping project in the Khartum area (No. 22) and a regional mapping project covering much of Renfrew County (No. 23) were completed in 1978 with funding provided by the Ministry of Treasury, Economics and Intergovernmental Affairs. The Renfrew project provides a basis for relating mineral deposits to geological environments and some preliminary conclusions on direction of exploration on a regional scale.

In northern Ontario helicopter supported detailed mapping in the Burntbush-Detour Lakes area (No. 12) and detailed mapping in the Rattray-McFadden Townships area (No. 17) were supported by the Ministry of Northern Affairs. The Amoco gold deposit discovery in the Detour Lake area has heightened exploration and development interest in the general area which formerly had received only reconnaissance examination. The Rattray-McFadden project represents the start of a program to study and determine the mineral potential of the Cobalt Embayment.

In support of the West Patricia Land Use Plan operation, a ground follow up investigation (No. 5) of uranium reconnaissance airborne surveys in northwestern Ontario was undertaken. The objectives of this project were to evaluate the uranium potential and classify mineral deposits located according to geological environments as a basis for evaluating regional potentials. Three types of uranium mineralization association were identified, however the total number of occurrences located was small.

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 1978-1979 winter period. These summaries and maps were designed as a means of rapidly disseminating highlights and general outlines of new information. More 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.

Reference

Bright, E.G.
No. 1 Slate Falls Area, District of Kenora

Henry Wallace

Introduction

During the 1978 field season the author completed a detailed mapping program (scale 1:15 840) in the Slate Falls area, begun in the summer of 1977. The total map-area covered approximately 570 km² bounded by Latitudes 51°07'5"N and 51°16'N and Longitudes 91°15'W and 91°45'W, and is centred about 120 km north of Sioux Lookout. Most of the work performed in 1978 was done in the western half of that area, around, and to the north of North Bamaji Lake.

Access to the area in the summer is restricted to float-equipped aircraft available for charter from Sioux Lookout, Red Lake and Pickle Lake. Within the area, excellent water access is provided by an extensive lake system including Fry, Bamaji, North Bamaji, Wesleyan and Kezik Lakes, which interconnect with large lakes of the Cat River — Albany River drainage system to the northwest and southeast.

Frequent aircraft traffic from Sioux Lookout services the small community at Slate Falls where telephone, radio and postal facilities are available.

A major hydro-electric transmission line which extends from Ear Falls to Pickle Lake transects the map-area.

Mineral Exploration History

Prospecting for gold began in this region in the late 1920s after discoveries around Red Lake to the west and Pickle Lake to the east. In 1927 a gold prospect was staked by P. Tivy near the southwestern shore of Wesleyan Lake (Laird 1930, p.22). The same ground was restaked and worked extensively by A. B. Connell, J. H. Stirrett and S. Williams in 1934 (Harding 1935, p.68).

A second gold occurrence was found by Connell Mining and Exploration Company Limited on the north shore of Fry Lake in 1935 (Harding 1935, p.69). This property was acquired in 1946 by Flicka Red Lake Mines Limited, and considerable prospecting, trenching and diamond drilling took place between 1946 and 1948 (Source Mineral Deposit Record, Geoscience Data Centre, Ontario Geological Survey, Toronto). A gold-silver occurrence at the eastern end of Bamaji Lake was trenched in 1965 by Dome Mines Limited and Sigma Mines (Quebec) Limited, but only low values were reported (Resident Geologist's Files, Ontario Ministry of Natural Resources, Sioux Lookout). In the same area in 1974 Dome Exploration (Canada) Limited performed ground magnetometer and electromagnetic surveys.

The Sanderson option, a gold-silver occurrence located about 5 km northeast of Slate Falls was investigated in 1966 by Cochenour Willans Gold Mines Limited. Extensive stripping and trenching were carried out, and nine diamond drill holes totalling 450 m in length were put down (Sage and Breaks 1976, p.322).
Uranium occurrences were discovered south of Moosetegon Lake in 1954 by McCombe Mining and Exploration Limited. Eleven shallow diamond drill holes totalling 172 m were put down along one mineralized zone at that time (Resident Geologist’s Files, Ontario Ministry of Natural Resources, Sioux Lookout). This area was re-examined by Kirkland Townsite Gold Mines Limited in 1968 when an airborne spectrometer survey was flown, and geological mapping and considerable trenching took place (Resident Geologist’s Files, Ontario Ministry of Natural Resources, Sioux Lookout). From 1969 to the present R. Knappett has done further prospecting and trenching in the area. Two smaller uranium-thorium showings have been located by Knappett east of the eastern end of North Bamaji Lake, and gold values have been reported along with the uranium-thorium (R. Knappett, personal communication). A small copper-silver occurrence just south of the easternmost extremity of North Bamaji Lake was also found by Knappett.

Several occurrences of molybdenite with pyrite and in some cases with chalcopyrite have been found around North Bamaji Lake since the discovery of the Loon Prospect (Sage and Breaks 1976, p.319) on the north shore of the largest island in the lake in the early 1960s. From 1965 to 1968 Cochenour Willans Gold Mines Limited did trenching, geological mapping, and 786 m of diamond drilling around the Loon prospect site (Resident Geologist’s Files, Ontario Ministry of Natural Resources, Sioux Lookout).

In the period from 1969 to 1974 a great deal of exploration activity occurred across this region principally in search of base metal sulphide deposits. In 1970, Canadian Onex Mines Limited flew a combined airborne magnetometer and electromagnetic survey over the central part of the map-area. This was followed up in 1971 with an induced polarization survey in the area to the north of North Bamaji Lake (Assessment Files Research Office, Ontario Geological Survey, Toronto).

In 1970-1971 Cochenour Willans Gold Mines Limited, in a joint project with Selco Exploration Company Limited performed a combined airborne geophysical survey covering much of the present area. This was followed immediately by a large number of ground magnetometer and electromagnetic surveys, geological and geochemical mapping and sampling programs, and considerable diamond drilling scattered throughout those parts of the area underlain by supracrustal rocks (Assessment Files Research Office, Ontario Geological Survey, Toronto).

In 1973 another airborne geophysical survey, including most of the present area, was commissioned by Union Miniere Explorations and Mining Corporation Limited. Diamond drilling of anomalies southwest of the western end of Fry Lake, north of Rockmere Lake, and in the northeastern corner of the map-area took place in 1974 (Assessment Files Research Office, Ontario Geological Survey, Toronto).

Since 1974 very little exploration activity has been reported, but recent renewed interest has been shown in the gold and uranium potential of the area.

**General Geology**

Up until 1977 when the current Ontario Geological Survey mapping program began, geological work in this area had been restricted to large scale reconnaissance mapping. Most of the present area was surveyed by Harding (1935) at a scale of 1:126,720. In 1960 it was mapped by Emslie (1960) at 1:253,440 as part of the “Roads to Resources” program. Most recently mapping was done in 1972 as part of Operation Pickle Lake (Sage and Breaks 1976), from which maps were prepared at a scale of 1:126,720.

This region is underlain by a variety of metamorphosed Early Precambrian (Archean) supracrustal and intrusive rocks belonging to the Uchi Belt geological subprovince (Ayres et al. 1971).

A succession of metavolcanics and metasediments occupies most of the northeastern part of the area around Fry, Moosetegon and Kaginot Lakes. The sequence narrows across the central part of the area north of North Bamaji Lake and pinches out north of Konegon Lake in the west. Metavolcanics are predominant, with major metasedimentary units occurring only along the northern and southern contacts with surrounding plutonic masses.

Between Fry Lake and Bamaji Lake the metavolcanics are mostly mafic pillow and massive flows with very few felsic to intermediate units. Many of these mafic flows are variolitic but most are equigranular amphibolite varying from aphanitic to very coarse-grained.

The only major felsic to intermediate metavolcanic sequence south of Fry Lake occurs along the northern shore of Bamaji Lake apparently overlying the northern mafic sequence. Dacitic to rhyolitic pyroclastic units altogether about 200 to 300 m thick strike parallel to the shore along much of the length of the lake. Most of the units are thin, well-bedded but highly sheared monolithic lapilli-tuff and lapillistone, but there are some relatively thick units (1-2 m) which may be classed as heterolithic lapillistone and tuff-breccia. Thinly bedded lenticular tuff and quartz-and feldspar-bearing crystal tuff units are common in a few places. In the area around the Fry-Bamaji Lake Falls the pyroclastic rocks are separated from the mafic sequence to the north by a wedge of polymeric orthoconglomerate in the south-central part of the area, south of North Bamaji Lake conglomeratic units containing high proportions of trondhjemitic clasts occupy similar stratigraphic positions. This conglomeratic sequence is believed by the author to unconformably overlie the trondhjemitic body around North Bamaji Lake. Hence the pyroclastic sequence along the Bamaji Lake shore belongs to a discrete cycle of volcanism considerably younger than that represented by rocks further north.

Along the southeastern shore of Bamaji Lake and along the northern side of the islands in the lake, fine clastic metasediments are predominant. Most of these rocks appear to be meta-wacke now biotite-plagioclase-quartz schists. Porphyroblasts of garnet and andalusite occur in some units but they are usually small. Despite metamorphic changes in textures and mineralogy, bedding and other primary sedimentary structures are commonly well preserved. Sparingly intercalated with these clastic
metasediments are fine grained, highly siliceous, laminaed units, some of which are weakly magnetic. These appear to be metamorphosed chert.

North of the east-west axis of Fry Lake the supracrustal sequence consists predominantly of mafic to intermediate pillowed flows interlayered with felsic to intermediate pyroclastic units, mostly lapillistone, lapilli-tuff and well-bedded (waterlain) tuff and crystal tuff. Some of the thicker pyroclastic units can be traced for several kilometres but most are thin discontinuous lenses. Most of these pyroclastic rocks are monolithic, the most common clast type being thylolite porphyry. Commonly the matrix material appears somewhat more mafic than the clasts. Included in the mixed sequence north of Fry Lake are several units of magnetic and pyritic chemical metasediments. These are rarely encountered in outcrop, but are known from drill hole data and can be traced in places on aeromagnetic maps (ODM 1976 a,b,c,d,e,f).

North of the metavolcanics, clastic metasediments, mostly feldspathic wacke-mudstone successions, form a relatively thick wedge overlying and in part interlayered with felsic to intermediate pyroclastic units.

Felsic to intermediate pyroclastic rocks are predominant around the southern part of Kagogit Lake. Most of the units consist of lapillistone and lapilli-tuff but coarse tuff-breccia was also mapped in several places. The pyroclastic sequence appears to thin rapidly toward the northeast and southwest where massive mafic flows predominate. It is not clear whether this thinning reflects primary topo-stratigraphic patterns or whether it is the product of structural deformation.

Along the southern shore of Bamaji Lake the supracrustal rocks are in contact with a large plutonic mass known as the Bamaji-Blackstone Granite (Sage and Breaks 1976). For the most part the contact is relatively sharp except for numerous minor felsspar and quartzfeldspar porphyry sills which intrude the metasediments for a few hundred metres to the north. In the extreme eastern part of the area the contact becomes migmatitic. The pluton consists predominantly of leucocratic foliated and gneissic biotite trondhjemite within the map-area. This very homogeneous body is separated from the supracrustal rocks to the north by a zone of massive to foliated, commonly xenolithic, hornblende trondhjemite and quartz diorite, about 450 m wide for most of its length.

This zone becomes more quartz monzonitic toward the southwest. Although the contact between these two trondhjemitic phases is not exposed it is believed to be intrusive since inclusions similar to the hornblende-rich phase are common in the leucocratic biotite trondhjemite especially near their mutual contact.

The areas around North Bamaji Lake and the southwestern corner of the map-area are underlain by leucocratic biotite trondhjemite which forms part of what has been called the “Bamaji Lake Complex” (Sage and Breaks 1976, p.309). In general the rocks in that area are characterized by high degrees of shearing and cataclasism. Only two major phases, one a medium to fine grained equigranular trondhjemite and the other a medium grained porphyroidal trondhjemite, were identified within this part of the “complex”. The highly deformed rocks around North Bamaji Lake may be the equivalents of less sheared granitoid trondhjemite to granodiorite rocks which occur north of the lake.

In the southwestern corner of the map-area highly foliated trondhjemitic rocks belonging to the “complex” are intruded by massive granitoid to pegmatoid quartz monzonitic rocks related to the Bamaji-Blackstone Granite, clearly establishing the relative ages of the two intrusions.

Along the south side of the large bay in the outlet from North Bamaji to Bamaji Lake, the upper contact of the “complex” is exposed. A regolithic unit about 3 m thick separates trondhjemite to the north from conglomeratic metasediments containing large trondhjemitic clasts to the south. This evidence supports the thesis that the “complex” is epizonal in emplacement (Sage and Breaks 1976, p.309).

In the central part of the map-area around Moose-tegon Lake and the eastern end of North Bamaji Lake, the main metavolcanic sequence is in irregular contact with the leucocratic trondhjemitic rocks of the “Bamaji Lake Complex”. A variety of porphyritic to equigranular trondhjemite to granodiorite dikes and sills ranging from less than 0.5 m to several tens of metres wide intrude the metavolcanics in such numbers that the contact is difficult to delineate precisely. These minor intrusions appear to be related to the “complex”.

The northern part of the area is underlain by granitoid rocks ranging in composition from biotite trondhjemite and quartz diorite to granite. Although distinct contacts between these phases are generally difficult to trace, throughout much of that area there appear to be a number of discrete, relatively homogeneous masses characterized by one or two predominant phases. In the extreme northwestern part of the map-area however, the intrusive history is very complex, with four or five major phases plus several minor intrusive varieties commonly occurring in single outcrops. In general the oldest phases are trondhjemitic and the youngest are quartz monzonitic to granitic.

Northeast of Fry Lake supracrustal rocks are intruded by massive hornblende granodiorite to syenodiorite of the subcircular Obaskaka Lake Pluton (Sage and Breaks 1976). Minor intrusions of felsic to intermediate feldspar and quartz porphyry are common particularly south of Fry Lake where they cut mostly mafic pillowed flows. By far the largest of these bodies is a massive feldspar porphyry plug, about 3 km by 1 km in dimensions, located on the southeastern shore of Fry Lake. The number and size of minor sills and dikes increase with proximity to the Bamaji Lake Complex in the central part of the area and to a lesser extent to the aforementioned porphyry plug in the eastern part. Pegmatitic, aplitic and felsic feldspar porphyry injections are ubiquitous within the Bamaji-Blackstone Granite and the immediate contact area.

Mafic sills appear to be very common within the southern Fry Lake metavolcanic sequence and in the north-central part of the area, but in many cases these rocks are indistinguishable from coarse amphibolitized mafic flows. Mafic to intermediate sills are also common within the supracrustal sequence along the axis of Bamaji Lake. Some of the larger bodies may be differentiated sills
Structural Geology

Major folds and faults can be recognized with reasonable confidence because of the excellent exposure in most parts of this area and because of the availability of detailed aeromagnetic maps (ODM 1976 a,b,c,d,e,f). Three major folds control the structure in the supracrustal sequence in this area. The largest and best defined is a complex isoclinal anticline. Part of this structure has an east-plunging axis and an east-trending axial trace which passes through the northern part of Fry Lake. East of Kaginot Lake this fold bifurcates with divergent axial traces curving to the north and southwest. The north-trending part of the fold which is relatively open, has an arcuate axial trace which extends northward out of the map-area between Burley and Scanes Lakes. Facing criteria are lacking in this part of the area. The structure is interpreted from lithologic and aeromagnetic data and from outcrop distribution patterns visible on air photos. The southwest-trending part of this fold system has an axial trace sub-parallel to the arms of Kaginot Lake. Limited facing criteria available indicate that this is an anticline. Closure to the southwest, which is evident from aeromagnetic data, suggests that this part of the main structure is southwest plunging, but minor structures in this area generally plunge toward the east or northeast.

The second major fold within the map-area is an east-trending syncline which is defined by aeromagnetic and outcrop distribution patterns and foliation patterns within relatively monotonous metavolcanic rocks. The axial trace extends from east of Moosetegon Lake, passing north of North Bamaji Lake to north of Konegon Lake where closure is obvious. Limited facing criteria and minor structural elements confirm this to be an east-plunging syncline.

A third major fold has an axial trace which extends sub-parallel to the power transmission line south of Moosetegon Lake. Interpretation of this fold is based on strong aeromagnetic evidence indicating closure to the northeast, and foliation patterns indicative of an antiformal structure.

Major faults and shear zones appear to be numerous in this area. They are recognized where major topographic lineaments occur in conjunction with obvious stratigraphic offsets, cataclastic textures in surrounding rocks, minor structures, etc. The longest fault runs down the length of Bamaji Lake parallel or sub-parallel to the strike of the supracrustal rocks. Rocks on the north shore of the lake are intensely sheared, and spectacular veinlets of pseudotachylite are quite common over a width of at least 200 m across the fault zone. The abundance of perfectly preserved pseudotachylite suggests that shearing along this zone was late in the deformational and metamorphic history of the area.

Several northeast-trending faults and lineaments meet the main fault zone at acute angles. None were observed to cross the main fault. In the central part of the area several major and numerous minor east-trending faults and shear zones splay out from the main fault zone and extend across the “Bamaji Lake Complex”, giving rise to its general cataclastic character. In the north-central part of the area between Kaginot Lake and the northern part of Fry Lake, the rocks are cut by a number of northeast and northwest trending fault sets which severely complicate stratigraphic correlation in that part of the supracrustal sequence. Very strong linear features are common in the large areas in the northwestern and southeastern parts of the map-area underlain by granitoid rocks. Most of these are probably faults but definitive criteria recognizable on the ground are generally lacking.

Minor structural elements generally parallel the major features. Mineral foliation is visible in most rock-types in the area, both supracrustal and intrusive. Generally this foliation parallels primary lithologic boundaries, as does foliation produced by the flattening of conglomerate clasts, pyroclastic tephra, pillows, etc. Gneissosity is developed to varying degrees parallel to mineral foliation in trondhjemitic rocks southeast of Bamaji Lake, and in some of the mafic intrusions exposed on the islands and along the shore of Bamaji Lake.

Economic Geology

Gold and Silver

Gold and/or silver values have been reported from most of the base metal and uranium showings in quartz veins and shear zones, but few precise assay results are available. Several of these are described in the following sections.

One occurrence under recent investigation primarily for gold and silver is known as the Sanderson option located 5 km northeast of Slate Falls (Sage and Breaks 1976, p.322). Pyrite, sphalerite, tetrahedrite, pyrrhotite and galena occur disseminated within narrow quartz veins following an east-trending shear zone which cuts mafic metavolcanics. One sample of mineralized quartz was assayed and found to contain 34.41 ounces of silver per ton, 0.47 ounces of gold per ton, and 1.49 percent copper (Sage and Breaks 1976).

A gold occurrence known as the Connell-Stirrett-Wil-
Uranium

A number of uranium-thorium occurrences are known in the area between Moosetegon, Bamaji and North Bamaji Lakes. Two of these have been described in some detail by Sage and Breaks (1976, p.329), and the main showing which is just south of a small lake about 1 km south of the western end of Moosetegon Lake is also described in another section of this volume (see Bond and Breaks, this volume).

In the main showing radioactivity was found in a series of trenches over a strike length of at least 125 m. The uranium and thorium occur in what appears to be a stratigraphic unit of calc-silicate material up to 3 m wide. This unit is approximately N75E, consisting of actinolite, calcite, dolomite and magnetite. Adjacent to the calc-silicate unit in several trenches is what appears to be a pyritiferous chert. The highest scintillometer readings were obtained from the calc-silicate unit rich in actinolite (host mineralogy for the uranium-thorium has yet to be determined). By comparison the surrounding mafic metavolcanics and ubiquitous sill-like trondhjemitic to granodioritic lenses gave low readings. Gold assays of 0.40 and 0.20 ounces per ton were reported from pyritic chert and pyritic trondhjemite from trenches at this showing (Sage and Breaks 1976, p.332).

A second area of abnormally high radioactivity is located about 700 m west of the main occurrence. In a series of shallow trenches, narrow veinlets (2 to 4 cm) of actinolite-biotite are seen to cut porphyritic biotite trondhjemite. Scintillometer readings indicate that uranium-thorium is concentrated within these veinlets. However, analyses of grab samples collected by Sage and Breaks (1976) of the veinlet material and of the surrounding trondhjemite gave values of 0.04 percent U$_{308}$ and 0.06 percent U$_{208}$ respectively (Sage and Breaks 1976, p.332).

A third showing found by R. Knappett by reconnaissance prospecting with scintillometer, is located about 600 m south of the eastern end of North Bamaji Lake. It consists of a thin (less than 40.7 m) unit of calc-silicate material, predominantly actinolite. This unit is somewhat similar to the host rock in the main showing which is approximately 1000 m along the regional strike to the east. The unit is brecciated and surrounded by trondhjemitic rocks which exhibit very low radiometric characteristics. Maximum scintillometer reading recorded here were generally a full order of magnitude lower than those taken at the main showing.

Molybdenum

The occurrence of molybdenite has been known for many years in several places within trondhjemitic rocks around North Bamaji Lake and the western end of Senior Lake. During the present survey it was also found in small quantities in two localities around the eastern end of Bamaji Lake within the Bamaji-Blackstone Granite (Wallace 1977, p.7), and on the shore of Kezik Lake just north of the map-area south of Lemon Island. These showings and prospects are described in detail in the appendix to this report, "Molybdenum Mineralization in the Slate Falls area" by I. Sutherland.

Chalcopyrite along with pyrite and molybdenite occurs sparsely disseminated within the trondhjemite of the Bamaji Lake Complex, and known quartz vein molybdenite deposits such as the Loon prospect invariably contain significant chalcopyrite. Significant copper contents from shear zones and associated quartz veins cutting metavolcanics were also reported in such places as the Sanderson option north of North Bamaji Lake (Sage and Breaks 1976, p.322) and the Knappet discovery south of the eastern end of North Bamaji Lake (Sage and Breaks 1976, p.322). The Knappett discovery south of the eastern end of North Bamaji Lake (Sage and Breaks 1976, p.322). Minor amounts of chalcopyrite with much more abundant pyrite and pyrrhotite have been reported from diamond drilling and other exploration work in mafic metavolcanics, intermediate to felsic pyroclastic rocks, felsic to intermediate intrusive rocks, mafic intrusive rocks and chemical metasediments in many parts of the area. Reported assay values however have shown only traces of copper.

Recommendations for Future Mineral Exploration

Although disseminated sulphide mineralization (pyrite and pyrrhotite) is widespread in the trondhjemitic rocks near the southern shore of North Bamaji Lake, nearly all of the molybdenite and chalcopyrite found in mapping the area was restricted to quartz vein occurrences. Where disseminated molybdenite was observed, evidence suggested
that its formation post-dated the pervasive mineral foliation. This tends to run counter to the theory that the mineralization here is of the "porphyry-type" (Wallace 1977, p.8). Instead, the concentration of the molybdenite-chalcopyrite occurrences near the southern part of the "complex" in and near quartz veins and pegmatite bodies which also clearly cross-cut the host rocks' mineral foliation suggests that the hydrothermal fluids which produced the mineralized veins were very much later than the "complex" intrusive event, and that they may have been derived from the younger quartz monzonitic body to the southwest of North Bamaji Lake. If these inferences are correct the granitoid terrain in the southwestern part of Bamaji Lake warrants investigation for molybdenite.

Although economically significant deposits of uranium-thorium in Early Precambrian (Archean) rocks are rare, the potential in this area should not be discounted. The considerable strike length of the main uranium showing south of the western end of Moosetegon Lake and the probability that at least one other similar showing occurs along strike suggests that a chemical metasedimentary unit comprising appreciable tonnages may be involved. Detailed radiometric surveys should be performed in this area particularly along strike to the east and west of the main zone, in order to establish the dimensions of the known calc-silicate unit and possibly to find other similar units. The east-northeast trending fold structure interpreted in this area suggests that similar stratigraphy may be found between Rockmere and Moosetegon Lakes and south of the northern half of Moosetegon Lake.

The metavolcanic sequences exposed along the large bays north of the western arm of Fry Lake and in the southern part of Kaginot Lake contain high proportions of intermediate to felsic pyroclastic rocks not noted on previous maps. Many of these units include phases as coarse as tuff-breccia and pyroclastic breccia. The large tephra is commonly rhyolitic to rhyodacitic in composition. Although visible sulphide mineralization appears relatively sparse in these rocks the area would appear to be worthy of further examination because lithologies present indicate an environment potentially favourable to the deposition of synvolcanic base metal sulphides and because there has been little previous mineral exploration in this part of the belt.

The same general remarks apply to the relatively thin sequence of pyroclastic rocks along the north shore of Bamaji Lake. This sequence represents a cycle of volcanism significantly younger than that which affected other parts of the area, with distinct chemical and metallogenic characteristics.

Molybdenum Mineralization in the Slate Falls Area
I.G. Sutherland

Introduction

During the mapping of the Slate Falls area the opportunity was taken to carry out detailed examination of the mineralization associated with the "Bamaji complex" in the context of its similarities to porphyry deposits (Colvine, this volume). While this work demonstrated that the mineralization was not associated with an epizonal intrusive affinity, the actual nature and extent of mineralization and indications of geological controls on mineralization were determined. The principal occurrences of mineralization are described below.

Loon Prospect

The Loon prospect is the largest and richest known occurrence of molybdenite in the area. It is located (see Figure 1) on the largest island in North Bamaji Lake and exposed primarily along the north-central shore of the island. First discovered by the Loon family of Slate Falls in the early 1960s, the property was then optioned in 1965 to Cochenour Williams Gold Mines Limited. Stripping, trenching, diamond drilling (784 m) and geological mapping of the claim group followed but the mineralization was determined to be uneconomic (Sage and Breaks 1976).

Molybdenite mineralization occurs sporadically throughout this large island but most of the known mineralized veins are restricted to the two northeasterly trending peninsulas on the north shore of the island and to a small island located about 300 m north of the easternmost peninsula. The molybdenite occurs with pyrite and traces of chalcopyrite and is confined to a complex series of quartz veins, lenses, and pods and, to a limited extent, the adjacent host rocks. This quartz vein system is hosted in variably sheared and recrystallized, leucocratic trondhjemites which are foliated in a primarily east-northeast direction; localized zones of shear resulting in minor foliation variations to east-southeast are common. The quartz veins are generally fairly fresh with little evidence of shearing apparent. The vein quartz varies from glossy to white and saccaroidal and most veins are locally very rusty from the oxidation-hydration of sulphides. In thin section the vein quartz is generally highly strained and polygonized with many grains displaying strain lamellae. Contact definition of the veins with host rocks ranges from very sharp to gradational, even within individual veins. The lenses and veins are very irregular in

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Figure 1—Distribution of molybdenum mineralization in the Slate Falls area.
terms of shape, size, orientation, and continuity. The amounts and types of sulphide and accessory minerals are also highly variable both within and between individual veins.

Many veins are fairly straight and pinch at the ends; others, particularly the larger and better mineralized veins, pinch and swell erratically and, in many cases, grade into a series of quartz lenses and/or pods. Veins and lenses occur both parallel or subparallel to the host rock foliation, especially in highly sheared zones, and across the same foliation direction.

Molybdenite is present as disseminations, banded disseminations, narrow seams and veinlets, disseminated clots, and as a thin paint within the quartz veining but minor stringers and disseminations also occur within the adjacent host rocks. Molybdenite mineralization is restricted to individual veins and not a particular zone. The richest observed vein occurs adjacent to a 15 cm vein of white quartz with trace pyrite. Pyrite is the most abundant sulphide and it is present within the quartz veins, along the quartz veins, along the quartz vein contacts, and in the immediate host rocks as disseminations to semi-massive and massive patches. Chalcopyrite occurs very sporadically and only in trace amounts within the quartz veins. Hydration and oxidation products, including ferrimolybdate, ilmenite, and malachite, are common.

Accessory minerals are present in many of the quartz veins in variable amounts. The richest of the molybdenite-bearing veins also hosts minor amounts of coarse grained biotite, fine to coarse grained, partially chloritized actinolite, epidote, and coarse grained, prismatic tourmaline. Other veins also have varying combinations and quantities of these accessories present as well a potassium feldspar. Smaller stringers and veinlets of quartz-tourmaline, quartz-actinolite, epidote, and muscovite were observed on the same island.

**Other Showings**

Other smaller molybdenite showings were observed in the vicinity of the community of Slate Falls, along the Cat River draining North Bamaji Lake into Bamaji Lake, and near the west end of Konegon Lake.

A small showing of quartz vein-hosted sulphides, including molybdenite, is located approximately 3 km north-east of Slate Falls. The host rock is a highly sheared, mostly fine grained, white, felsic rock which has apparently been highly silicified. The only exposure is in a small trench with poor exposure but the country rocks of the intermediate area are predominantly weakly foliated mafic metavolcanics with sills of interfingered biotite trondhjemite occurring to the south. The vein quartz is grey to white with bands and patches of potassium feldspar concentrations. Sulphide minerals are also concentrated in patches with pyrite and trace amounts of sphalerite, molybdenite, and chalcopyrite all present.

Two kilometres southwest of Slate Falls along the northwest shore of North Bamaji Lake is a small molybdenite showing in highly sheared trondhjemite. Minor pyrite, molybdenite, and chalcopyrite occur in a white quartz vein up to about 10 cm wide. Due to limited exposure, shape and extent of the vein is unknown. Pyrite occurs as disseminations and semi-massive patches within the quartz vein and as disseminations in the sheared wall rocks. Molybdenite disseminations and paint occur in localized amounts within the quartz vein. A single, disseminated grain of chalcopyrite was also observed with pyrite in the vein material.

A similar showing was described by Sage and Breaks (1976) on a small island 1.5 km southeast of Slate Falls where molybdenite, pyrite, chalcopyrite, and fluorite were reported in a quartz vein. Due to high water levels this occurrence was not seen by the author. Along the shore chip samples of white quartz vein with minor disseminated molybdenite and of quartz-muscovite-chlorite-tourmaline schist were found. This occurrence is located about 2.5 km east of the previously described showing.

Two separate showings of molybdenite were found near Konegon Lake to the west of North Bamaji Lake; one is located about 1 km north of the western tip of Konegon Lake, just north of the hydro-electric power line and the other occurs about 1.5 km west of the same end of the lake. Both showings have only a trace of molybdenite in small irregular quartz veins. Host rocks are moderately sheared and foliated, biotite trondhjemite to granodiorite.

A number of small, scattered molybdenite occurrences are present along the Cat River channel flowing south from North Bamaji Lake into Bamaji Lake, primarily along the western shore. Trace amounts of molybdenite occur in quartz and quartz-feldspar veins/veinlets and as disseminations within the country rocks. Host rocks are mostly highly sheared and recrystallized, frequently quartz-porphyroblastic, biotite to muscovite-biotite trondhjemite and granodiorite. Abundant medium grained to pegmatoid quartz monzonite dikes cut the country rocks in this area but no molybdenite was found in these. Evidence for metasomatism and/or element remobilization includes: biotite stringer veinlets that cut the foliation; localized abundances of prismatic tourmaline, especially in very highly sheared zones; patchy distribution of potassium feldspar in many of the rocks; and very broad zones of high shear and abundant sericitization resulting in extensive muscovite-chlorite schist. Most of the showings of molybdenite are present as fine to medium grained, disseminated flakes which are commonly oriented across the foliation along late stage fractures. One such fracture had a small lens of aggregated molybdenite flakes along it. The remaining showings occur as very small pods (2-3 mm) or as disseminations of molybdenite along the outer edges of small, irregular quartz and quartz-potassium feldspar veins or veinlets.

Molybdenite occurs in numerous, small showings along the northeast and southwest shores of Senior Lake. The largest of these showings is located at the entrance to the large bay in the north-central region of Senior Lake. It consists of a mineralized quartz vein that occupies the intrusive contact between a fine to medium grained 'felsite' to the south and a weakly foliated to unfoliated, epidote-biotite trondhjemite to granodiorite to the north. The 'felsite' is mineralized with fine grained, disseminated py-
rite and is cut by tiny epidote stringers. Both of the intrusive phases are cut by minor dikellets of coarse grained to pegmatoid quartz monzonite. The quartz vein is about 20 cm at its widest and best mineralized location and it pinches out to the east and west. Molybdenite mineralization of locally up to 15 percent MoS₂ occurs as disseminations, banded disseminations, small stringers, and paint, primarily within the quartz vein with disseminated pyrite. Pyrite occurs in varying amounts over the entire exposed length of the quartz vein (approximately 25 m) but the presence of molybdenite is restricted to only about 5 m of the vein.

The two neighbouring outcrops to the north and south host small irregular quartz veins with minor disseminated pyrite, especially along the borders, and traces of disseminated molybdenite. The country rocks are the same weakly foliated biotite trondhjemite to granodiorite.

Four, adjacent occurrences are present to the north-east of the same large bay along the northwestern shore. Minor pyrite and traces of molybdenite ± chalcopyrite occur in small, irregular quartz-potassium feldspar veins or lenses. The host rock is a weakly foliated biotite trondhjemite to granodiorite. The host rock foliation of S70E is cut by an east-west trending, mineralized, quartz-epidote-chlorite veins of 2 to 5 cm in width and of irregular shape with a few, small, mafic inclusions that is cut by felsite dikes of variable width, many of which are pyritic, pegmatoid, quartz monzonite dikes, and pyritic to barren quartz veins.

Along the southern shore of Senior Lake, due east of the previous showings, a small occurrence of molybdenite in a quartz vein system was found, hosted in a weakly foliated, biotite-rich (locally chloritized), trondhjemite to granodiorite. The host rock foliation of S70E is cut by an east-west trending mineralized, quartz-epidote-chlorite vein of 2 to 5 cm in width and of irregular shape with a few, small, branching veinlets. Fracture controlled epidote veinlets and stringers are also present with abundant iron and possibly silica metasomatism adjacent to them. Fine to medium grained, disseminated cubes of pyrite and disseminations and disseminated clots of molybdenite are restricted to the quartz vein material. Molybdenite is present in amounts up to 2 percent but this mineralization is very localized in extent, and many nearby quartz veins are essentially barren of any sulphides.

A single molybdenite occurrence is located in a small bay of Kezik Lake approximately 820 m north of the northern edge of the Slate Falls map-area, just next to the north-south boundary between Red Lake and Patricia mining division Inequigranular, medium to coarse grained, biotite trondhjemite to granodiorite is cut by dikes of an intermediate intrusive rock, coarse grained quartz monzonite dikes, and mineralized quartz-potassium feldspar veins. Only one such quartz-feldspar vein was found to contain molybdenite where it occurs in trace amounts with 1 to 2 percent disseminated pyrite, and accessory biotite and tourmaline. The vein is of variable width (up to 8 cm) and both the quartz vein and the adjacent wall rocks are mineralized with pyrite and molybdenite as disseminations and narrow stringers and seams. Medium to coarse grained, prismatic tourmaline occurs as small clusters within the vein material. These small occurrences appear to be too limited in extent and too widely scattered to be of economic significance.

References


No. 2  Birch Lake Area, District of Kenora, Patricia Portion

P.C. Thurston¹

Location

The centre of the map-area lies 116 km northeast of Red Lake. The eastern portion of the area from Casummit Lake eastward and from Springpole Lake eastward was mapped this season. Access to the area is by float- or ski-equipped aircraft from Red Lake or Ear Falls. Within the map-area Birch Lake and Springpole Lake are interconnected by an excellent portage. Springpole Lake and Seagrave Lake are connected by a good portage; Casummit Creek connecting Casummit Lake and Birch Lake is navigable by canoe with little difficulty.

Mineral Exploration²

The exploration history of the area was described in Thurston (1977). Within the eastern part of the map-area, the following are the major properties:

Grand Bay Explorations Limited owns a group of patented claims west and south of Casummit Lake. Geological mapping in a continuing gold exploration program was carried out in 1976.

Amax Exploration Incorporated conducted an airborne electromagnetic survey and ground follow-up in 1973 and 1974 over most of the area north of Birch Lake. Bralorne Can-Fer Resources Limited examined Cu-Mo mineralization south of Mink Lake in 1969-1970. Canex Aerial Exploration Limited performed an electromagnetic survey and diamond drill holes were drilled for a total of 792 m in an area covering the central portion of Birch Lake in 1969-1970².

M. Kostynuk held several groups of claims centered upon Richardson Lake and the eastern part of Casummit Lake. A portion of this was optioned in 1962 to Cochenour Willans Gold Mines Limited who drilled 10 diamond drill holes with a total footage of 647 m on the property east of Casummit Lake in 1974². The group of claims north of Richardson Lake achieved production of 1126 ounces² of gold during the period using a shallow shaft. Four holes totalling 639 m were drilled by Cochenour Willans Gold Mines Limited on their own property north of Casummit Lake in a gold exploration project in 1962². Cochenour Willans Gold Mines Limited also did further drilling (11 holes, 1591 m) in 1975 on the gold deposit of Argyso Gold Mines Limited².

Dickenson Mines Limited diamond drilled 11 holes (327 m) in 1960 and 1962 on a claim group at Richardson Lake². Following an electromagnetic survey Dome Exploration (Canada) Limited did diamond drilling (691 m) on anomalies north of Birch Lake in the Joneston Lake area². In 1969 Falconbridge Nickel Mines Limited examined the

¹ Northern Archean Subsection Leader, Precambrian Geology Section, Ontario Geological Survey, Toronto.
² Information from Resident Geologist’s Files, Ontario Ministry of Natural Resources, Red Lake.
Johnson Island area of Birch Lake with airborne magnetometer and electromagnetic surveys followed by diamond drilling (482 m). A gold prospect owned by K. Koetzur on Deer Island was optioned to Falconbridge Nickel Mines Limited in 1970.

A gold prospect east of Keigat Bay of Birch Lake has been held by O.J. Stoops, K. Koetzur and Canamer Mining Corporation at various times and an unknown number of diamond drill holes were drilled (380 m) in about 1966.

Exploration for volcanogenic massive sulphide mineral deposits is currently being conducted by Selco Mining Corporation Limited and the Dighem Syndicate in the area.

**General Geology**

All bedrock in the map-area is Early Precambrian in age; part of the Birch-Uchi Lakes metavolcanic-metasedimentary belt within the Uchi Subprovince (Ayres et al. 1971). Previous mapping of parts of the area (Furse 1933; Harding 1936; Horwood 1937) was at a reconnaissance scale. The present mapping is an attempt to extend the units found to the south (Thurston 1975, 1976) into this area. The major results of this approach are:

1. The intermediate and felsic metavolcanics centered on Shabumeni Lake are correlated with Cycle II in the Confederation Lake area (Thurston 1976);
2. The mafic to felsic metavolcanics centered on Seagrave Lake are correlated with Confederation Lake Cycle I;
3. The metasediments centered on Birch Lake are younger than Confederation Lake Cycle III.

The major supracrustal lithologies in the map-area proceeding from north to south are:

1. East-trending mafic metavolcanics extending from north of Casummit Lake through to the east boundary of the map sheet;
2. East-trending meta-wackes and minor ironstone at the east end of Birch Lake which may be stratigraphically correlated with felsic and intermediate pyroclastic rocks found at Casummit Lake and to the west;
3. Southeast-trending, steeply dipping mafic metavolcanics succeeded to the south in the area of Springpole Lake by shallow northward dipping (15-25 degrees) mafic flows and intermediate pyroclastic rocks;
4. The southern part of the area, around Seagrave Lake, is underlain by steeply dipping mafic metavolcanics with subordinate amounts of distal facies intermediate and felsic pyroclastic rocks.

**Structural Geology**

In the portion of the area mapped this year, the rocks strike in an easterly direction. The units in the area have been subdivided into a steeply dipping suite with dips in the 60-90 degrees range and a shallowly dipping suite with dips in the range 15-45 degrees.

Within the steeply dipping suite a major syncline occurs centered upon the east end of Birch Lake, succeeded well to the south in the Seagrave Lake area, by a syncline centered upon the central part of Seagrave Lake and an anticline which extends from McNaughton Township to the area north of Bertha Lake (Johns 1977).

The shallowly dipping suite forms an anticline centered upon the north-south portion of Springpole Lake. Other occurrences of the shallowly dipping suite are:

1. The Shabumeni Lake fault (Thurston 1977) which extends along the east shore of Shabumeni Lake and then north-northeastward to Mink Lake;
2. The Swain-Birch Lake fault, an extension of the Swain Lake fault of Goodwin (1967) which extends from just north of Swain Lake to the southwest bay of Birch Lake;
3. The Grace Lake fault branches from the Swain-Birch Lake fault and extends southeastward from the east end of Swain Lake through Grace Lake.

**Economic Geology**

Gold exploration in the map-area has concentrated upon chert horizons and discordant quartz veins. The Argosy mine produced during its operating life (1934-1938, 1940-1942, 1946-1952) a total of 250,903 t yielding 3168.67 kg Au and 55.61 kg of Ag.1 There gold occurs in discordant quartz veins cutting metasedimentary and felsic metavolcanic rocks at a high angle.

Gold occurs in association with concordant sulphide pods (pyrite) and discordant quartz veins cutting oxide facies ironstone on the Canamer Mining Corporation property on the east end of Birch Lake.

Base-metal sulphide mineralization was examined in gabbroic rocks in the Superstition Lake area.

The lens of felsic metavolcanics centered on the north shore of Birch Lake and a body of felsic quartz porphyry and associated spherulitic felsic meta-pyroclastic rocks on the northern portion of Birch Lake are the two major areas with potential for volcanogenic base-metal sulphide mineralization within the map-area.

The recent higher price of gold increases the potential of some occurrences in the map-area, particularly the Argosy mine. There, the ironstone and the felsic metavolcanics ought to be examined with a view to large tonnage, low grade operation. The price rise also increases the potential of the Canamer occurrence, as it is somewhat reminiscent of the gold occurrences at Pickle Crow (Thomson 1938).

1Information from Resident Geologists Files, Ontario Ministry of Natural Resources, Red Lake.
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Introduction

During the 1978 field season, a two year project was initiated to map in detail at a scale of 1 inch to 880 feet (1:10 560) the Townships of Byshe, Ranger, Willans, and Heyson in the southeast portion of the Red Lake Early Precambrian metavolcanic-metasedimentary belt. During the summer, mapping was virtually completed in Byshe, Ranger and Willans Townships to the south and east of Balmer Township mapped in 1977 (Pirie and Grant 1978).

Access

Most of the three townships are accessible by water from Keg, Gullrock and Ranger Lakes which are part of the Chukuni River system draining southeast from Red Lake itself. The west side of Byshe Township is accessible from Highway 105 which joins Red Lake with Ear Falls and Highway 17. The east side of Willans Township can be reached from the Reed Limited logging road to their Camp 81 which trends north northeast from Highway 105 near the Snowshoe Portage on the Chukuni River to an area just south of Sobel Lake, some 5 km east of the northeast corner of Willans Township. The northern and eastern parts of Ranger Township can only be reached on foot from Ranger Lake or by helicopter landing in small clearings in swamps. Much of the eastern parts of Ranger and Willans Townships are poorly exposed due to extensive sand, gravel and till as well as swamp cover related to outwash from the large Trout Lake Moraine some 10 km to the northeast.

Mineral Exploration

In the past the map-area has been explored for gold and more recently for base metals but few mineral showings have been discovered. In Ranger Township exploration activity has been confined to the southwest portion adjoining Balmer Township to the west where the mafic metavolcanics and associated narrow interflow metasediments trend east-southeast to Gullrock and Ranger Lakes. In 1946 Abbot Red Lake Mines Limited conducted some detailed geological mapping and a magnetometer survey. In the same year on an adjoining property, Lauder Red Lake Mines Limited carried out geological mapping and diamond drilled 1573 m in eight holes, most of which was carried out on the Balmer Township side of the property. Found Lake Mines Limited in the same year also did

1 Geologist, Precambrian Geology Section, Ontario Geological Survey, Toronto.
2 Information from Resident Geologist’s Files, Ontario Ministry of Natural Resources, Red Lake.
geological mapping and diamond drilled 884 m in 10 holes on their property which also straddled the Balmer Township boundary to the north of those mentioned above. Also in 1946 Ketona Red Lake Mines Limited carried out a magnetometer survey of their property which adjoined the Found Lake Mines Limited property to the east. In 1970 following airborne and ground electromagnetic surveys, Cochenour Williams Gold Mines Limited diamond drilled 555 m in nine holes on their property southwest of Ranger Lake but intersected only barren sulphide mineralization in interfowl metasediments.

In Williams Township exploration has been confined mainly to the belt of mafic metavolcanics which trend east-southeast from the northwest corner of the township. In 1947 J.G. Gordon diamond drilled 83 m in three holes and in 1949. J. Ashford diamond drilled 59 m in two holes on their respective properties on the east shore of Gullrock Lake. Eros Red Lake Mines Limited held claims in the northwest corner of the township extending into Byshe and Ranger Townships and on the east side of Gullrock Lake. They diamond-drilled a total of 1836 m in seven holes in the northwest corner of Williams Township. In 1960 Conquest Exploration Limited conducted trenching and diamond drilled 619 m in fifteen holes on their property east of Gullrock Lake. Much of their activity was centred around a quartz vein which contained local concentrations of pyrrhotite, pyrite, galena, sphalerite and chalcopyrite. In 1965 Northolt Mining Corporation Limited conducted a magnetometer survey over the same property and diamond drilled 307 m in three holes in the following year. On the property to the east in 1965, Gullrock Mining Corporation Limited carried out ground electromagnetic and magnetometer surveys. In 1966 Canadian Nickel Company Limited diamond drilled 151 m in one hole on a small claim group just north of Williams Lake. In the same year, Lancaster Mining Corporation Limited carried out electromagnetic and magnetometer surveys and diamond drilled 305 m in two holes on their claims which extended across the northwest corner of the township into Byshe Township. In 1969 Cochenour Williams Gold Mines Limited conducted a ground electromagnetic survey and diamond drilled 125 m in two holes in the northwest part of the township. In 1976, Selco Mining Corporation Limited carried out ground geophysical surveys to check airborne electromagnetic survey anomalies but did not observe any significant new anomalies. In 1978 the same company conducted an airborne electromagnetic survey over part of the northern half of the township and presently hold a block of claims east of Gullrock Lake.

In Byshe Township past exploration activity has been confined to the western and northern part of the township. In 1945, Detrocana Gold Mines Limited diamond drilled 987 m in five holes on their property which straddled the township boundary with Heysen around Sully Creek. In 1947 Valloc Gold Mines Limited carried out geological mapping and magnetometer surveys on their property just north of Sully Creek. In 1950 the Woodford Syndicate carried out similar surveys on their property northwest of Keg Lake. In 1959, Queensland Explorations Limited conducted geological mapping and a self potential survey on their claims west of Keg Lake and in the same area in 1973 Hudson Bay Exploration and Development Company Limited followed up a ground electromagnetic survey with 87 m of diamond drilling in one hole. In 1963 Dickenson Mines Limited diamond drilled 416 m in one hole on their claims north of Keg Lake. To the northeast of Keg Lake, L.W. Hermiston held claims which included a trenched showing of base metal sulphides in intermediate metavolcanics. The claims were optioned by Kerr Addison Mines Limited who conducted a ground electromagnetic survey in 1969 over the area of interest. In 1972 the owner diamond drilled 40 m in one hole on the property. In 1973, the property was optioned by Mid-North Engineering Services who conducted ground electromagnetic and magnetometer surveys and diamond drilled 822 m in eight holes. In 1969 Cochenour Williams Gold Mines Limited followed up an airborne electromagnetic anomaly by diamond drilling 95 m in one hole near the mouth of Sully Creek on Keg Lake. In 1971, the same company carried out magnetometer and electromagnetic surveys on claims east of Chukuni River north of Keg Lake. In 1966 Peterson Red Lake Mines Limited conducted trenching and diamond drilled 3037 m in 37 holes on their property south of the Chukuni River extending northwards into Balmer Township. Minor chalcopyrite-pyrite vein mineralization was encountered in the trondhjemitic phase of the intermediate intrusive complex which underlies much of the claims.

General Geology

Regional geological mapping was carried out by Horwood (1940) on all three townships. Unpublished detailed mapping of Byshe Township was carried out during the early 1970s under the supervision of R.A. Riley, then resident geologist at Red Lake, and these data were used extensively during the present fieldwork.

Most of Byshe Township is underlain by a sequence of Early Precambrian metavolcanics which is progressively migmatized towards the south, eastwards into Williams Township and northeastwards into Ranger Township where the metavolcanics are in contact with coarse grained batholithic rocks.

The east-southeast trending sequence of mafic metavolcanics with minor interfowl metasediments mapped in Balmer Township (Pirie and Grant 1978) continues southwards through Ranger and Williams Townships and is in contact with batholithic rocks to the northeast in Ranger Township. The mafic metavolcanics are fine grained, generally well foliated to schistose near the batholith and commonly have a light to dark striped appearance due to epidote alteration. Locally pillow structures with altered interiors are present. Compositionally these mafic rocks vary from tholeiitic to highly magnesian (basaltic komatiite). Southwards from the batholith in Williams Township, the mafic rocks are less foliated, more commonly pillow, locally variolitic and with medium grained massive flow interiors. The interfowl metasediments comprise thin layered chert with pyrite, pyrrhotite and garnet-
rich layers and laminations with clastic lithic wacke interbeds in places. Southwards from Balmer Township into Byshe Township, the mafic metavolcanics become intermixed with feldspar porphyritic tuffs lapillstene and tuff-breccia of intermediate composition and themselves tend towards an intermediate composition although pillow structures, pillow breccias, flow-top breccias and quartz filled amygdules are still present in places. On the east side of Keg Lake, these rocks are intermixed with characteristic crowded plagioclase-porphyritic intermediate metavolcanic flows which contain knots of biotite and are locally pillowed and brecciated at flow tops. This material underlies much of the northern part of Keg Lake but interdigitates westwards and is interbedded southwards with another characteristic thick unit of monolithic to heterolithic lapillitstone containing angular fragments of fine-grained dark material which varies from intermediate to mafic composition from place to place. The minor amount of matrix is fine grained and more chloritic in composition than the clasts. The origin of this unit which is up to 12 km in strike length and up to 1.5 km thick at the thickest part around the south end of Keg Lake is uncertain, but it does appear to be pyroclastic rather than hyalo-clastic.

South of the intermediate to mafic lapillitstone unit east and west of Starratt Channel is a sequence of felsic flows, tuff, lapilli-tuff and minor lapillitstone which can be subdivided using the quartz-plagioclase phenocryst ratio into units of plagioclase-porphyritic tuff and flows with colour index about 10 to 15 and quartz-rich tuff, lapilli tuff and minor flows which are generally medium bedded and ungraded with colour index 5 to 8. Some of the quartz-rich beds may have been reworked but others contain pumiceous fragments and are of pyroclastic origin.

On the large peninsula in the southwest portion of Byshe Township these felsic rocks become progressively more metamorphosed and recrystallized and contain variable proportions of coarse-grained granitic material, although commonly retaining the original layering and coarser breccia structures. Eastwards across the islands in southeast Byshe Township and the southern half of Willans Township the high grade equivalents of the felsic metavolcanics are intimately associated with coarse pink granitoid material. In the extreme southwest corner of Byshe Township, the felsic metavolcanics are partly intermixed with units of intermediate metavolcanic flows of two types. One is fine grained, medium green, highly amygdulitic, locally pillow and brecciated and the other contains plentiful plagioclase phenocrysts commonly over 1 cm in length set in a matrix similar to the amygdular flow type. These flows are also well pillowed in places to the west in Heyson Township.

Intruded into the metavolcanics in the northern part of Byshe Township are a number of intermediate phases which form a complex known locally as the “Howey Diorite”. The eastern portion of the complex is largely composed of medium-grained, massive to foliated trondhjemite to quartz diorite with colour index 10 to 18 due to biotite, chlorite and tremolitic amphibole. The western portion contains a medium- to coarse-grained diorite phase to the south of the small bay in the Chukuni River. It has variable colour index greater than 25 due to actinolite and magnetite and contains less than 5 percent quartz. To the west this phase is in contact with more typical trondhjemite to quartz diorite phases. Fine-grained intermediate dikes cut all the medium and coarse grained phases of the complex.

The granitoid batholith rocks vary in appearance around the metavolcanic belt. In northern Ranger Township a coarse grained, pink, potassic felsspar-porphyritic, biotite quartz monzonite is the most common rock type and southwards in the metavolcanics a medium grained pink leucocratic quartz monzonite to granite becomes the dominant granitoid phase of the migmatites in Willans and southern Byshe Townships. Between Starratt Channel and Highway 105 to the west a more discrete pluton consisting of medium grained leucocratic quartz monzonite with trondhjemite to granodiorite phases intrudes the metavolcanics. Smaller bodies of biotite hornblende quartz diorite to diorite occur around the southern part of Starratt Channel and towards the southwest corner of Byshe Township. All of the major granitoid phases and migmatites are cut by late pink pegmatitic and aplitic sheets, dikes and stringers.

**Structural Geology**

Despite the preservation of pillow structures and bedding in the metavolcanics only two top determinations were made in the three townships. Both of these occur in the felsic tuff units on Gullrock Lake by Starratt Channel and indicate that these units are facing north. In Byshe and Willans Townships most units trend east to east-southeast and dip vertically or steeply to the north, parallel to the stratigraphy outlined in the southern portion of Balmer Township (Pirie and Grant 1978). The few facing directions uncovered in Balmer Township all indicate younging to the south and therefore it is suggested that a synclinal axis trending roughly eastwards passes through Keg Lake. Because of the lack of observations however, the structure may be much more complex than this. Foliation is parallel to the bedding in Byshe Township. In Ranger Township it trends more southeasterly out of Balmer Township before turning eastwards as the mafic metavolcanics trend through the northern part of Willans Township and out of the map-area. In the migmatites forming the southern half of Willans and Byshe Townships, the layering and foliation locally vary considerably but in general they also have an easterly trend and are steeply dipping to vertical.

**Economic Geology**

**Gold**

Exploration prior to 1960 in the map-area was almost entirely devoted to the search for gold but no significant gold values were discovered. Along the northern portions of Byshe and Willans Townships some of the pillowed mafic...
metavolcanics tend towards a more intermediate composition but no broad zones of highly altered and pervasively silicified mafic metavolcanics similar to the rocks around the Campbell and Dickenson mines in Balmers Township were noted by the field party.

**Base Metal Sulphide Mineralization**

The small base metals showing trenched by L.W. Hermiston northeast of Keg Lake is interesting in that sphalerite and galena are present along with pyrite which is disseminated throughout thin layers as well as forming the sulphide-rich laminations in an otherwise siliceous host rock. The wall rock to the mineralized material is pale coloured and siliceous but it may be altered mafic to intermediate metavolcanics with the sulphides being associated with a narrow interflow ironstone unit. Geophysical surveys and diamond drilling in the vicinity of the showing have failed to outline any extensions from the trenched zone. Elsewhere in the eastern Red Lake supracrustal belt similarly mineralized narrow sulphide ironstone units in mafic metavolcanics have proved to be unproductive. Similarly the showing east of Gullrock Lake which contains pyrite, galena, sphalerite and chalcopyrite concentrations in a quartz vein enclosed in typical mafic metavolcanics does not have the characteristics of a major potential base metal environment. The considerable volume of intermediate to felsic metavolcanics present in Byshe and Willans Townships as well as in Heyson Township to the west do exhibit characteristics which theoretically are indicative of base metal potential but no sulphide bearing zones have been uncovered and few airborne electromagnetic anomalies are present.

In the trondhjemitic to dioritic intrusive complex locally known as the "Howey Diorite", located in the northwest portion of Byshe Township, minor chalcopyrite and pyrrhotite are present in local disseminations and quartz veins set in the latest leucocratic trondhjemitic phase of the complex. Minor pink cobalt bloom staining was noted along with this mineralization in a few places. Trenching on small showings of this type in the area has so far indicated little potential but the textures, relationships and environment of the mineralization strongly suggests a porphyry copper type setting and the association of cobalt with the chalcopyrite is interesting. More significant zones of this type of mineralization may be present elsewhere in the complex or in similar intrusive units in the supracrustal belt.

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No. 4  Geology of the Red Lake Area, District of Kenora
James Pirie1

Introduction

A project to produce a 1:50,000 scale geological map and synoptic report covering the entire Red Lake metavolcanic-metasedimentary belt of Early Precambrian age was initiated during the 1978 field season. The study will integrate all the previous detailed lithological mapping to help understand the inter-relationships between stratigraphy, structure and economic geology of the belt.

General Geology

During the 1978 field season, detailed mapping was carried out in parts of Dome Township; the "keystone" township linking the eastern and western parts of the belt previously mapped by Ferguson (1966). The thick sequence of mafic metavolcanics which strikes southwestward from the southeast corner of McDonough Township and the McFinley Peninsula, interdigitates with a thick sequence of similarly trending felsic pyroclastics and metasediments at the north end of Mackenzie Island. From top determinations of sedimentary structures, the entire supracrustal succession on Mackenzie Island and the islands to the northwest faces northerly. On the east shore of Mackenzie Island by the Bruce Channel the lowermost rocks are thin- to medium-bedded wacke-mudstone turbidites which locally contain sedimentary structures such as ripple-marks and graded bedding. These rocks are overlain by a thick succession of felsic pyroclastic rocks although the detailed contact relationships are obscured by the presence of the Dome and Mackenzie Island Stocks which are composed of porphyritic quartz diorite, granodiorite and trondhjemite. The felsic pyroclastic rocks comprise a variety of thin to thick bedded quartz-feldspar porphyritic tuff, lapillistone and breccia which are in general monolithic although towards the top chert pebbles are not uncommon. Graded bedding is common throughout, and near the top current bedding is observed. Locally narrow layers containing flattened pumice fragments are present. The unit is overlain by a narrow section, best exposed on southwest Goddray Island, of interbedded, medium-bedded oligomictic pebble conglomerate with a large felsic pyroclastic content and quartzose wacke followed by interbedded mudstone and wacke layers and finally capped by a sequence of thicker units of mudstone and white to dark limestone containing lenses of pyrite. Above this and best exposed on the Parnell Islands is a thick unit of laminated to thin-bedded slaty mudstone with medium-bedded wacke and graded wacke-mudstone turbidite layers in places. To the northwest on the shore of Red Lake, the metasediments

1 Geologist, Precambrian Geology Section, Ontario Geological Survey, Toronto, Ontario.
have given way to fine grained mafic metavolcanic flows some of which are magnesian-rich and well sheared with pyrite in disseminations and fracture fillings. From earlier mapping by Riley (1975) and Pirie and Sawitzky (1977) as well as from the regional airborne magnetic and electromagnetic maps (OGS 1978), this mafic unit with interflow sulphide-bearing metasediments, extends a considerable distance to the southwest and northeast as a stratigraphic marker horizon.

Remapping in the southeast corner of Dome Township has outlined a southward-facing sequence of supra-crustal rocks similar to that mapped to the east in Balmoral Township (Pirie and Grant 1978). On McNeely Bay and the Cable Peninsula is a thick unit of felsic to intermediate quartz and feldspar pyroclastic rocks not unlike the felsic material mapped on Mackenzie Island. This is overlain by highly amygdular, pillowed altered mafic metavolcanic flows, followed by wacke and conglomerate containing felsic metavolcanic clasts, and then by more pillowed mafic metavolcanics. The latter are intruded by a portion of the intermediate intrusive complex known locally as the Howey Diorite.

**Structural Geology**

The northwest-facing sequence on Mackenzie Island and Parnell Islands and the south-facing sequence in the southeast corner of Dome Township may form the limbs of a major anticlinal fold the nose of which is obliterated by the presence of the Dome Stock southeast of Mackenzie Island. The bedding and main foliation, on and to the north of Mackenzie Island trend northeast whereas in the eastern part of Dome Township and into Balmoral Township the main foliation and lithologies trend east-southeast. This latter foliation may be later than the former and related to the formation of the major anticline because a fracture cleavage trending generally east to east-south-east cross-cuts the northeast-trending bedding and foliation on the northwest side of Mackenzie Island.

**Economic Geology**

The recently published airborne magnetic and electromagnetic maps of the Red Lake area (OGS 1978) indicate a large number of conductors within the primarily mafic metavolcanic sequence in the northeast and eastern part of the belt. Drilling of these conductors to date has shown that many of them are due to the presence of sulphide-bearing interflow metasediments which have little or no base metal potential. However, examination of the geological setting of some of the gold ore zones in the Dickenson mine in Balmoral Township (Pirie and Grant 1978) shows that economic gold values occur along with pyrrhotite and pyrite where they form layers, lenses, stringers and disseminations in hydrothermally altered mafic metavolcanics which may have little or no quartz-carbonate veining in association. Examples of this ore occurrence at Dicken-son mine include the 'East South C' zone, the 'I' zone and the 'East South C Footwall' zone. This latter zone has only recently been delineated as a substantial low grade ore-body, in places over 15 m wide where the gold values are found in the pyrrhotite and pyrite bearing mafic metavolcanics (W. Valliant, Dickeenson Mines Limited, personal communication). Future investigation of iron sulphide bearing zones in the mafic metavolcanics should note the nature and degree of hydrothermal alteration present and barren sulphide-bearing material should be assayed thoroughly for gold where the conditions warrant.

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No. 5 Ground Evaluation of Airborne Radiometric Anomalies in Northwestern Ontario

W.D. Bond and F.W. Breaks

Introduction

As part of the mineral potential evaluation being undertaken by the northwestern administrative region of the Ministry of Natural Resources for the West Patricia Land-Use Plan in northwestern Ontario, the authors conducted follow-up ground surveys of airborne radiometric responses resulting from the federal-provincial gamma-ray spectrometer survey. The ground survey was done in order to:

i) evaluate the economic potential of uranium within the designated areas; and

ii) classify the types of deposits according to geological controls in order to provide general guidelines for future exploration endeavors.

Location

The survey covered an area bounded by Latitudes 50°00' to 54°00'N and Longitude 88°00'W to the Manitoba border. Eight complete NTS sheets (53A, B, C, F, G; 52I, P, O respectively) and portions of three other NTS sheets (53 D, E, K respectively) were included in the survey area for a total of approximately 140 000 km². Most of the area is situated well north of the Trans-Canada Highway and is accessible only by float-equipped, fixed-wing aircraft.

Previous Geological Work

Except for that portion of the Berens River Block lying between Red Lake and Setting Net Lake most of the map-area has been covered by previous reconnaissance (1:125 000) surveys (Bennett et al. 1967; Bennett and Riley, 1969; Thurston et al. 1969; Thurston and Carter, 1970; Thurston et al. 1971, 1975; Sage et al. 1973; Sage and Breaks 1976; Sage et al. 1974; Ayres et al. 1972). These geological surveys and further detailed geological surveys (1:15 840) by Ayres (1969, 1970, 1971, 1972a, 1974), Wood (1975, 1977) and Wood et al. (1976a,b) have indicated almost all of the known uranium occurrences are spatially associated with the Bearhead Lake Fault Zone which has been reported (Ayres 1970, 1972a; Wood 1975) to occur at Setting Net Lake, Favourable Lake, and North Spirit Lake. Airborne radiometric data has been released for the following five areas: Stull Lake Sheet (OGS-GSC 1978a), Island Lake Sheet (OGS-GSC 1978b), Opasquia Lake Sheet (OGS-GSC 1978c), North Spirit Lake Sheet (OGS-GSC 1978d), and the Deer Lake Sheet (OGS-GSC 1978e). The six NTS sheets situated in the eastern and southeastern half of the area (Wunnumin Lake 53A, North Canibou Lake 53B, Makop Lake 53G,
Armstrong 521, Miminiska Lake 52P, and Lake St. Joseph 52O) were flown during the 1978 field season and this data is to be released in early 1979. Data from these six NTS sheets were scanned during the 1978 field season and follow-up ground surveys were conducted in these areas also.

**Previous Exploration**

Most of the anomalies indicated by the joint federal-provincial radiometric reconnaissance program are in the vicinity of the Bearhead Lake Fault Zone. This zone has been known for its radiometric anomalies since the mid 1950s but it was not until the late 1960s that any significant exploration was done. The Keevil Mining Group has completed the most extensive study on the area. Companies that have been active in the area are listed in Table 1. Except for a uranium occurrence at Bamaji Lake, the other anomalies indicated on the federal-provincial radiometric maps have not been previously explored. A history of the exploration work done on the Bamaji Lake occurrence is given in Sage and Breaks (1976, p.325-326) and Wallace (1977, p.5,7).

**Nature of Anomalies**

The present ground survey was restricted to investigation of anomalous zones (Figure 1) characterized by concentrations greater than or equal to 2.0 ppm eU (equivalent uranium) as defined on the federal-provincial reconnaissance radiometric maps. Three of the five NTS sheets for which contour data is available are radiometrically flat having only one or two eU anomalies on each sheet. However, the east half of the Deer Lake and the west half of the North Spirit Lake Sheet each have a substantial number of anomalies having a concentration of greater than 2.0 ppm eU. Only two anomalies in the entire survey area, both of which occur on the North Spirit Lake Sheet, indicate concentrations greater than 3.0 ppm eU. The west half of the North Spirit Lake Sheet, between Setting Net Lake and McInnes Lake indicates overall background concentrations greater than 1.0 ppm eU. Correspondingly a large anomalous background mass is also indicated on the federal-provincial total count contour map over this same area and this anomalous area is related to a combination of:

i) abundant outcrop

ii) extensive bedrock exposure resulting from a large forest fire burn of several years ago; and

iii) the presence of several radioactive areas.

The anomalies indicated on the federal-provincial eU contour radiometric maps are generally circular and range from 0.5 to 2.5 km in diameter. A few anomalies in the vicinity of the Bearhead Lake Fault Zone are linear in trend due to coalescing contours from several individual circular anomalies. The more detailed airborne radiometric survey conducted during the present survey generally registered between one and ten individual anomalous peaks which required further exploration within each of the anomalous areas indicated on the federal-provincial radiometric series. That is, follow-up ground exploration was done selectively on only those peaks that could not be explained as being due to i) topography or degree of exposure or ii) differences in known geology (e.g. granitic versus mafic metavolcanic) that obviously lead to differences in background uranium concentrations. Follow up ground scintillometer surveys of these individual peaks generally indicated the presence of one to ten specific "hot spots" of varying magnitude and scale. In some instances entire outcrop areas indicated uniform anomalous values above background, but in most cases the anom-

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**TABLE 1**

**EXPLORATION IN THE BEARHEAD LAKE AND HORNBY LAKE AREAS.**

**BEARHEAD LAKE FAULT ZONE (Favourable Lake to North Spirit Lake)**

<table>
<thead>
<tr>
<th>Company</th>
<th>Toronto Assessment File Number*</th>
<th>Date of Work*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Albatros Gold Mines Ltd.</td>
<td>63.2353</td>
<td>1968</td>
</tr>
<tr>
<td>Cam Mines Ltd.</td>
<td>63.2278</td>
<td>1968</td>
</tr>
<tr>
<td>Cassette Mines Ltd. (now Summit Explorations and Holdings Ltd.)</td>
<td>63.2429</td>
<td>1968</td>
</tr>
<tr>
<td></td>
<td>63.3331</td>
<td>1969</td>
</tr>
<tr>
<td>Keevil Mining Group</td>
<td>2.478, 2.286, 63.2478</td>
<td>1969-1971</td>
</tr>
<tr>
<td>Siggasco Exploration Ltd.</td>
<td>67.797</td>
<td>1956</td>
</tr>
<tr>
<td>Noranda Exploration Co. Ltd.</td>
<td>2.2433</td>
<td>1976, 1977</td>
</tr>
<tr>
<td>Tudale Exploration Ltd.</td>
<td>63.2487</td>
<td>1969</td>
</tr>
</tbody>
</table>

**HORNBY LAKE AREA (about 19 km south of the Bearhead Lake Fault Zone)**

<table>
<thead>
<tr>
<th>Company</th>
<th>Toronto Assessment File Number*</th>
<th>Date of Work*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cochenour Explorations Ltd.</td>
<td>2.483</td>
<td>1970</td>
</tr>
</tbody>
</table>

*From Assessment Files Research Office, Ontario Geological Survey, Toronto.
lies were found to be small (usually several metres wide), isolated, highly discontinuous patches of irregular radiometric contour shapes situated in areas having background uranium concentrations only.

**Geological Controls of Uranium Mineralization**

Within the surveyed area, uranium mineralization is restricted to three major associations. Two of these associations (A & B below) are grossly similar to those noted in the English River Subprovince (Breaks et al. 1975, p.31-32) The three associations are:

A) Magmatic

i) Late silicic intrusive phases
ii) Early intermediate to mafic intrusive phases

B) Diatexitic (end stage of anatexis), see Breaks and Bond (1977)

C) Hydrogenic

Two associations, the magmatic and the diatexitic, are present along the Bearhead Lake Fault Zone itself. The hydrogenic association has only been found at two places in the vicinity of Bamaji Lake.

**Magmatic**

**Late Silicic Intrusive Phases**

The majority of known uranium occurrences indicated in the present survey area fall into this category. Typically the anomalous uranium concentration is associated with pink-weathering, late, unmetamorphosed plutonic rocks of generally quartz monzonite to granite (sensu stricto) compositions. Granite compositions appear to be exceedingly rare throughout much of the Early Precambrian of northeastern Minnesota. Variations in composition due to increased content of quartz or myrmekite (plagioclase-quartz intergrowths) especially within pegmatitic phases, are locally present. Syenitic phases carrying anomalous uranium values are locally present in the Hampton Lake area. Textures of these late silicic phases vary from massive to porphyritic and equigranular to inequigranular. Grain size is generally medium to coarse-grained but is most commonly pegmatitic. The medium to coarse-grained phases tend to be compositionally homogeneous (mostly quartz monzonite), pegmatitic phases tend to be compositionally inhomogeneous (dominantly quartz monzonite but containing patches of trondhjemite and granite). Pegmatitic phases appear both as consanguinous diffuse pods of varying scale and as sharply defined dikes which, at the margin of batholiths, commonly trend perpendicular to contact zones. In summary, the uranium mineralization is commonly associated with both equigranular medium to coarse-grained and inequigranular pegmatitic quartz monzonite phases.

The two major uranium concentrations within the entire study area are representative of this association. On the south side of the Bearhead Lake Fault Zone uranium mineralization is associated with a major batholith of granodiorite to quartz monzonite composition. Uranium mineralization is also found associated with several different batholiths in the vicinity of the Hornby Lake 'greenstone' belt (situatuated near Hampton Lake, Figure 1). In both cases the uranium mineralization tends to be concentrated near the margin of the batholiths.

Uranium concentrations in anomalies of this association are confined to erratically distributed patches having highly irregular radiometric contours and to late, cross-cutting dikes. The former, where found in exposures of uniform, homogeneous compositions, generally exhibit no telltale signs of their presence and are extremely hard to find without ground scintillometers. Anomalous patches on single exposures vary in extent but in general, those having the greatest magnitude are only tens of square centimetres in area. For example, in the Hornby Lake area, a dike varying in composition from quartz monzonite to syenite to locally hybrid syenite was found cutting homogeneous diatexite (for terminology see Breaks and Bond 1977, p.173-186). Scintillometer readings indicated a patch about 1.4 m² in area having a value of about 12 000 cpm (total count U + Th + K); within this patch a small 15 cm square was found to have a value of 20 000 cpm (total count). Most of the anomalous areas of the potassic magmatic association were found to have concentrations of between 5000 and 40 000 cpm (total count) or between 2 and 15 times background. The highest readings of this association (greater than 100 000 cpm total count, i.e. off scale) were found along the Bearhead Lake Fault Zone between Setting Net Lake and Favourable Lake. This ground has previously been extensively explored for uranium and many of the highest values were obtained from previously excavated trenches.

Several features appear to be common to those areas having the highest uranium concentrations within the late silicic magmatic association, in many cases these characteristics are not entirely exclusive or indicative of the highest radioactivity.

i) Smokey quartz in contrast to white or clear weathering quartz is common to the anomalous areas. Along the Bearhead Lake Fault Zone quartz-rich pods of smokey grey colour commonly found in pegmatites often yield the highest values. In other areas however, e.g. Hornby Lake area, the smokey quartz pods do not necessarily yield the highest values.

ii) Magnetite is the most common accessory mineral associated with the potassic magmas and is commonly more concentrated in those areas having higher radioactive values.

iii) Syenitic phases are fairly rare but, when present, gen-
generally yield higher radioactive values. This association reflects the strong direct relationship between higher values of radioactivity and greater modal potassium content found to occur in the study area.

iv) Hybrid phases generally have higher values but this relation is not entirely inclusive.

v) Sphene is extremely significant in indicating the higher anomalous areas in the Bearhead Lake Fault Zone. Elsewhere although undoubtedly present it is not nearly as evident or abundant.

vi) In many cases the uranium is most concentrated in the coarser pegmatitic phases but in some other cases, the finer phases exhibit greater radioactive values.

vii) The magnitude and scale of the anomalous areas are generally low and of limited extent. Values tend to be extremely erratic over short distances. For example, a small 5 cm wide dike of quartz monzonite found just north of Hampton Lake (in the Hornby Lake area) was found to contain values that varied from 17 000 cpm (total count) to 5000 cpm over a distance of 1 m.

viii) Uranophane staining is common along fractures within the late potassic phases but usually does not indicate highest uranium concentration.

**Early Intermediate to Mafic Intrusive Phases**

Radioactive areas associated with these phases are found sporadically along the Bearhead Lake Fault but are most common in the Hornby Lake area. Uranium mineralization in this association is much less common in relation to the late silicic varieties and probably only account for about 5 percent of the anomalies encountered within the survey area. These phases compositionally encompass quartz diorite, syenodiorite, trondhjemite and magnetite-hornblendite-biotite porphyritic granodiorite to quartz monzonite. Whereas the mafic content of the late silicic intrusive association is generally less than 5 percent except locally in spheine- or magnetite-rich pods, the mafic content of this association is generally between 10 and 20 percent. Mafic accessory minerals nearly always include biotite + hornblende + magnetite; most of the phases of this association are medium- to coarse-grained and are weakly to extensively recrystallized. The one exception is a coarse-grained porphyritic granodiorite to quartz monzonite present in the Hornby Lake area. Without exception phases related to the intermediate to mafic category are always associated with and cut by dikes of the late silicic intrusive association. Absolute radioactive values of the intermediate to mafic intrusive association are always lower than those of the corresponding late silicic intrusive phases. Where the early intermediate to mafic intrusive phases have anomalous radioactive values, the associated late silicic potassic phases are themselves almost always anomalous. However, the reverse relation is not always true; the radioactive late potassic phases are commonly found affiliated with early, more mafic intrusions that are not anomalously radioactive. Most of the absolute values obtained from these more mafic phases are about 5000 to 6000 cpm (total count) (that is about 2 to 3.5 times background) but locally reach up to 17 000 cpm (total count) (i.e. about 10 times background). Anomalous values of over 3.5 times background are exceedingly rare.

The fact that most of the radioactive values obtained from phases of this association are lower in absolute magnitude than the later silicic potassic phases is to be expected as uranium tends to concentrate in the latter phases more readily. It is possible that some of the potassic intrusions are differentiates from the earlier more mafic phases. According to Bohse et al. (1974), during crystallization uranium is partitioned into the melt phase and it is possible in this connection that the uranium was concentrated into the residual, fluid-enriched melts concentrated at depth. Whether these two end members of the magmatic type of deposits are genetically related is not known at this writing.

**Diatexitic**

Several occurrences of uranium are associated with the homogeneous diatexitic stage of anatexis of metasediments that are observed to occur sporadically along the north side of the Bearhead Lake Fault Zone. Homogeneous diatexite is the product of the extreme stage of anatexis if carried to completion (Breaks and Bond 1977, p.184). Several occurrences related to this association occur at Azure Lake (near the Manitoba-Ontario boundary), north of Borland Lake and Favourable Lake. The highest readings obtained were in the neighbourhood of 20 000 cpm (total count) over several metres but most values in anomalous areas were about 5000 to 7000 cpm (total count) over a few tens of metres.

**Summary Statement on Localization of Uranium Anomalies of Magmatic and Diatexitic Association**

The following may be more apparent than real but there are several common patterns of disposition of the uraniumiferous deposits in the study area:

i) most of the anomalies are located near the Bearhead Lake Fault Zone;

ii) the two areas having the most numerous anomalous zones (i.e. the Bearhead Lake Fault Zone (between Favourable and Setting Net Lakes and the Hornby Lake area) are both marginal to sedimentary sequences.

At the Bearhead Lake Fault Zone, the uranium is present in both the magmatic and diatexitic sedimentary associations; the faulting has overprinted both these major rock units. In the Hornby Lake area the uranium mineralization is associated only with magmatic phases while the metasediments indicate relatively low values. It is fairly widely accepted that uranium and thorium are enriched in the younger most siliceous, felsic, potassic magmatic phases (Bohse et al. 1974) and concentrate especially in the water-rich phases (Smithson and Decker 1973). The reason for the association of uranium mineralization in magmatic rocks adjacent to sedimentary rocks in the study area is not known but the metasediments definitely

W.D. BOND & F.W. BREAKS

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represent a possible original source. Smithson and Decker (1973) suggest the concentration of uranium and thorium in the upper crust is not due to major element differentiation within a magma but is more probably explained as a concentration in a fluid phase which could easily be expected to show upward migration tendencies. Thus, the localization of uranium around the Bearhead Lake Fault Zone may best be explained by derivation from mineralizing solutions, associated closely with felsic igneous intrusives, which migrated upward along faults from a deep-seated source. This hypothesis implies that the Bearhead Lake Fault Zone has been active over a protracted period of geological time prior to and outlasting plutonic activity. It seems reasonable to postulate that the sedimentary rocks along the Bearhead Lake Fault Zone (because they contained small uraniferous concentrations in their partially melted diatexitic stage of migmatization), may at least in part be the source of some of the uranium mineralization. This latter source does not seem to apply to the Hornby Lake area. On the basis of presence of cataclastic textures, the present survey has been able to trace the Bearhead Lake Fault Zone out from a point midway between Azure Lake and Borland Lake southeast to North Spirit Lake for a total strike length of at least 125 km. Except for a few interesting concentrations, most of the uranium occurrences along the fault zone are relatively low in value. These low values, when coupled with a strike length of at least 125 km suggest, however, that this represents a significant uraniferous geochemical domain with attendant potentials of concentrated or large low-grade deposits and radiation levels of possible significance in land-use planning.

Hydrogenic

Uranium mineralization occurs in several localities in the Bamaji Lake area. To date there are three known showings that are located between North Bamaji Lake and Mooseategon Lake. All three showings are located on the east periphery of the Bamaji Lake complex (Sage and Breaks 1976, p.328). The radioactive "hot" areas are associated with either actinolite-rich lenses (in two of the showings) or with a calc-silicate horizon (the main showing) which is situated at the contact between massive and pillowed mafic metavolcanics and fine-grained trondhjemite. The most extensive showing occurs near the east periphery of the Bamaji Lake complex (Sage and Breaks 1976, p.332) and silver (trace to 0.16 ounce per ton, Sage and Breaks 1976, p.332) are also present although not visible in the field. Uranium mineralization of 0.25 percent (Resident Geologist's Files, Ontario Ministry of Natural Resources, Sioux Lookout and Assessment Files Research Office, Ontario Geological Survey, Toronto) has been reported. The present survey indicated the radioactivity was most concentrated in the eastern portion of the calc-silicate unit which gave values of approximately 40 000 cpm (total count) and in one place greater than 100 000 cpm (total count) over a 7 to 10 cm width. Samples have been submitted for trace element analysis to see if the actinolite-rich lenses or the calc-silicate unit have a mafic volcanic affinity. All three showings appear to be on about the same stratigraphic level and they may in fact be continuous. The calc-silicate unit, when coupled with the presence of a chert horizon may indicate that the mineralization is a stratigraphically controlled hydrogenic precipitate (McMillan 1977, p.49), particularly if the analyses indicate no mafic volcanic affinity.

References

Ayres, L.D. 1969: Geology of the Muskkrat Dam Lake Area; Ontario Dept. Mines, GR74. Accompanied by Maps 2162, 2163, 2164 and 2165, scale 1 inch to ½ mile.


1971: Geology of the Trout Lakes Area, District of Kenora (Patricia Portion); Ontario Div. Mines, GR113, 197p. Accompanied by Map 2270, scale 1 inch to ½ mile.


No. 6  Savant Lake — Crow Lake Special Project
Districts of Thunder Bay and Kenora

N.F. Trowell¹, C.E. Blackburn¹, G.R. Edwards² and J.R. Bartlett³

In 1976, N.F. Trowell and C.E. Blackburn began a joint project (Trowell and Blackburn 1976) involving a regional study of the stratigraphy, structure, and economic geology of the Early Precambrian (Archean) metavolcanic-metasedimentary belts between Savant Lake and Crow Lake. The project involves both compilation of past geological work and selective field mapping.

During the 1978 season field studies were undertaken in the Sioux Lookout — Gullwing Lake area, by N.F. Trowell; in the Eagle Lake — Wabigoon Lake — Stormy Lake area, the Populus Lake — Mulcahy Lake area, and the Harris Lake — Otukamamoan Lake area by C.E. Blackburn; and under their general direction G.R. Edwards examined the Crow (Kakagi) Lake — Sioux Narrows area and J.R. Bartlett the Loggers Lake — Southeast Bay (Minnitaki Lake) area. Reports on each of the areas follow.

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² Graduate Student, University of Western Ontario, London
³ Geological Assistant, Precambrian Geology Section, Ontario Geological Survey, Toronto.

Previous compilations encompassing these areas are available (Maps 2115 and 2169, Davies and Pryslak 1967; Davies et al. 1970) and would be of assistance in following these reports.

The aims of this ongoing project are to gain a better understanding of the petrogenetic and structural evolution of this portion of the Wabigoon Belt (Mackasey et al. 1974) and to determine, more clearly, the interrelationships of geological environment and mineral deposits within this area.

Because of the nature of the project emphasis is directed towards examination of the metavolcanic-metasedimentary belts and only very limited study was done on the batholithic granitic areas.

In conjunction with this project a geochronology program initiated by Blackburn and Trowell was carried out under the direction of D. Davis, Royal Ontario Museum. Within the geographical confines, but independent of this project, detailed mapping of the Zarn Lake area was completed under the direction of R.O. Page (this volume).

Savant Lake Area

N.F. Trowell

No further field work was undertaken in the Savant Lake area, previously investigated by Sutcliffe (in Trowell et al. 1977). At the present time several companies are extensively exploring the Handy Lake Volcanics (No. 1 on location map) for base metal sulphide mineralization. Trace element analyses from the Savant occurrences (Trowell 1978) indicate that the tin and mercury values are relatively high suggesting that geochemical exploration methods involving mercury detection might be considered in this area.

Sioux Lookout — Gullwing Lake Area

N.F. Trowell

Location

The area (No. 2 on location map) includes the towns of Sioux Lookout and Hudson; Highways 642, 72 and 116 and subsidiary gravel roads transect the area providing access to the numerous lakes within the region.
Mineral Exploration

Exploration in the past concentrated mainly on gold and to a lesser extent pyrite-pyrrhotite occurrences. Pyrite was mined at the North Pines mine from 1901 to 1921 (Johnston 1972). A minor amount of gold was taken from the Eimiller claims on the south shore of Vermilion Lake (Johnston 1972). Chisholm (1951) described the extent of exploration activity during the early part of the century.

Gold mining, albeit on a small scale, is presently underway at Goldlund Mines Limited (Speed 1978) in Echo Township. Rare earth element bearing pegmatites in the southwestern portion of the area are presently being examined and staked (P. Palonen, Resident Geologist, Ontario Ministry of Natural Resources, Sioux Lookout, personal communication, 1978). Differentiated and multi-phase mafic to ultramafic intrusive complexes, situated within the Southern Volcanic Group (see J.R. Bartlett, this summary) are being examined for their possible mineralization (P. Palonen, personal communication, 1978). Base metal exploration, initially spurred on by the discoveries in the Sturgeon Lake area, during the period 1969 and 1972, is continuing (Resident Geologist Files, Ontario Ministry of Natural Resources, Sioux Lookout).

General Geology

Turner and Walker (1973) subdivided the Sioux Lookout "greenstone" belt into: (1) Northern Volcanic Belt, (2) Northern Sedimentary Belt (Abram Group); (3) Central Volcanic Belt, (4) Southern Sedimentary Belt (Minnitaki Group); and (5) Southern Volcanic Group. Their subdivision has been retained with modifications where noted.

Northern Volcanic Belt

The Northern Volcanic Belt comprises a mafic metavolcanic sequence, and a predominantly metasedimentary sequence (Patara Sediments, Pettijohn 1934, 1935).

The metavolcanic sequence consists of mafic flows, dioritic and gabbroic textured intrusive equivalents; minor fragmental units, thin interflow beds of wacke siltstone, and graphitic sulphidic and interlayered magnetite ironstone and quartz units. A major zone of hyaloclastic breccia, locally carbonatized, forms the hanging wall of the North Pines mine pyritic body (Johnston 1972).

The mafic metavolcanic sequence is tentatively subdivided by the author into (1) high iron tholeiitic basalt (Jensen 1976) flows and (2) high magnesia tholeiitic basalt (Jensen 1976) flows.

A quartz magnetite, locally sulphidic, ironstone unit locally overlies the mafic metavolcanic sequence. Ironstone clasts similar to this unit, occur in the mafic volcanic clast conglomerate formation of the Patara Group (see below). This ironstone unit is tentatively assigned to and defines the top of the metavolcanic sequence.

The Patara "Sediments" can be subdivided into several lithologic units of volcanic and of sedimentary character. The author proposes that the term Patara Group be used at this time as a collective term for these contrasting lithologies.

A 'transitional breccia' comprises the basal unit of the Patara Group. It is comprised of angular mafic volcanic clasts set in a mafic wacke matrix. To the north this breccia grades into mechanically disaggregated pillows, to the south into mafic volcanic clast conglomerate.

The breccia is overlain by a sequence comprising conglomerate; pebbly wacke, lithwacke, and wacke, and minor shale. This in turn is succeeded by a shale and wacke siltstone unit, characterized by soft sediment deformation, extending from Frog Rapids in the east to Slate Island in the west.

On the northeast shore of Vermilion Lake shale/siltstone-clast conglomerate occurs in lensoid units, up to 5 by 0.5 m in cross section within arkosic wacke and lithwacke.

A quartz pebble conglomerate extends from Highway 116 east to Pelican Lake.

In contrast with the conglomeratic units of the Patara Group noted above an intermediate to felsic volcanic breccia formation extends westward from Whitefish Island. Coarse volcanic breccia occurs in graded beds separated by finer lapilli tuff, tuff, and finely laminated tuff beds. Clasts are angular to slightly subrounded and are up to 0.6 by 0.3 m in size.

Felsite and quartz-feldspar porphyry occur on the islands in north-central Vermilion Lake. Sericitic alteration is ubiquitous, possibly a metamorphic equivalent of primary hydrothermal alteration. Disseminated pyrite with trace chalcopyrite mineralization is common. Quartz and quartz tourmaline veining are locally extensive. Autoclastic breccia occurs on Whitefish Island. While a flow origin is not ruled out the author interprets this unit to be an eroded hypabyssal volcanic intrusion, and the intermediate to felsic volcanic breccia formation to be its eruptive equivalent. Two outcrops of a similar felsite are found on the north shore of the west portion of Abram Lake. They occur at approximately the same stratigraphic level as those on Vermilion Lake and may be both lithologically and time correlatable to them.

A similar body of quartz porphyry, quartz feldspar porphyry and felsite is situated on the south shore of Vermilion Lake. It exhibits similar alteration, and sulphide mineralization with more intensive quartz-tourmaline veining. Quartz eyes up to 3 cm in diameter characterize this body. This body appears to intrude the intermediate to felsic volcanic breccia pyroclastic conglomerate of the Patara Group. This breccia that extends down the centre of Vermilion Lake is characterized by the presence of abundant intermediate and felsic volcanic clasts, some of which are similar to the porphyry and felsite units.
discussed above. Coarse heterolithic breccia beds contain angular clasts up to 1.5 by 0.9 m in size. They are commonly separated by thin tuff to lapilli-tuff beds. Towards and on the south shore of Vermilion Lake reworking has produced subrounded clasts in the conglomerate units with associated graded wacke beds possibly deposited by turbidity currents (see discussion of Eimiller Claims under “Economic Geology”).

The Northern Volcanic Belt is a predominantly south facing overturned sequence. Minor recumbent folding has repeated portions of the mafic metavolcanic sequence and Patara Group at Vermilion Lake. The Patara Group conformably to unconformably overlies the volcanic rocks. Trondhjemitic and trachytic textured sills characteristically intrude the Patara Group.

**Northern Sedimentary Belt (Abram Group)**

The Abram Group overlies the Patara Group. It comprises in ascending order (1) the Ament Bay Formation, (2) the Daredevil Formation, and (3) the Little Vermilion Formation (Turner and Walker 1973). On the south shore of Vermilion Lake, conglomerate of the Ament Bay Formation overlies the quartz porphyry body described above. The contact is sharp but the lower metre or so of the conglomerate contains clasts identical to the porphyry intrusion: there is no evidence of a regolith. Near the south margin of the porphyry a narrow zone of bedded and graded pebbly wacke and siltstone contains quartz-feldspar porphyry clasts and individual 1 cm quartz grains similar to those of the intrusion. These observations suggest an erosional unconformity between the Patara and Abram Groups.

At the east end of Vermilion Lake, however, there appears to be a transition, albeit sharp, from volcanic-clast conglomerate of the Patara Group to granitoid-clast conglomerate of the Abram Group.

The majority of clasts in the Ament Bay Formation at Vermilion and Little Vermilion Lakes are of the quartzfeldspar porphyry (trondhjemite) variety possibly derived from synvolcanic hypabyssal intrusions. On Abram Lake medium-grained equigranular trondhjemite and microcline porphyry granodiorite to quartz monzonite clasts are present. Multiphase, foliated, and mafic volcanic inclusion-bearing granitoid clasts are also locally present. No gneissic textured clasts were observed.

The arkoses of the Ament Bay Formation are characterized by upwards of 25 to 30 percent sand-sized quartz. In the Vermilion, Little Vermilion, and Abram Lakes area the arkoses locally exhibit large scale trough cross-stratification. To the southwest in the Lateral Lake-Maskinonge Lake area the arkoses are commonly cross bedded and locally graded. Turner and Walker (1973) have interpreted the conglomerate and arkose of the Ament Bay Formation to be subaerial alluvial fan deposits.

The Daredevil Formation apparently overlies the Ament Bay Formation but top criteria are lacking. It is composed predominantly of intermediate to felsic tuff and minor lapilli tuff. On Little Vermilion Lake mafic tuff and minor wacke siltstone beds are present. The author (in Trowell et al. 1977) has previously interpreted the Daredevil and Ament Bay Formations to be intercalated at Abram Lake. While the contact on Little Vermilion Lake is sharp there is no evidence for a fault contact.

The Little Vermilion Formation overlies the Daredevil Formation. It is composed of thinly bedded wacke and pebbly wacke, thin bedded wacke-siltstone and shale, and sedimentary-clast conglomerate. Grading and the presence of partial Bouma cycles suggest deposition by turbidity currents. The sedimentary-clast conglomerate was likely produced by pre-lithification gravity slumping.

The Abram Group faces predominately south though folding is evident on the south shore of Vermilion Lake. The Little Vermilion Formation is folded and its eastern extension has been faulted with possible displacement to the west end of Abram Lake where interlayered quartz and magnetite ironstone occurs within thickly bedded wacke units; one outcrop of sedimentary-clast conglomerate occurs along the north shore of the west portion of Abram Lake.

**Central Volcanic Belt**

The Central Volcanic Belt is composed of mafic and intermediate metavolcanic flows and fragmental rocks and re-deposited volcanic fragmental rocks. It is divisible into several lithologic assemblages based upon composition, and mode of extrusion and deposition. The author’s interpretation is based on the work of Page (Page and Clifford 1977; R.O. Page, personal communication, 1977-1978), and Johnston (1969, 1972).

A felsic metavolcanic sequence exposed in the area south and west of Superior Junction appears to form the base of the Central Volcanic Belt. It is composed of felsic pyroclastic/autoclastic breccia, possible flows, and apparent intrusive material representing the eroded remnant of a hypabyssal volcanic dome. Minor mafic metavolcanic flows appear to be either infolded or intercalated within the assemblage.

A broad laterally extensive sequence of mafic flows overlies this basal sequence. The flows are variably pillowed, porphyritic, and rarely variolitic. Hyaloclastic and autoclastic breccias comprise the upper portions of flows or occupy an interf low position. Characteristic of this mafic flow assemblage are numerous interflow beds of intermediate to felsic tuff and wacke units of volcanic provenance. They range from several centimetres to several metres in thickness. Individual beds vary from massive to graded; flame structures and rare cross-bedding are indicative of deposition by simple settling and by subaqueous debris flows respectively. An assemblage of intermediate flows and fragmental rocks overlies the lower mafic flow assemblage. In the area south of Sioux Lookout this assemblage is predominantly andesitic in composition while to the southwest in Pickerel Township intermediate to felsic pyroclastic rocks and re-deposited fragmental rocks could represent outpourings from a separate volcanic centre.

This assemblage is unique to the Savant Lake — Crow Lake area both in the vast amounts of andesitic material and in the unique chemistry of the andesites them-
selves (R.O. Page, personal communication, 1978). Quartz-feldspar porphyry and felsite intrusions intrude the Central Volcanic Belt west of Neepawa Island and at Pickerel Arm. They are similar in appearance to intrusions previously described in the Patara Group. Possible autoclastic breccia facies are locally present. They are probably synvolcanic hypabyssal intrusions but the time of intrusion is not known.

The Central Volcanic Belt appears to be fault bounded along both margins making its age relationships with respect to both the Abram and Minnitaki Groups somewhat equivocal.

Southern Sedimentary Belt (Minnitaki Group)

The Minnitaki Group is predominantly composed of wacke-siltstone, arkose, and granitoid clast conglomerate. The granitoid clasts are predominately trondhjemitic quartz-feldspar porphyry and were likely derived by erosion of hypabyssal volcanic intrusions. The conglomerate is mainly confined to the area of East Bay, Minnitaki Lake where they have been interpreted as proximal turbidites of the resedimented association (Walker and Pettijohn 1971). To the southwest finer wacke-siltstones are of the deep water turbidite association.

A laterally continuous unit of quartz-magnetite ironstone occurs in the Minnitaki Group just north of its contact with the Southern Volcanic Group (see below). From west to east this unit appears to occupy a transgressive position with respect to its associated clastic sediments.

At present it has not been resolved whether the Minnitaki Group is the folded equivalent, albeit showing lateral facies changes, to the Abram Group as Johnston (1972) suggested or whether it is a younger clastic metasedimentary sequence as suggested by Turner and Walker (1973).

The metavolcanic sequences in Pickerel Township appear to be more likely intercalated within rather than necessarily infolded in the Minnitaki Group metasediments.

Southern Volcanic Group

For a detailed discussion of the Southern Volcanic Group see Trowell’s (in Trowell et al. 1977) and Bartlett’s (this summary) discussions of this group, specifically in the Southeast Bay area of Minnitaki Lake.

Structural Geology

The first phase of folding would appear to be flexural folding about subhorizontal generally east-northeast trending axes. Later folding involved the development of Z-shaped folds associated with right hand slip along east-northeast trending faults and minor crenulation folds again associated with late northeast (dominant) and northwest (minor) trending faults. There is some suggestion in the South-west Bay area of Minnitaki Lake that cataclastic zones, possibly associated with the first phase of folding, were subsequently deformed during later folding. While right hand sense of movement dominates, local S-shaped folds indicate the opposite sense. Late movement associated with the Minsiiss River Fault Zone involved reactivation of these faults with the development of pseudotachylite and brittle deformation cataclastic zones. Vertical movement and thrusting were likely associated with these faults.

Economic Geology

Gold

Chisholm (1951) has summarized the known gold occurrences in the area. Gold mineralization situated within a granodiorite dike is presently being mined at the Goldlund mine (Speed 1978). The author suggests the following areas and lithologies as possible prospecting targets for gold mineralization:

1) The contact zone between the quartz porphyry intrusion on the south shore of Vermilion Lake and metasediments of the Patara and Abram Groups. The Eimiller claims occurrence (Johnston 1972) is situated within a silicified zone at the contact between turbiditic wacke and conglomerate (north) and quartz-feldspar porphyry (south). Gold mineralization here could be related to an original erosional unconformity with subsequent concentration of the gold by quartz veining associated with shearing. If so, there is likely a favourable stratigraphic horizon for gold prospecting.

2) The iron carbonate bearing stratigraphic horizons in the intermediate to felsic volcanic breccia facies of the Patara Group.

3) The quartz-feldspar porphyry and felsite intrusions of the Patara Group and within the Central Volcanic Belt. Specific areas to be checked are those with abundant disseminated sulphide mineralization and/or extensive fracturing and quartz-tourmaline veining.

4) The locally sulphidic carbonatized hyaloclastic breccia horizon of the lower mafic metavolcanic sequence, Northern Volcanic Belt. The North Pines mine pyritic ore body is situated within this horizon; it too should be checked for its gold content (as well as for its abundance of Cu, Pb, Zn, Ag, Sn etc.).

5) Small granitoid plugs that are situated within the lower mafic metavolcanic flows of the Southern Volcanic Group near the contact with the bordering granitic complex. Quartz veining, locally with trace gold, occur within these plugs (P. Palonen, Resident Geologist, Ontario Ministry of Natural Resources, Sioux Lookout, personal communication 1978).

Copper-Nickel (Chromite, Platinoid Group Elements)

No copper-nickel occurrences are known in the area. The ultramafic and gabbroic intrusions that occur at the
boundary between the lower and upper mafic metavolcanic assemblages of the Southern Volcanic Belt should be examined for their potential for Cu, Ni and Cr and platinum group elements mineralization (also see Bartlett, this summary).

Molybdenum

Molybdenum occurs in quartz and pegmatite veins at the contact of the Lateral Lake stock with amphibolite facies metasediments and metavolcanics (Colvin and McCarter 1977). Other occurrences in the southwest portion of the area have likewise been summarized by Colvin and McCarter (1977).

The author would suggest that the quartz-feldspar porphyry intrusions of the Patara Group and Central Volcanic Belt and the granitoid plugs near the base of the Southern Volcanic Group should likewise be examined as to their molybdenum contents.

Lithium, Cesium, Tungsten, Tin, and Rare Earth Elements

The Kozawy-Leduchawski lithium-cesium occurrence in Webb Township is presently being re-examined and new staking is underway (P. Paionien, Resident Geologist, Ontario Ministry of Natural Resources, Sioux Lookout, personal communication, 1978). A thorough investigation of all the pegmatite, quartz veins, and granitoid plutons in the southwest portion of the area is required to determine the extent of potential lithium, cesium, and tungsten mineralization and also of tin and rare earth elements.

Base Metal Sulphide Mineralization

The author suggests three areas where there is favourable stratigraphy and lithologies for potential base metal sulphide mineralization.

Loggers Lake — Southeast Bay (Minnitaki Lake) Area

J.R. Bartlett

Location

Abram and Minnitaki Lakes provide access to the western portion of the area (No. 3 on location map). Loggers Lake is accessible by float-equipped aircraft. In the map-area the English River was not navigable over much of its course. Highway 642 passes along the eastern boundary of the area. A float-equipped helicopter was used to gain access to isolated areas of outcrop.

Mineral Exploration

Past exploration concentrated mainly on the pyrite-pyrhotite occurrences east of Southeast Bay, and to a lesser extent the quartz-magnetite ironstone zone and gold occurrences in the vicinity.

Minnitaki Lake Mines Limited conducted ground electromagnetic, magnetometer and induced polarization surveys between 1977 and 1978 in the eastern and southeastern portions of the map-area. All recent diamond drilling has been done on pyrite-pyrhotite occurrences on, and to the east of, Southeast Bay. Mattagami Lake Mines Limited (eight holes, 1057 m), and Geophysical Engineering Limited (four holes, 406 m) have been the most active companies, completing their drilling in 1977 and 1978 respectively. Denison Mines Limited (eighteen holes, 1826 m) and Goldray Mines Limited (eight holes, 863 m) conducted a diamond drilling program in 1972 and 1973, as did Combined Metal Mines Limited (three holes, 345 m) in 1973.

General Geology

The area is underlain predominantly by mafic to intermediate metavolcanics. Intermediate to felsic metavolcanics occur locally. The southernmost portion of the area is underlain by an extensive granitic batholith. The metasediments occurring to the north are generally epiclastic and contain extensive deposits of quartz-magnetite ironstone. In their subdivision of the Sioux Lookout "greenstone" belt, Turner and Walker (1973) gave the name "Southern Sedimentary Belt (Minnitaki Group)" to these metasediments, and "Southern Volcanic Group" to the metavolcanics.

The mafic metavolcanics occur mainly in the vicinity
of Loggers Lake and in the eastern portions of the area. There are local occurrences throughout the Southeast Bay area and westward. South and southeast of Loggers Lake there is a hybrid zone of amphibolitic, dioritic, and quartz dioritic phases. This hybrid zone ranges in width from about 4 km in the vicinity of Flying Loon Lake to about 1 to 2 km, south of Loggers Lake. The zone pinches out against the granitic batholith to the west of Loggers Lake. Towards the southwestern corner of the map area the mafic metavolcanics adjacent to the intrusion are gneissic or more massive, rather than amphibolitic. Mafic flows with intercalations of pyroclastic and metasedimentary material extend from south of, to 5 km north of, Loggers Lake. The mafic flows are commonly porphyritic with phenocrysts of plagioclase or dark green amphibole, or both.

Pillowed mafic flows are common, and north of Loggers Lake. Amygdaloidal flows with both quartz and carbonate amygdules are present in the Loggers Lake area. A stronger foliation is developed northwards over the Loggers Lake area, as well as a finer grain size in the mafic flows. Shearing is locally observed to be intense at the eastern end of Loggers Lake. There local autobrecciation in mafic flows was also observed. The author believes that this mafic metavolcanic zone continues to, and past, Highway 642.

The mafic metavolcanics on Southeast Bay are similar to those outcropping in the Loggers Lake area. These rocks are typically porphyritic with both amphibole and/or small to large plagioclase phenocrysts, and some flows are pillowed. Many vesicular flows are present here and all are highly sheared.

Mafic to intermediate metavolcanics underlie much of the western and central portions of the map-area. These rocks are exclusively flows, generally massive and fine grained, though many are plagioclase porphyritic. Fewer flows are pillowed or vesicular and some flows are amygdaloidal with quartz amygdules. Throughout the area the intermediate to mafic flows are typically sheared. At the mouth of the English River on Southeast Bay intense shearing has produced a distinctive banding in the rock. Intermediate metavolcanic flows are prominent, though not extensive, at three locations in the map-area. In the vicinity of Way Lake in the central portion of the area there is a zone approximately 3 km wide of fine grained, commonly porphyritic, intermediate and intermediate to felsic flows. They are typically massive to weakly foliated, while some show brittle deformation features which may be related to faulting. On the west shore of Southeast Bay is exposed a 1 km wide section of intermediate flows which are typically pillowed and porphyritic with small plagioclase phenocrysts, and are considerably fractured. This fracturing is related to a fault just to the north of this section of rock. The southernmost bay of Southeast Bay contains several outcrops of pillowed and amygdaloidal intermediate flows, some of which show evidence of autobrecciation. Both quartz amygdules and pillows here are quite large, the latter being 3 to 4 m in length.

A characteristic lithology of the central and western portions of the map-area is a fine- to medium- to locally coarse-grained intermediate (dioritic) intrusive rock. It intrudes only those areas underlain by metavolcanics. Most of these intrusive bodies are small and localized, though a large exposure occurs at the northeast part of Southeast Bay. In the vicinity of Twinflower Lake some of these intrusions are mineralized. A small zone of massive pyrite and chalcopyrite was observed at one outcrop on Twinflower Lake and at another a minimal amount of covellite was discovered.

Other than one large area at the northwest end of Southeast Bay, pyroclastic rocks generally occur as felsic or intermediate bands between mafic or intermediate flows. The greatest concentration of interflow pyroclastic material is in the Loggers Lake area. Here felsic and intermediate tuff and lapilli-tuff bands are typically less than 1 m in thickness. North of Loggers Lake several interflow intermediate tuff beds reach thicknesses of 10 m. A large, though possibly isolated, area of dominantly intermediate to felsic pyroclastics occupies much of the northwest region of Southeast Bay. Lithic tuff and heterolithic tuff-breccia are most common. Some intermediate and felsic crystal tuffs are present in the southern portion of this section. The coarse fragment size suggests that these are near vent deposits. These pyroclastics are sheared and foliated.

Interflow metasediments are almost exclusively restricted to the Loggers Lake area, with a minor occurrence west of Smock Lake. These rocks are mainly wacke with some associated siltstone and mudstone. The thickness of the interflow metasediment beds varies, ranging up to 30 m.

Those metasediments occupying the northwestern and north-central portions of the map-area belong to the Southern Sedimentary Belt (Minnitaki Group) (Turner and Walker 1973). These rocks are predominantly interbedded wacke and argillite, with a small proportion of granitoid clast conglomerate. Locally arkose and arenite occur, particularly in the region of Twin Bay. An extensive, though discontinuous, zone of interlayered magnetite ironstone and quartz, consisting of several thick bands and a multitude of thinner bands is traceable from the northwestern part of Southeast Bay to the western extremity of the map-area. It continues beyond the western border of the map-area for a minimum distance of 15 km, and may extend to, and continue past, the western shore of Sandybeach Lake (Hurst 1932). Pyrite is a common accessory mineral, particularly in the argillites, which locally contain up to 10 percent pyrite.

Within the map-area two ultramafic and two mafic intrusions were observed. To the west of Way Lake a magnetite-rich ultramafic intrusion corresponds with a local magnetic anomaly of 61 000 gammas. The other ultramafic intrusion outcrops on the English River in the south-east corner of the map-area. It was formerly a coarse-grained pyroxenite, but it has undergone extensive retrogressive metamorphism. A yellow, powdery, possibly radioactive mineral is present throughout the rock. At this outcrop there occurs a very small, local occurrence of gabbro, which is likely a different phase of the same intrusion. The other mafic intrusion is also a gabbro body. This outcrop is located on a small lake to the west of Smock Lake.
Magnetite and pyrite are present in this rock in accessory amounts, and chalcopyrite in trace amounts. Intrabelt granitoid intrusions are generally manifested in two forms in the map-area: as small, sparse masses of quartz, feldspar, or quartz-feldspar porphyry, and as a large area of granitic rock in the vicinity of Smock Lake. The Smock Lake granitic intrusion is composed predominately of porphyritic granodiorite with minor hornblende syenite and quartz monzonite.

The large granitic batholith which occupies the extreme southern portion of the map-area is generally granodioritic in composition. In the Loggers Lake area the contact with the metavolcanics to the north is not sharp. Within the metavolcanic zone are outcrops which exclusively consist of granitic rocks. The rocks within the granitic intrusive zone typically contain inclusions of metavolcanic material. Commonly medium to coarse grained and biotitic, these granodiorites are weakly to strongly foliated, and range from gneissic in the west to porphyritic (K-feldspar phenocrysts) in the east. Fine grained leucocratic quartz monzonite dikes crosscut the granitic rocks of this southern intrusion.

### Structural Geology

The Loggers Lake area is dominated by an east to east-southeast trending syncline, the axis of which is located in the main part of Loggers Lake. Tight isoclinal folding about sub-vertical axes occurs in the area immediately east of Loggers Lake. Shearing associated with brittle faulting has occurred approximately 0.5 km east of here. Roughly northeast-trending lineaments in the eastern portion of the map-area may indicate faulting. North of Smock Lake an east-trending mylonite zone extends at least 3 km into the map-area.

Several generations of faulting, and possibly folding as well, complicate the geology of the Southeast Bay area. A series of major east-trending faults dominates the area. Commonly, but not always, these faults form the contacts between metavolcanic and metasedimentary zones as in the central and northern portions of the map-area. Shearing at the mouth of the English River is believed by the author to indicate the presence of an east trending fault zone which extends indefinitely to the east and west. An offset of this fault zone is accounted for by the presence of a later major north-trending fault. This fault occupies roughly the centre of Southeast Bay and extends from the granitic batholith in the south to at least East Bay in the north. In the northern portion of the area the offset due to the fault may exceed 4 km. A major northeast-trending fault extends from Twin Bay to Parnes Lake and may persist indefinitely past these locations.

Observations of drag folding in the metasediments of the northern portion of the map-area indicate an angular type of folding. Angular to isoclinal folding dominates in the Southeast Bay area. Outcrop scale folding, mainly on the east shore of Southeast Bay indicates the presence of areal Z-type and isoclinal folds which commonly plunge to the southwest at shallow angles. Lineations developed in the pyroclastic rocks occupying the northeast corner of Southeast Bay invariably plunge to the west at moderate angles.

### Economic Geology

Associated with the almost ubiquitous shearing in the Southeast Bay area are numerous quartz veins. Visible gold was observed by the author in one quartz vein only, on the northeast shore of Southeast Bay. In 1951, gold was noted by geologists of Paymaster and Gillies Lake-Empire Gold Properties along shear zones south of Twin Bay. Considering the present high value of gold, exploration should be directed to quartz veins in close proximity to these major faults.

The dioritic intrusive bodies should be examined for possible copper mineralization. Exploration should centre around the Twinflower Lake area where massive pyrite and chalcopyrite, and a minimal amount of covellite were discovered.

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**Eagle Lake — Wabigoon Lake — Stormy Lake Area**

**C.E. Blackburn**

### Location

This area (No. 4 on location map) encompasses that investigated by the author in 1977 (Blackburn in Trowell et al. 1977). It includes Eagle, Wabigoon and Stormy Lakes in the north and southeast, and the Manitou Lakes in the southwest. Apart from bulk rock sampling, only limited further work was carried out in this area by the author in the 1978 season.

Access to the eastern portion of this area has been greatly facilitated by the continued development of the Manitou Access Road, that will eventually link Dryden in the north with Highway 11 at Nickel Lake in the south. Construction is currently in progress on the final 15 to 20 km of the mid-section of this road east of the Manitou Lakes. Timber cutting by Reed Paper Company of Dryden is proceeding midway between Eagle Lake and Lower Manitou Lake, and south of Stormy Lake, with concomitant opening up of country by lumber roads in those areas.
Precambrian — Wabigoon Belt

Mineral Exploration

Mineral exploration up to 1977 was discussed previously (Blackburn in Trowell et al. 1977). Interest in the area has been maintained since the 1977 field season, with continued exploration for new occurrences and investigation of older properties and occurrences. Emphasis has been placed on volcanogenic base metal sulphide mineralization, copper and nickel in gabbros, and uranium. Recent activity within the area has been documented by Beard and Rivett (1978). Since publication of that report activity has continued particularly in the base metal programs.

General Geology

The general geology was discussed previously (Blackburn in Trowell et al. 1977). Several salient points not brought out in that discussion are mentioned here.

Blackburn in Trowell et al. (1977) noted that the area can be divided into a northern and a southern supracrustal domain, characterized, among other features, by equal amounts of volcanic and sedimentary rocks, and by predominantly volcanic rocks, respectively. Within the southern supracrustal domain considerable stratigraphic correlation has been established by the present work, and by a previous synoptic survey in the Manitou Lakes area (Blackburn 1976d,e). In conjunction with major element chemical analyses of samples taken along section lines at right angles to regional structure and stratigraphy, a major three-fold division of the volcanic sedimentary sequence is postulated (Blackburn et al. 1978). The lowermost volcanic unit is predominantly a series of Mg-rich tholeiitic basalt flows that outcrop between the south side of Lower Manitou Lake and Wapageesi Lake. This is in turn overlain by a highly variable, middle sequence of tholeiitic to calc-alkaline, basalt to rhyolite, flows and pyroclastic rocks, with associated metasediments, that occupy broad areas. The uppermost volcanic unit, that is conformable to unconformable on the middle sequence, consists predominantly of Fe-rich tholeiitic basalt. It outcrops in two areas, one that is triangular shaped centred on Boyer Lake, the other that is elongate immediately south of the Wabigoon Fault (Satterly 1941; see Blackburn in Trowell et al. 1977 for discussion) at Eagle and Wabigoon Lakes. This latter area was referred to by Blackburn (in Trowell et al. 1977, p.41) in discussion of the complete volcanic sequence at these lakes.

Economic Geology

A discussion of the economic geology of this area is given by Blackburn (in Trowell et al. 1977). Further mention is made here of lithium, beryllium and tungsten occurrences located in Zealand and Brownridge Townships, and lithium and cesium in Webb Township. The author has not seen these occurrences, but their association with probable anatectically derived pegmatites marginal to the English River Subprovince suggests that further investigation should be carried out along this zone, as noted by Breaks et al. (1975, p.32).

Populus Lake — Mulcahy Lake Area

C.E. Blackburn

Location

The area investigated (No. 5 on location map) extends from Dryberry Lake in the west to Mulcahy Lake in the east. Emphasis was placed on volcanic, sedimentary and mafic intrusive rocks within this area.

Access to most of the area is by air. A lumber road extending westward from Dryden passes close to and south of Mulcahy Lake, currently terminating south of Beaverhouse Lake.

Mineral Exploration

Numerous copper, copper-gold, and copper nickel deposits have been located immediately south of the area discussed here (Davies 1973). Within the present area, copper-nickel deposits were found in the 1930s near Kathleen Lake, and investigated by, among others, the International Nickel Company of Canada Limited, and Falconbridge Nickel Mines Limited. During the late 1950s Falconbridge Nickel Mines Limited sank a shaft to 622 m and carried out considerable exploratory cross cutting, drifting, and drilling. As of 1957, when operations were suspended, the Kenbridge property had an indicated reserve of 2 967 760 t, grading 1.06 percent nickel and 0.54 percent copper (Davies 1973).

Just south of this area, continued stand-by status of the Maybrun Mines Limited copper-gold property at Head Bay of Atikwa Lake is reported (Beard and Rivett 1978). This deposit was discovered in the 1950s, and investigated by Noranda Mines Limited, and subsequently Maybrun Mines Limited. Following a long period of inactivity, brief production was carried out in 1974 (Beard 1975). The property was described by Davies (1973).
Following the recognition of a large gabbroic body in the vicinity of Mulcahy Lake (Moorhouse 1939, Davies and Watowich 1956) considerable exploration has been carried out for copper and/or copper-nickel deposits, in particular by Falconbridge Nickel Mines Limited. No significant deposits have been discovered to date.

In recent years exploration for volcanogenic massive sulphide mineralization has been carried out in the Populus-Fisher Lakes area, with limited success.

General Geology

The area investigated essentially covers the Populus Lake area mapped by Davies and Watowich (1956). Metavolcanic and metasedimentary rocks trend northeastward. As noted in the Eagle Lake—Wabigoon Lake—Stormy Lake area immediately to the east (Blackburn in Trowell et al., 1977, and this report), the metasediments of the Warclub “series” (Burwash 1933) lie to the northwest, and the Populus metavolcanics (Davies and Watowich 1956) to the southeast, and are in sharp mutual contact. The former lie within the Northern Supracrustal Domain, the latter in the Southern Supracrustal Domain.

Northern Supracrustal Domain

The Warclub “series”, although predominantly metasedimentary, also contains distinct pyroclastic units that have not previously been documented, and interbedded minor mafic flow units, both at Warclub Lake. Previous discussion (Burwash 1933; Fraser 1943; Davies and Watowich 1956) as to relative age of the Warclub “series” was based on whether adjacent metavolcanics are older or younger; it is probable that both older and younger metavolcanics exist, in addition to metavolcanics that are undoubtedly interlayered with the metasediments. The age of the Populus metavolcanics relative to the Warclub “series” is not known, because of faulting, along the contact, as postulated here and previously suggested by Davies and Watowich (1956).

At Warclub Lake tight folding of the metasediments is indicated by a limited number of top determinations from graded bedding. At Hawkcliff Lake small scale S- and Z-folds are visible though top determinations indicate only one major northeasterly plunging syncline. Southward from Hawkcliff Lake toward Stoot Lake, lack of good graded beds prevents further analysis, but the presence of a distinct magnetite ironstone marker band that can be traced at least 30 km along strike without folding suggests that folding, if present, is about subhorizontal axes. Discontinuous ironstone bands occur further eastward, towards Eagle River and Dryden: it is improbable that they are one repeated band, but unclear as to how many bands are repeated by folding; here too, subhorizontal fold axes are indicated, though folding is complicated by two later generations of Z-folds (Blackburn in Trowell et al. 1977). At least one, and perhaps both, of these later generations of Z-folds is increasingly prevalent close to the contact of the Warclub “series” with the Populus metavolcanics. As suggested for the Eagle Lake—Wapigon Lake area (Blackburn in Trowell et al. 1977), it is probable that these later small scale folds indicate a component of dextral offset along the Wabigoon Fault (Satterly 1941), the locus of which is the contact between the northern and the southern supracrustal domains.

Pyroclastic rocks occupy a central position at Warclub Lake, and were previously mapped as arkose and arkosic greywacke (Davies and Watowich 1956) in the Populus Lake area, and arkose and quartzite, with subordinate conglomerate, by Davies (1973) in the adjoining Atikwa Lake area. Davies and Watowich (1956), p.6 noted “Lenses of volcanic breccia or agglomerate near Warclub Lake” but did not distinguish them on the map, while an “intraformational conglomerate” discussed by Davies (1973, p.8) that occurs along the southeast shore of Warclub Lake is in fact felsic tuff-breccia and pyroclastic breccia. Fine grained siliceous bedded tuffs occur at Silly and Stoot Lakes, immediately adjacent to the domains boundary. It is probable that felsic pyroclastics occur elsewhere in parts of the Warclub “series” not examined by the author, possibly along strike between Warclub and Stoat Lakes.

The Warclub “series” at Dryberry Lake is intruded by granodiorite of the Dryberry batholith. Remnant sedimentary beds and mafic metavolcanics and gabbros help define a broad dome structure underlying the east end of Dryberry Lake. It is quite probable that metasediments at Highway 71 near Bunny Lake, discussed by Edwards (this report) are stratigraphic equivalents.

Southern Supracrustal Domain

Reversals of pillow tops in the Populus metavolcanics were recognized by Davies and Watowich (1956). Further determinations made by this author established three fold axes trending northeastward: a central syncline along the northwest arm of Populus Lake, and underlying Fisher Lake (here named the Fisher Lake Syncline), is flanked by an anticline at Betula Lake (here named the Betula Lake Anticline), and an anticline beneath central Populus Lake (here named the Populus Lake Anticline).

The positioning of these fold axes leads to the observation that a band of rhyolite along the northwest side of Betula Lake is repeated across the Betula Lake Anticline, and lies near the centre of the lake. Coarse, gabbroic rock that may be of intrusive or flow origin is similarly folded around the Betula Lake Anticline and its form suggests that the anticline plunges to the northeast. Rhyolite at Fisher Lake lies in the core of the Fisher Lake Syncline. The Betula Lake Anticline appears to terminate against the contact of the Populus metavolcanics with the Warclub “series”, further supporting a fault contact between the southern and northern supracrustal domains.

The northeastward continuation of the Populus Lake anticlinal axis is contentious: based on four pillow tops determined by Davies and Watowich (1956), the axis is here interpreted to curve eastward to terminate at the east end of the metavolcanic belt, approximately 1 km west of Beaverhouse Lake.
The Populus metavolcanics are predominately basaltic flows, apart from the rhyolite noted above, and tuffaceous pyroclastic rocks at the north end of Fisher Lake. They are intruded by the western end of a noritic body centred on Mulcahy Lake.

Mulcahy Lake Norite

The eastern end of this large intrusion was first mapped by Moorhouse (1939). Following determination of its full extent by geologists of the Canadian Pacific Railway, Development Section, the remainder of the body was mapped by Davies and Watowich (1956), and later included in a comparative study by Davies (1966).

It was suggested by Moorhouse (1946) that the body may be synclinal, and by Davies and Watowich (1956) that it may be funnel shaped. These suggestions were based on the observation that peridotite lenses occur along the northern and southern edges of the body, and may have "originally formed a discontinuous ring near the contact with the country rocks" (Davies and Watowich 1956, p.11). This suggestion would necessitate an inward facing of successive phases of the intrusion. Distinct layering, noted by Moorhouse (1939, 1946), and Davies and Watowich (1956) is especially developed near Mulcahy Lake, where a recent forest fire has exposed spectacular outcrops. The banding is undoubtedly primary, and due to variation in proportion of ferromagnesian minerals to plagioclase. Within bands there is gradation from norite to anorthosite. Their parallelism, consistent northeasterly orientation, sharp contacts between bands, and in the vicinity of Mulcahy Lake, the consistent gradation from melanocratic to leucocratic from southeast to northwest suggests their horizontal emplacement, with subsequent tilting to the northwest. Lack of good exposure and/or well developed gradation within bands across the whole body prevented precise determination of structure, but from available information gathered along a complete north-south section across the body it is probable that the body is neither funnel shaped nor folded, but was emplaced as a sheet, and later tilted into its present vertical position. Distinct evidence for both crystal settling in the layered sequence and flow within layers is presented by the above noted gradation of mineralogy, and presence of cross-beds, truncated beds, cut-and-fill structures, slump folds, and exotic rafted-in clasts. Magnetite is commonly concentrated in the lower, mafic portion of layers, and also occurs in discrete pods that vary from a few centimetres to many metres in length.

At McKinstry and Eastern Chicken Lakes granitic phases occur within the confines of the Mulcahy Lake intrusion, as outlined by Davies and Watowich (1956). These rocks were not inspected by the present author, but speculation might be made that they represent granophyric differentiates near the top of the northwest facing intrusion. If this is true, a comparison can be made between layered rocks of the Mulcahy intrusion and those of other intrusions, e.g. Layered Zone of the Doré Lake complex at Chibougamau (Allard 1976). The Doré Lake complex, as noted by Allard (1976) has a granophyric zone above the layered zone. Early workers did not recognize its association with the underlying mafic rocks, considering it to be an independent granitic intrusion.

The relationship of the ultramafic rocks 1 km north of Morah Lake (Moorhouse 1939; Davies and Watowich 1956), to the Mulcahy Lake intrusion remains problematical. Their location at the interpreted stratigraphic top of the body is unusual if they are part of the Mulcahy Lake body. Evidence for intrusive contact was neither found nor negated by the author. It is notable that similar peridotites occur along strike within mafic metavolcanics at the west end of Eagie Lake near Prendible Island (Moorhouse 1939).

Apart from narrow cumulate pyroxenite zones at the base of layers, ultramafic rocks were only encountered at one other location within the Mulcahy Lake intrusion, along the lumber road that traverses the southeast corner of the body, south of Mulcahy Lake: an altered pyroxenite to peridotite intrudes layered noritic rocks, about 1 km east-southeast of Snaré Lake. The peridotitic rocks noted by Moorhouse (1939, 1946) at Straight Lake were not investigated by the present author.

Economic Geology

Copper-gold occurrences have not been located in the area discussed here. However, their presence in mafic metavolcanics along strike to the south, at Head Bay of Atikwa Lake, suggests that the Populus metavolcanics may be suitable hosts for such deposits.

Copper-nickel deposits associated with coarse mafic, gabbroic rock occur at Kathleen Lake, south of Populus Lake. According to company records of Kenbridge Nickel Mines Limited, as documented by Davies (1973, p.44), the mineralized zones occur in a vertically plunging mafic breccia plug. The present author visited the dump and found much heavily carbonatized mafic metavolcanic country rock. Sulphide minerals occur in this rock, but mostly in gabbroic phases that may or may not be intrusive. Sulphides found were pyrrhotite, pentlandite, chalcopyrite, and minor bornite or chalcocite. Massive sulphide mineralization contains up to 40 per cent chalcopyrite. Of note is the association of blue quartz with the ore minerals. Similar coarse mafic rocks occur within the Populus metavolcanics, but it is probable that these were thoroughly investigated in the 1930s and 1950s.

The Mulcahy Lake norite body, although investigated previously, is considered a potential host for copper-nickel ores. The recognition that it is a sheet-like body facing northwestward has bearing on any future exploration program.

Platinoid-group metals, such as chromium, vanadium and titanium have a potential in the Mulcahy Lake body. Iron, in the form of magnetite in this body, is associated with titanium. However, chrome and vanadium are not known to occur. As for copper-nickel exploration, the
recognition of the sheet-like form of this body is significant, in that comparisons might be made with the Bushveld, Stillwater, or other chromium-bearing complexes. Apparent lack of a complete developmental sequence, as suggested first by Moorhouse (1946), may preclude concentration of platinoid group metals, since those at Bushveld and Stillwater are found within the lower ultramafic sequences, analogues of which may be absent in the Mulcahy Lake intrusion.

**Copper-zinc** mineralization of volcanogenic association is potentially favourable within Populus metavolcanics, especially in the vicinity of felsic metavolcanics as at Fisher and Betula Lakes. Inspection by the author of trenches excavated by Lynx-Canada Exploration Limited on the large island in Fisher Lake showed the presence of chalcopyrite and sphalerite in one trench group only, but significantly within an aguagene breccia right at the contact between mafic pillowed metavolcanics and rhyolite.

At Betula Lake, rocks mapped as monzonite by Davies and Watowich (1956) contain up to 15 percent quartz, are low in mafic mineral content, and possess textures characteristic of subvolcanic felsic (porphyry) phases. They may therefore be the subvolcanic phase of rhyolites at Betula Lake. Such similar volcanic centres have been suggested as exploration targets for base metal deposits in the Manitou-Stormy Lakes area (Blackburn in Trowell et al. 1977; Beard and Scott 1976).

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**Harris Lake — Pickwick Lake Area**

**C.E. Blackburn**

**Location**

The area investigated (No. 6 on location map) included that portion of the new Manitou Access Road that crosses the Otukamamoan Lake metavolcanic belt (Blackburn 1973) and lumber roads that branch off it, and a stretch of country centred on the Manitou Stretch bridging the gap between recent detailed mapping at Lower Manitou Lake (Blackburn 1976c) and Esox Lake (Edwards and Sutcliffe 1977). The latter area, with abundant lake water access, may be reached via the Cedar Narrows road that branches off the Manitou Access Road near Winkle Lake.

**Mineral Exploration**

Exploration up to 1970 in the Otukamamoan Lake metavolcanic belt was discussed by Blackburn (1973). Subsequently, exploration has been conducted around the Tupman Lake Antiform and at Otukamamoan Lake, over electromagnetic conductive zones that lie within or close to rocks mapped as felsic to intermediate metavolcanics by Blackburn (1973). There is little record of exploration in the area bridging Lower Manitou and Esox Lakes, apart from old gold occurrences (Thomson 1934; Beard and Garratt 1976). To the west, at Straw Lake, the old Straw Lake Beach mine was of importance during the 1930s. The area has undoubtedly been covered by airborne electromagnetic and magnetic surveys, but apparently with few resultant conductors found.

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**General Geology**

Previous mapping by Blackburn (1973) of the Otukamamoan Lake metavolcanic belt suggested that mafic flows had been folded about three north trending folds: the centrally disposed Tupman Lake Antiform, and two flanking synclines. None of these folds had been identified by Thomson (1934) in the Straw-Manitou Lakes area that adjoins to the north. Construction of the new Manitou Access Road across the Otukamamoan Lake metavolcanic belt, from Sawbill Lake in the south to Arms Lake in the north has exposed numerous well formed pillowed volcanic flows. All of these flows display pillows that face consistently southwestward; thus the previously inferred syncline at Winkle Lake (Blackburn 1973) does not exist. Lack of newly discovered pillow tops on the west side of the belt, in the vicinity of Twist and Vista Lakes, prevents confirmation of continuity of the Tupman Lake Antiform axis north of Pickwick Lake. Because of the presence of west facing pillows on the west side of Pickwick Lake (Blackburn 1973) the previously inferred syncline flanking the Tupman Lake Antiform is corroborated.

The southwesterly facing pillows exposed along the Manitou Access Road are all either vertically dipping or dip northeastward, corroborating the previous interpretation of a northeasterly plunge for the Tupman Lake Antiform, and establishing that the antiform is an antiformal syncline.

A sequence of quartz-feldspar ± biotite ± amphibole ± garnet schists, previously interpreted by Blackburn (1973) as derived from tuff and lapilli tuff are well exposed along the new road. Their uniform thin-bedded
character leads to a new interpretation of these rocks as metasediments. Thin-bedded ironstone was observed at one locality along the road, and had previously been mapped elsewhere within this sequence (Blackburn 1973). It is probable that much or all of this sequence, that wraps around the Tupman Lake Antiform, is metasediment, and not metavolcanic as previously mapped (Blackburn 1973). The possibility arises that it might provide a stratigraphic link between metasediments at Esox Lake and metasediments of the Rainy Lake area.

Also notable is the fact that pillowed mafic flows, that contain units that are markedly plagioclase phyric, face away from the Irene-Eltrut Lakes batholithic complex, both along the south side of the Manitou-Stormy Lakes metavolcanic-metasedimentary belt, and in the Otukamaano Lake metavolcanic belt. The Otukamaano Lake metavolcanics are therefore probably the stratigraphic equivalents of the lowermost metavolcanic unit in the Manitou-Stormy Lakes area (see Eagle Lake — Wabigoon Lake — Stormy Lake Area, this report).

In that part of the present area north of the Otukamaano Lake belt, very few top determinations were made by the present survey because of the rapidity of investigation coupled with a lack of suitable lithologies and, in places, outcrop. Pyroclastic rocks, mostly intermediate, predominate. At Dogfly Lake, coarse pyroclastic rocks dominate on the north shore of the lake, tufs on the south. A sinistral fault oriented north-northeasterly underlies Van and central Dogfly Lakes, paralleling a much longer sinistral fault that passes through Vista and northward between James and Kahabeness Lakes. North-northeast trending faults, most of which have sinistral displacement, are a pervasive feature of the area between the Manitou Lakes in the north and Rainy Lake in the south (Parkinson 1962; Davies and Pryslak 1967; Blackburn 1973, 1976a,b,c, 1977).

At the southwest end of Lower Manitou Lake, strong schistosity with a northeasterly orientation is pervasive across the width of the lake (3 km). This schistosity can be mostly attributed to shearing along the Manitou Straits Fault which, as noted in the Lower Manitou-Uphill Lakes map-area (Blackburn 1976c), has a number of subsidiary, parallel faults. The wide schist zone was not encountered in a traverse across the belt from Manitou Stretch to Harris Lake, though narrow zones of schist occur in places. The major component of movement has probably been taken up in faulting along the whole length of the Manitou Stretch, as noted for the west end of this waterway by Thomson (1934) and Edwards and Sutcliffe (1977).

Felsic to intermediate pyroclastic rocks mapped by Edwards and Sutcliffe (1977) at Missus and Mister Lakes continue northeastward into Harris Lake. Other newly located rocks include some thin siliceous metasediments outcropping along the northwest shore of this lake, and pyroxenitic to pyroclastic rocks on islands in the centre of the lake.

**Economic Geology**

**Gold** occurrences west of the present area, at Straw Lake, are associated with quartz veins in sheared felsic metavolcanics (Thomson 1934; Beard and Garratt 1976; Edwards 1977; Edwards and Sutcliffe 1977). The continuation of these felsic metavolcanics into Harris Lake makes this area of interest in gold exploration. Edwards and Sutcliffe (1977) found gold values in porphyry phases within the Lawrench Lake batholith close to the edge of the metavolcanic belt; these authors noted the possibility of phases of this batholith being subvolcanic equivalents of felsic metavolcanics within the metavolcanic belt, so that a genetic link for gold values in these two rock types may be made, making both equally amenable to exploration.

**Base metals.** The present delineation of coarse pyroclastic rocks at Dogfly Lake, and at Harris Lake, in both places associated with finer, tuffaceous, rocks, suggests a proximal to distal facies relationship, with concomitant possibility of vent fumarolic activity and potential volcanogenic massive sulphide deposits.

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**Crow (Kakagi) Lake — Sioux Narrows Area**

**G.R. Edwards**

**Location**

The area investigated (No. 7 on location map) in 1978 included those supracrustal rocks exposed in the following areas:

- a) along Highway 71 between the Sabaskong Batholith contact south of Kakagi Lake and the Dryberry Batholith contact north of Bunny Lake;
- b) along secondary roads in the area of Sioux Narrows;
- c) shoreline of South Narrow Lake (west of Kakagi Lake);
- d) shoreline of the south part of Snake Bay (Lake of the Woods).

In addition, two chemical section traverses were completed, one between Katimiagamak Lake and Kakagi Lake and the other from Snake Bay (Lake of the Woods) to Emm Bay (Kakagi Lake).

Access to the area is by Highway 71 or by boat therefrom except for Katimiagamak Lake which is reached by air.
Mineral Exploration

Gold occurrences discovered mainly during the gold prospecting "boom" which lasted from the late 19th Century to the 1930s are scattered throughout the area.

The only past producing mine of importance in the area was the Regina mine at Regina Bay, Lake of the Woods. A recent compendium of deposits is given by Beard and Garratt (1976).

Despite considerable exploration activity in the vicinity of Kakagi Lake for base metal (copper-zinc) deposits, to date only a few isolated showings have been reported.

General Geology

Supracrustal strata in the area investigated are steeply dipping and folded on a large scale between Early Precambrian (Archean) granitic batholiths.

Kakagi Lake — South Narrow Lake Area

In this area from the Sabaskong Batholith contact to a point about 2 km northwest of Girard Lake, Highway 71 crosses the stratigraphy roughly in a north-northwesterly direction.

Deformed, medium to low grade mafic metavolcanic flows predominate between the Sabaskong Batholith contact north-northwest along the highway. Gabbroic textured mafic rocks occur with fine grained flows about 1.5 km north of the contact and are probably coarse grained mafic flows.

The mafic metavolcanics here are considered by the author to be a north to northeast facing thin remnant of what was a thicker mafic platform correlative to that south of Kakagi Lake (see Kaye 1974a,b).

Stratigraphically above the mafic flows is a sequence of variably textured, mainly intermediate composition, pyroclastic and pyroclastic-derived rocks. This sequence lies in a synformal keel between the flanking mafic platform sequences and occurs on the highway between a point about 2 km southwest of South Narrow Lake and Muskie Lake (Kakagi Lake). In general, the pyroclastic rocks are better preserved than the mafic flows to the south.

Layered mafic intrusions of the type previously described by Davies and Morin (1976) and Kaye (1974a,b) for the Kakagi Lake area appear to have intruded only the pyroclastic rocks.

Northwest of Muskie Lake, the highway traverses southeast to east facing mafic metavolcanic flows running roughly parallel to stratigraphy from about 2 km northwest of Girard Lake as far north as Snake Bay where the belt bends northwest.

Several ophitic to porphyritic (plagioclase) gabbro-like bodies that apparently have intruded the flows were observed along the highway.

In the vicinity of Girard Lake close to the old Trojan and Mascotte shafts (Kaye 1974b) the country rock is diorite or leucogabbro exhibiting varying degrees of brecciation. A feldspar porphyritic granitic dike of unknown width has intruded the diorite almost parallel to the rock cut along the highway. Both the dike and the brecciation are probably related to the emplacement of the Robinson Lake stock (Kaye 1974b) located 1 km to the southwest.

Snake Bay — Reed Narrows Area

Highway 71 roughly parallels stratigraphy from Snake Bay to Sioux Narrows. The rocks are predominantly east to northeast facing mafic metavolcanic flows with minor zones of flow breccia. In the vicinity of and south from Regina Bay (Lake of the Woods) numerous thin subvertical dikes of feldspar and quartz-feldspar porphyry have intruded the mafic flows and appear to be related to the emplacement of the granitic stock which occupies much of Regina Bay.

Northeast from Sioux Narrows the highway again traverses the stratigraphy (mafic flows). Evidence collected in 1977 (Edwards et al. 1977) indicates that the metavolcanics here, which are continuous with the sequence south of Regina Bay (to Kakagi Lake), face northeast.

Reed Narrows — Dryberry Batholith Contact

Two kilometres west of Reed Narrows the rock type changes abruptly from little deformed mafic metavolcanics to strongly deformed metasediments some of which are turbidites. The contact is not exposed on the highway but it is interpreted by the author to be a fault contact, probably the northwest extension of the regional Pipestone-Cameron Fault (see Edwards et al. 1977).

The deformed metasediments northeast of the fault are similar to those described by Edwards (in Trowell et al. 1977) in the Lobstick Bay area. Towards Reed Narrows, these metasediments become tuffaceous. North of Reed Narrows and occupying much of the western part of Long Bay as well as part of the north shore of Lobstick Bay is a 3.5 km thick sequence of intermediate to felsic (quartz-) feldspar porphyry, (quartz-) feldspar porphyry autobrecchia and/or deformational breccia, and tuff to tuff-breccia.

The northern margin of the body is a gradational contact with highly folded metasediments. These sediments of variable, generally turbiditic nature form the margin of the supracrustal belt in this area. The grade of metamorphism is at least medium grade, increasing toward the batholith contact. Near the contact originally sandy beds in the metasediments have been completely recrystallized and the silty beds are mainly biotite. Static, thermal metamorphism appears to have predominated. A gneissic intrusive phase has developed near the contact and stromatic and pytgmatic structures are common. Batholith material in the endocontact zone could easily be diatexite. Possible andalusite and sillimanite were identified in some crenulated zones in the exocontact.

South of Mooseview Lake, the metasediments are in-
truded by a wedge of gabbro and minor pyroxenite which widens abruptly eastward toward Berry Lake. These rocks may be correlative with those mafic intrusions described by Davies and Watowich (1956) in the Atikwa Lake area and by Blackburn (this report).

Structural Geology

Mafic metavolcanics between Kakagi Lake and Long Bay (Lake of the Woods) form a relatively simple southeast to east to northeast facing homoclinal sequence wrapping broadly around the Aulneau Batholith to the west. West of Kakagi Lake where the west trending supracrustal belt has been pinched between the Aulneau and Sabaskong Batholiths pyroclastic rocks and mafic intrusions form the core of an uncertainly delineated synform. Fragment linear plunges vary from 35 to 75 degrees, mainly in the northeast quadrant, in the South Narrow Lake area.

North of Long Bay — Regina Bay (Lake of the Woods), north of the proposed northwestern extension of the Pipestone-Cameron Fault, structure is much more complex. The volcanic porphyry complex north of Long Bay and Lobstick Bay appears to have been folded along a west-northwest trending axis. This is suggested by the presence of metametasediments both to the north and south of the complex and by apparent “closure” west of Mist Inlet north of Long Bay. The metametasediments on both sides of the volcanic complex exhibit complicated fold patterns such that the interpretation of scattered top determinations is not always possible.

The relationship between the metametasediments in the northern part of the area and the Dryberry Batholith are of interest on a regional scale. Contact relations here, as previously discussed in this summary, indicate that at least some of the granitic material in the Dryberry Batholith is derived from remelting of these metametasediments, a condition similar to that which exists in the English River Belt or Subprovince (Breaks et al. 1978).

Metasediments in the Bunny Lake area and further north in the vicinity of Andy Lake are correlative at the present stage of mapping with those in the Populus Lake-Mulcathy Lake area (Blackburn, this report). The interlayering, whether it be stratigraphic or structural, of what may be the western extension of English River Belt metametasediments with Wabigoon Belt metavolcanics in the area between Andy Lake and Long Bay (Lake of the Woods) indicates that the relationship between these two belts may be more transitional than generally supposed.

Economic Geology

Gold remains the most important commodity in the area. At the old Regina mine (south of Regina Bay of Lake of the Woods) gold occurred in a quartz vein that varied in width from 2 to 6 m and was emplaced in altered mafic metavolcanics adjacent to the granitic stock at Regina Bay. Notably, sphalerite occurred as accessory mineralization with native gold.

Several old unproductive gold occurrences are located between Kakagi Lake and Whitefish Bay (Lake of the Woods). These include particularly the aforementioned Mascotte and Trojan occurrences as well as the old Bully Boy and Combined occurrences (Fraser 1943).

A good target for base metal exploration is the felsic to intermediate metavolcanic complex in the Long Bay — Lobstick Bay area, Lake of the Woods. It should be kept in mind that folding has probably destroyed any simple layer-cake stratigraphy which may have existed in this area. Metasediments adjacent to this volcanic complex may represent, in part, basin deposits adjacent to the original volcanic structure.

Granitic stocks and associated porphyry dikes intruding mafic metavolcanics in this area appear to have provided thermal mechanisms for the deposition of gold in the host rock (e.g. the Regina mine and the Trojan and Mascotte occurrences). It is likely that mineralizing solutions adjacent to these plutons also carried base metals which would be deposited at lower temperatures further from the intrusion either in veins or near fumarole sites if the intrusion was shallow enough. Traces of malachite and azurite were discovered in diorite about 400 m west of Girard Lake on Highway 71.

The possibility of copper and nickel mineralization in mafic intrusions always exists. The gabbro pyroxenite body which intrudes the metasediments west of Berry Lake should be examined for possible mineralization as in the Denmark Lake area further east (Kaye 1973).

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No. 7 Zarn Lake Area, District of Kenora
R. O. Page

Location and Access

The area mapped is bounded by Latitudes 50°00' and 50°11'N and by Longitudes 91°33' and 91°45'W, including portions of NTS sheets 52J/4NE and 52J/4SE. The easternmost portions of Block 10 and Drayton Township, and a portion of Benedickson Township, are also included in the map-area. Thunder Bay lies about 240 km to the southeast while the closest population centre, Sioux Lookout, is about 15 km to the west. Some locations within the map-area require float plane service or canoe portaging, but general access can be gained from Sioux Lookout via paved road (Highway 642), boat, or Canadian National rail service.

History of Mineral Exploration

Exploration and development of mineral resources within the map area was initiated in the early 1930s following the discovery of several gold occurrences. Two of these, the Alcona Gold Mines Limited and Split Lake Gold Mines Limited properties (located 0.8 km southwest and 0.4 km southeast of Split Lake, respectively), received underground development, but work was discontinued after several years due to lack of continuity of the mineralized zones and poor market conditions. Other early gold prospects were trenched and/or diamond drilled without significant results.

Between 1947 and 1963, various prospectors and exploration companies investigated portions of the map-area with geological mapping, ground geophysical surveys, trenching, and shallow diamond drilling. All of this work was directed toward potential gold mineralization associated with quartz or quartz-carbonate veining, mostly in the area between Rosnel siding (Canadian National railway, south shore of Botsford Lake) and the north ends of Split and Enira Lakes. Low gold values discouraged further work on most of these prospects. The Richards occurrence (located about 0.8 km south of Black Lake) was staked in 1951, restaked in 1963 for Bankfield Consolidated Mines Limited, and has yielded interesting but erratic Au-Ag values.

Base metal showings (Cu, Zn, Pb) at and about 0.5 km south of Rosnel have been investigated by W.H. Thompson of Sioux Lookout over the period 1964 to 1975. Options were taken on this ground by Asarco Exploration Company of Canada Limited (1970 to 1972) and New Insco Mines Limited (1975). Geological mapping, ground electromagnetic and magnetic surveys and 17 short diamond drill holes have failed to locate economic mineralization.

Kerr Addison Mines Limited (1968 to 1969) con-

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

2 Information from Assessment Files Research Office, Ontario Geological Survey, Toronto.
ducted an extensive diamond drilling project at the west end of Botsford Lake (south of Hidden Lake). Fifteen holes totalling over 3350 m intersected pyroclite-quartz-magnetite ironstones interbedded with mafic metavolcanics; chalcopyrite was associated with pyrrhotite in some of these drill holes, but not in significant amounts.1

Selco Exploration Company Limited (1971 to 1972) investigated portions of the area between the north ends of Split and Enira Lakes with ground geophysical surveys, locating several magnetic anomalies. Selco Exploration Company Limited (1971) also drilled three short holes in the area south and east of East Bay, Minnitaki Lake (southwest map corner), but conductive zones found there were apparently not of economic interest.

Exploration activity known in the map-area during the 1978 field season included the staking of eight claims in three groups (by prospectors), and detailed geological and geophysical surveys conducted by Mattagami Lake Mines Limited. Claims staked include: four claims over the old Alkenore-Buffalo gold prospect (about 1 km east of the north end of Ty Lake); three claims over a portion of the original Alcona Gold Mines Limited property; one claim west of Martin Creek, midway between McDougall Mills and the north end of Clamshell Lake.

General Geology

Bedrock within the Zarn Lake map-area is apparently all of Early Precambrian age. Roughly two-thirds of the area is underlain by extrusive, mafic to felsic metavolcanics, several hypabyssal intrusive bodies, and minor metasedimentary units. The southeastern one-fifth of the area consists of a poorly exposed biotite granodiorite to quartz monzonite pluton which was mapped in reconnaissance fashion (traverse spacing about 1 km). A small portion of the southeastern map corner was not examined. The northwestern third of the area (all ground north of Botsford Lake) contains highly deformed granitoid intrusive rocks and layered, trondhjemitic to quartz monzonitic gneissic rocks, all being a portion of the English River Gneiss Belt. This area was also mapped in reconnaissance style, and about 18 km² in the northwestern map corner were left unexamined.

Detailed mapping (0.5 km spaced traverses) within the predominantly metavolcanic terrain has outlined eight major units. Felsic metavolcanics south of the west end of Botsford Lake (extending from Alcona to Out Lake) consist of rhyolite to dacite pyroclastics and flows; these rocks were previously mapped as "older intrusives" (Horwood 1937). Felsic metavolcanics also occur in the Forty-Mile and Enira Lakes area, and consist of dacitic to rhyolitic pyroclastics and derived schists. Intermediate metavolcanics occurring in the Kirk-Star-Michaud Lakes area are the probable eastern extension of andesitic pyroclastics and flows first described by Pettijohn (1936).

Tonalitic to trondhjemitic, high level intrusive rocks are found in the southern Clamshell Lake area. These plutonic rocks contain minor to abundant accessory carbonate and chlorite. A multiphase, diorite-quartz diorite-trondhjemitic intrusive complex extends south and east of Rosnel and was not previously fully outlined (Horwood 1937). Biotite to hornblende biotite granodiorite forms the core of a small stock centered on Split Lake; the border zone consists of xenolith-rich granodiorite to mafic intrusive rock.

Vein quartz and quartz porphyry bearing conglomerates, along with well-bedded, quartz-poor pebbly sandstone and minor slate occur in the southwest corner of the area. These metasediments form the eastern extension of the Minnitaki Group, first described by Pettijohn (1936) and defined by Walker and Pettijohn (1971). The inferred source rock for the quartz porphyry delimited, an oval plug outlined by Horwood (1937), has been shown, however, to consist only of several small (less than 0.5 km), isolated masses of porphyritic trondhjemitic surrounded by the metasediments. Age relations between the two rock types were not defined in observed outcrops.

 Sulphidic magnetite-grunerite-quartz ironstone, wacke, and slate are found within mafic metavolcanics along the length of Botsford Lake. These units may represent the eastern extension of Abram Group metasediments (Daredevil Formation?) as defined by Turner and Walker (1973). Quartz-bearing metasediments occur at various other locations within the metavolcanic succession and are apparently of volcanic derivation. The remainder of the volcanic-sedimentary terrain consists primarily of mafic to intermediate metavolcanics with gabbroic sills and isolated lenses of felsic metavolcanics.

Metamorphic grade throughout the area is generally within the greenschist facies, with the following exceptions.

a) Mafic and intermediate metavolcanics bordering the Split Lake stock have attained epidote-amphibolite to amphibolite grade metamorphism, but locally occur as hornfels. Pyrope-almandine porphyroblasts are a common constituent in country rocks southeast of the stock, but their occurrence here appears to be anomalous for the map-area as a whole, as well as within the contact aureole. They occur at approximately the same structural level as the Alcona prospect and Split Lake prospect.

b) Mafic metavolcanics surrounding the Zarn Lake pluton (SE map corner) are of amphibolite facies metamorphic grade and felsic metavolcanics on the south shore of Forty-Mile Lake have been converted to garnet-bearing quartz muscovite schists.

c) Mafic metavolcanics found in closest proximity to the gneissic terrain (north shore of Botsford Lake) appear to have attained epidote-amphibolite facies metamorphic grade.

Structural Geology

Three major structures have been defined within the map-area. These may have a bearing on mineral exploration
and include:

a) Kirk Lake syncline;
b) Split Lake dome;
c) Botsford Lake fault

The Kirk Lake syncline trends northeast to north through Kirk Lake and apparently exposes the youngest metavolcanics in the map-area. Regional correlation with similar rocks ("formation 4" of Page and Clifford 1977) exposed about 13 km to the southwest in Northeast Bay of Minnitaki Lake provides a starting point for stratigraphic reconstruction. In general, metavolcanics older than "formation 4" may be traced around the Split Lake dome, suggesting that all three major groups of felsic metavolcanics (mentioned above) may be time-equivalent. Extension of these correlations into the Black Lake-Clamshell Lake-Rosnel area cannot be made as yet, due to complexities imposed by intrusive bodies. Contacts within this area suggest, however, that the stratigraphy is oriented along a north-south, rather than east-west, major direction.

Rock fabric measurements defining the Split Lake dome suggest that both Alcona and Split Lake mines are located where fracturing and ore deposition was favoured by a tensional stress environment in the country rocks. A third zone of similar structural style has been defined within the mostly overburden-covered area south of Forty Mile Creek between Split and Enira Lakes; this area probably warrants further prospecting for gold.

The Botsford Lake fault has been traced at intervals along the south shore of Botsford Lake or the Canadian National railway across the entire map-rea. It is a late structure, affecting all rocks in its vicinity. Movement on the fault is at least in part right-lateral with apparent displacement upthrown on the north. No estimate has been made of total displacement. The regional nature of this structure suggests that volcanic and sedimentary units exposed on Botsford Lake may bear no correlation with rocks exposed south of the Canadian National rail line.

### Economic Geology

Two types of potential deposits merit attention within the Zarn Lake map-area, these being gold mineralization in quartz veins and base metal massive sulphide bodies. Gold prospects would appear to be especially favourable at this time, with prices as of this writing reaching C$250 per ounce (US$215 per ounce).

Three gold occurrences within the map-area (Richards occurrence, Alcona prospect, and Split Lake prospect) all exhibit a similar mineral association: quartz-carbonate-sulphides (pyrite + galena ± sphalerite ± chalcopyrite)-Au. These three showings occur within mafic metavolcanics and are all at approximately the same structural (stratigraphic?) level within the Split Lake dome. The Split Lake stock is virtually free of any alteration or veining one might ascribe to sub-volcanic hydrothermal activity and is probably unrelated to volcanism in the area. Clamshell Lake intrusions, however, commonly contain abundant groundmass carbonate and the mafic mineral is generally altered to chlorite. This body is cut by numerous basaltic dikes, carbonate-sulphide veins, and the border phase is difficult to distinguish from undoubted felsic pyroclastics within the country rocks.

Future exploration should consider the possibility that these showings are time equivalent in nature, possibly related to the emplacement of the Clamshell Lake intrusion. Further, the zone of complex structure between the north ends of Split and Enira Lakes may be especially favourable to quartz vein deposition.

Favourable environments for base metal massive sulphide mineral deposits within the map-area may be restricted to areas of felsic metavolcanics, and to areas in the vicinity of known prospects. Felsic metavolcanics in the Alcona-Out Lakes area have been tested with airborne geophysical surveys and many outcrop areas have been stripped. The lack of claim staking and additional work suggests that good conductive zones are not present. This area lies immediately south of the Botsford Lake fault, however, and complex fold and/or fault structures may obscure horizons of interest. More refined exploration methods, probably including rock geochemistry, will likely be required to fully test this ground.

Felsic to intermediate metavolcanics in the Forty-Mile and Enira Lakes area have only received cursory examination. Selco Exploration Company Limited (1971 to 1972) attributed two magnetic anomalies to disseminated magnetite and/or pyrrhotite within mafic metavolcanics also occurring in this area1, but definitive testing of these zones is not known. Eastern extensions of both rock bodies are into substantially covered ground north of Zarn Lake.

Known base metal prospects within the map-area include the sulphide bearing ironstone at the west end of Botsford Lake and the showings near Rosnel (Thompson’s prospect). The former appears to have been adequately tested by Kerr Addison Mines Limited’s drilling program and is not thought to be of significant potential. The latter, however, appears to merit closer examination.

The Rosnel occurrence consists at depth of disseminated pyrite, chalcopyrite, and sphalerite within carbonatized quartz-sericite schist, based on New Insco Mines Limited drill hole data1. Most of the rocks in the area contain minor to abundant carbonate (siderite?), while felsic dikes and local shear zones further complicate the picture. Overall significance of this prospect is difficult to assess because of structural complications imposed by the Botsford Lake fault (to the north) and local intrusive bodies (to the east and southeast), but two points may be noted:

a) Much of the early work on the showing appears to have been directed at sulphidic magnetite-grunerite-quartz ironstone outcropping north of Rosnel on the south shore of Botsford Lake, these are likely equivalent to the ironstones investigated by Kerr Addison Mines Limited further southwest and are probably not of economic potential.

b) No exploration is known which might cover the possi-

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1 Information from Assessment Files Research Office, Ontario Geological Survey, Toronto.
Possible southwest extension of the Rosnel occurrence; in particular, the mostly covered ground between Black and Out Lakes should contain rocks which are time-equivalent to those in the Rosnel area, as well as the northern extension of the Kirk Lake syncline. Although one may expect complex geology, the Rosnel to Out Lake area appears to warrant more thorough investigation for massive sulphide mineral deposits.

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No. 8 Howard Falls Area, District of Thunder Bay
S.E. Amukun

Location

The center of the map-area is located some 250 km northeast of the city of Thunder Bay, and is accessible by float-equipped aircraft which can be chartered from Jellicoe, Geraldton or Nakina (see location map). The top eastern one-quarter of the area can be reached by gravel logging roads branching off from the road to O'Sullivan Lake, which is a continuation of Highway 643 from Highway 584 (Nakina Road). Howard Falls area covers an area of 520 km² and its limits are Latitude 50°15'N to 50°30'N and Longitude 87°15'W to 87°30'W.

Access within the central part of the area is poor because there are few large lakes and rivers. The only large lakes in the map-area include: Sollas, Deeds and Cecil (east central); Abamasagi, Meta(north central); and Gzowski (southwest).

Mineral Exploration

The history of the mining activity in the area has been linked to a number of events viz.: 1) In 1904 the Onaman Iron Ranges were discovered, located astride the southern border of the map-area. This led to a rush by prospectors in the neighboring area and the area of study (Moore 1908; 1909). Several surveys have been conducted in the map-area as part of the exploration surveys of the north Onaman Iron Ranges. These surveys were mainly done by ground vertical magnetic intensity and electrical resistivity work only and include exploration work by Sudbury-Onaman Pyrites Limited (1953), Canadian Cliffs Limited (1953), Rohmer and Christianson (1953), Leo Lambroff (1954) and Pierre Mauffette (1958). 2) The completion of the Canadian National Railway line through the southern part of the area in 1913 greatly improved access into the area and triggered mining exploration activity (Hopkins 1916; 1917). As a result, gold was discovered by F.W. King-Dodds in 1915, 1.2 km east of Howard Falls (Kindle 1931, p.96). A shaft was sunk on this property in 1916 to a depth of 18 m; no report of subsequent work is available but the ground is now covered by four patented claims numbered KK479, KK480, KK481 and KK1415. 3) Exploration activity was also initiated following the discovery of a copper showing by Teck Exploration Company Limited in the fall of 1954 just west of the map-area (Langford 1958). As a result of this activity exploration surveys were conducted by numerous companies in an area which crosses the western edge (north

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

2 Information from Assessment Files Research Office, Ontario Geological Survey, Toronto.
half) of the present map-area. The geophysical surveys by Silver Miller Mines Limited (1955) were done by electrical resistivity methods and covered portions of the map-area. 4) As a result of improved sophistication of airborne and ground geophysical survey methods in the 1960s and 1970s, the area was re-investigated in search of base metals. Numerous recent exploration surveys including diamond drilling, geophysical and geological-geochemical methods have been conducted over isolated portions of the map-area by F. Koosel (1970) (ground magnetic and electromagnetic surveys). North Coldstream Mines Limited (1970) (airborne and ground magnetic and electromagnetic surveys), Tontine Mining Limited (1970) (ground magnetic and electromagnetic surveys), Noranda Exploration Company Limited (1976) (airborne and ground magnetic and electromagnetic surveys), NWT Copper Mines Limited (1970, 1976) (ground magnetic and electromagnetic survey). Over the last few years two major exploration companies, Imperial Oil Limited (Esso Minerals Limited) and Mattagami Lake Mines Limited have been conducting systematic investigation of rocks of the surrounding country and including the map-area. Most of this work has involved airborne and ground geological-geophysical surveys. Some of the results are filed in Assessment Research Office, Toronto, under E.W. Bazinet (1976), Mattagami Lake Mines Limited (1976).

The present ownership of claims in the map-area includes patented claims of Rohmer and Christianson, Pierre Mauffette, Leo Lambroff, King-Dodds prospect, and non-patented claims of Noranda Exploration Company Limited, NWT Copper Mines Limited, Mattagami Lake Mines Limited, E.W. Bazinet (Esso Minerals Limited), and Leonard Clarke.

**General Geology**

The area has not recently been mapped in detail, however a reconnaissance study by Kindle (1931) and a geological compilation map (Pye et al. 1965) include all of the map-area. Many of the rock units outlined by the detailed mapping of the surrounding areas of Little Marshall Lake (Amukun 1978), Willet Lake (Amukun 1977a) and Gledhill Lake (Amukun 1977b) extend into the current map-area.

All consolidated rocks except for Middlet to Late Precambrian (Proterozoic) diabase dikes are of Early Precambrian (Archean) age and comprise an altered metavolcanic-metasedimentary and gabbroic assemblage bordered and intruded by composite plutons of granitic rocks.

The metavolcanics occupy about one-half of the map-area and are composed of mafic (70 percent), intermediate (5 percent) and felsic types (25 percent). The predominant mafic volcanic rocks have locally been metamorphosed to chlorite-amphibole schists but consist largely of pillowed flow units separated by interflow tuff units and metasediments. The pillowed flows are intercalated with minor usually massive to foliate flows, porphyritic units, amygdaloidal-vesicular units and mafic pyroclastic rocks. The mafic metavolcanics are overlain by pyroclastic rocks of predominantly intermediate to felsic composition. A local unit of tuff-breccia to pyroclastic breccia outcrops on the west shore of Cecil Lake. In these rocks, large felsic bombs are set in a siliceous and sericitic matrix.

Two metasedimentary units occur in the areas around Sollas and Gzowski Lakes. The Sollas Lake unit is predominantly composed of eroded volcanic material and forms the eastern limit of the metasedimentary subunit of the Marshall Lake Anticline (Amukun 1978). The Gzowski Lake metasedimentary unit principally comprises a local, possibly turbidite sequence, of well-bedded, finely laminated, graded and cross-bedded, wacke, argillite and slate, with minor meta-arkose, chert, graphite schist and siltstone. Flame and ripple structures are often preserved in laminated sandstone-mudstone beds.

The metavolcanics and metasediments are intruded by dikes and sills of metagabbro, metadiorite, lamprophyre and quartz and feldspar porphyry that pre-dated metamorphism and granitic emplacement. The northern one quarter of the map-area is underlain by metamorphosed gneissic rocks of the English River Belt, that have largely been considered metasedimentary migmatites (Breaks, Bond and Stone 1978).

Four composite granitic stocks intrude the gneissic belt and the metavolcanic-metasedimentary rocks. Two of these stocks were previously described as the Gzowski Lake and Deeds Lake stocks (Amukun 1977a). The other large stock located east of Sollas Lake was previously unmapped. It is composed of quartz diorite at the borders, and granodiorite to quartz monzonite at the core. A smaller stock consisting of large zoned porphyroblasts of feldspar is predominantly porphyritic syenodiorite and outcrops west of Wilgar Creek, about 3000 m east of Deeds Lake Stock.

**Structural Geology**

The poor outcrop distribution limits the amount of structural interpretation that can be made. However, several units of the Marshall Lake Anticline and Marshall Creek Syncline (Amukun 1978) have been traced into the map-area where they terminate against the granodiorite to quartz monzonite stock located east of Sollas Lake. Several other antiform synform pairs have been indicated by pillow facings in the area east and northeast of Gzowski Lake and elsewhere in the map-area, however only one anticline located east-southeast of Gzowski Lake has been confirmed by graded and cross-bedded top determinations. Several later folding features were recognized in many areas throughout the map area in form of minor (1-10 m) drag folds, chevron folds and complex crenulations.

Two and occasionally three foliation orientations were recorded especially in the metasedimentary unit located around Sollas Lake. These orientations intersect bedding at oblique angles.
**Economic Geology**

Geophysical surveys have been conducted over much of the area most recently by Imperial Oil Limited (Esso Minerals Limited), NWT Copper Mines Limited, Noranda Exploration Company Limited, F. Koosel, Tontine Mining Limited and Mattagami Lake Mines Limited. The combined geophysical surveys included ground magnetic and electromagnetic surveys, and radem surveys. The results of these surveys are summarized in files 1, 2, 3, 4, 5, 6, and 7 respectively. Sampling of several of these surveys were followed up by diamond drilling. For example, in the area located on the 7th Base Line, 0.8 km west of Sollas Lake, several conductive zones were tested by two holes totalling 179 m by Mattagami Lake Mines Limited in 1976. Hole OL-B-77-2 collared on claim TB435149 intersected 1.9 m of massive sulphide mineralization (80 percent pyrite, 15 percent pyrrhotite, 5 percent silica) containing low to trace base metals in sheared telsic metavolcanics, and hole OL-A-76-1 collared on claim TB435146 intersected 3.7 m and 3.0 m of massive sulphide mineralization (65-95 percent pyrrhotite, 15-20 percent pyrite, 5-10 percent chert fragments) and 4 m brecciated chert containing 40 percent sulphide mineralization (60 percent pyrrhotite, 40 percent pyrite) with minor to trace base metals in cherty, graphitic metasediments.

The areas located about 3000 m west of and (3700 m) north of Venus Lake were tested by 13 diamond drill holes totalling 1591 m by Tontine Mining Limited in 1970. In the area to the west of Venus Lake, narrow zones containing 40 to 60 percent sulphide mineralization (pyrite, pyrrhotite and marcasite) are reported to have been intersected in cherty and graphitic metasediments, while pyrite and pyrrhotite were cut in narrow sections within chloritic and slightly graphitic mafic pyroclastics and flows. In both cases trace to no values of base metals were observed.

Assessment files indicate that several other attractive conductor areas are located in the area, especially in the Cecil-Sollas-Marshall Lakes area and the area around Venus Lake, but that the conductive areas tested so far are due to zones of pyrite, pyrrhotite, marcasite, graphitic schists, cherty ironstone with only trace to low values of base metals. Exploration focus has recently been directed at known base metal showings in the Marshall Lake area immediately to the west (Amukun 1978). Some of the host rocks of the Marshall Lake showings extend into the current map-area. During mapping of these rocks, no sulphide mineralization of note was observed.

The iron prospects of Canadian Cliffs Limited, and R.K. Rohmer-T. Christianson located west of Suni station just south of the map-area were investigated by vertical magnetic intensity surveys done in 1953. Although several diamond drill holes were recommended, no further work is reported (Amukun 1977b). The Sudbury-Onaman pyrite property located 3360 m north of Venus Lake was examined by a resistivity survey in 1952. Sampling of several of the pits and trenches together with drill samples show the pyrite to contain approximately 39 percent sulphur and 41 percent iron, but tonnage estimate was not reported. The Pierre Mauffette property is located 3700 m east of Suni station just south of the map-area and was tested by 6 diamond drill holes totalling 598 m in 1958. It was found to be composed of banded magnetite ironstone that is interbedded with metasedimentary and metavolcanic host rocks. In 1954 the Leo Lambroff property located about 2400 m northwest of the southeast corner of the area was tested by two drill holes totalling 60.5 m. The drilling and trenching indicated several parallel veins numbered 9, 10, 11 and 12. No. 9 vein is 0.6 m wide and strikes northeast. A 9.8 m deep shaft on this vein indicated assay values of $2.85 gold per ton, $1.25 silver per ton and $0.60 copper per ton (1954 prices).

A copper-nickel bearing mineral occurrence observed on claim TB2287/8 about 3700 m southeast of Howard Falls was the object of exploration survey programs consisting of ground magnetic and electromagnetic surveys by McIntyre Porcupine Mines Limited and by NWT Copper Mines Limited in 1970. Trenching and diamond drilling were also completed on the showing. Although several minor magnetic and electromagnetic anomalies were outlined by the surveys, they were interpreted to represent diabase dikes and disseminated iron sulphides in the coarse-grained mafic flows, and the surveys failed to detect the known zone of the reported copper-nickel mineralization.

On July 24, 1954, D. Linklater and E.P. Scott staked a nickel property south of and adjoining the south shore (southwest bay) of Meta Lake. This prospect then known as Meta Lake nickel property was tested by two pits in 1915 and 1918 (Kindle 1931, pp.104; Hopkins 1917, p.225), but sampling by Hopkins (1917) failed to return nickel or platinum values. The area immediately west of this prospect is staked by Leonard Clarke of Beardmore.

A major portion of Gzowski and Kowkash Townships was covered by airborne and ground magnetic and electromagnetic surveys. The anomalies of the surveys were for the most part considered to be indicative of the distribution of magnetite-sulphide bearing ironstone and a few mafic intrusive rocks.

A local occurrence of tuff-breccia to pyroclastic breccia exposed on the shores and west of Cecil Lake may warrant exploration attention.

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No. 9  Radioactive Diatremes North of Lake Superior

R.P. Sage¹

Introduction

In 1976 radioactive intrusive breccias were discovered near the west flank of the Port Coldwell alkalic complex by prospectors working for Gulf Minerals Canada Limited. The discovery of other radioactive showings within intrusive breccias of the area has stimulated uranium exploration in the region. As a result of mapping by the author on the Slate Islands (Sage 1974, 1975) and of alkali-carbonatite complexes within Ontario (Sage, in prep.), it has been recognized that diatreme structures occur within the same tectonic and petrologic setting as alkali-carbonatite complexes. Consequently the Ontario Geological Survey undertook a program of investigating a number of diatreme structures north of Lake Superior. With the possible exception of the Gold Range diatreme, the diatreme structures investigated can be considered as one feature of the much larger alkalic rock-carbonatite petrogenetic province located north of Lake Superior, dominated or related directly to the evolution of the Lake Superior basin and mid-continent gravity high. Figure 1 indicates the location of the diatremes discussed in the text.

Gold Range Diatreme

Location and Access

The Gold Range diatreme (1 on Figure 1) occurs north-east of Schreiber, Ontario. The breccia can be reached by walking north along a claim line which cuts a trail leading to the west side of the Ontario Hydro reservoir located east of Schreiber. The claim line cuts the trail 660 m west of the reservoir. The breccia is 240 m north of the trail and approximately 36 m west of the claim line. Lamont Lake is located at Latitude 48°49'N and Longitude 87°14'W and the breccia is located approximately 1.6 km east of the lake.

Mineral Exploration

The breccia was trenched and sampled for its gold content presumably in the 1930s (Harcourt 1938). These trenches are largely filled but sections of several can still be examined. There is no record of subsequent work.

General Geology

The breccia was first described by Harcourt (1938) who interpreted it as an explosion breccia. Harcourt (1938) described the breccia as follows:

On claim T.B.3,411 north of the Gold Range property, an outcrop of conglomerate or pseudo-conglomerate 1 chain by 2 chains in area is apparently completely isolated from other sediments. The rock is made up of fragments of rhyolite, greenstone, iron formation, and granite, some apparently well rounded, others sharply angular. The rock is intruded by a body of lamprophyre on one side and is surrounded by grey rhyolite. A polished slab of the rock shows that the fragments are nearly all angular and that at least some of the round surfaces are due to a conchoidal fracture in the fragments. The matrix is now composed very largely of quartz and sulphides, which penetrate fractures crossing the fragments. It is conceivable that the rock is the result of explosive volcanic activity, or it may be a partially exposed lens of conglomerate.

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The author found the observations of Harcourt (1938) to be generally correct (Figure 2). The breccia unit appears to be somewhat smaller (12 by 12 m) than suggested by Harcourt and conchoidal fractures are not visible in samples collected in the field. The breccia occurs at the margin of a relatively large body of biotite-rich lamprophyre which contains large inclusions of iron formation and granite. The lamprophyre locally contains rounded blebs of carbonate and locally contains visible interstitial carbonate. The close spatial relationship of the breccia and lamprophyre suggests to the author that the breccia may be a result of local relatively high level release of carbon dioxide from the intruding carbonate-bearing lamprophyric magma. The breccia consists dominantly of angular to subangular clasts of cherty ironstone and pink fine-grained granite. The breccia is cemented with quartz and pyrite. The pyrite also occupies fractures within the clasts.

Structural Geology

The lamprophyric body is slightly elongate in plan view (Figure 2) with the long axis striking northwest. The long axis trend lies parallel to the trend and extension of the Michipicoten Island fault (Hinze et al. 1966) that lies along the north margin of the Lake Superior basin. The Michipicoten Island fault intersects the Big Bay — Ashburton Bay fault (Hinze et al. 1966) near the Slate Islands which are also the site for extensive diatreme activity. It is unclear whether the Gold Range diatreme and lamprophyre are actually related to this faulting but the author considers this possibility as likely. A linear ravine or gulley exists immediately south of the exposed breccia and lamprophyre and may reflect the presence of some shearing and/ or faulting.

Economic Geology

The Gold Range structure is small and earlier prospecting for gold evidently was not encouraging. No base metal sulphide mineralization was noted and a check of the area with a scintillometer failed to detect any radioactivity. The structure does not appear to be of significant economic interest.

Neys Diatreme

Location and Access

The Neys diatreme (5 on Figure 1) occurs on the shore of Lake Superior on the west side of the Coldwell Peninsula and is completely enclosed within rocks of the Port Cold-54

well alkalic rock complex. The intrusive breccia is located approximately 4.0 km south of the Neys Provincial Park headquarters and access to the breccia is possible by boat which can be launched on the Little Pic River within the park. The diatreme is located at 48°44'54"N Latitude and 86°37'58"W Longitude.

Mineral Exploration

No record exists of any work being done on this structure for economic mineral deposits. Balint (1977) completed an unpublished Bachelors Thesis on the unit at Lakehead University.

General Geology

The breccia (Figure 3) cuts coarse grained pink to reddish brown amphibole syenites. The syenite displays weakly developed trachytooidal texture and discontinuous streaky banding which is in part probably schlieren. The syenite is cut by alkalic, composite dikes which in turn are cut by the breccia. Mapping by Balint (1977) indicates a structure approximately 240 m long and a maximum of 75 m wide. The author concur with Balint's (1977) mapping. The breccia has a north of east trend and is likely vertically dipping. The breccia consists of rounded clasts up to several metres in size of alkalic gabbro, syenite nepheline syenite, and amphibolite hornfels. With the exception of the hornfels all clasts are locally derived from the alkalic rocks of the Port Coldwell complex. The amphibolite clasts may have been rafted upwards or fallen downwards. Studies by McCallum et al. (1976) and McCallum (1976) indicated that clasts derived from stratigraphically high levels may occur at structurally deep levels within any given diatreme. This results from the collapsing gas column after emplacement and sloughing from the sides of the diatreme pipe. Along the south margin of the breccia dike a thin dike of medium grained trachytic syenite is present which is up to 30 cm in width. Within the breccia and along the north contact an irregular dike of fine grained, equigranular, reddish brown quartz syenite is present. Neither the trachytooidal syenite or quartz syenite dikes cut the enclosing coarse grained syenite. The matrix of the breccia consists of comminuted rock debris derived from the clasts. The matrix also consists of fine grained clinopyroxene, olivine, hornblende, alkali feldspar, plagioclase, and opaques (Balint 1977). Balint (1977) concluded that the matrix may have been derived from partially crystallized gabbroic material accompanying the gas during diatreme formation. Local areas of the diatreme are deeply iron stained from the oxidation of disseminated pyrite and pyrrhotite within the breccia matrix.
Figure 2—Geology of Gold Range Diatreme. Geology by R.P. Sage.
Figure 3—Geology of Neys diatreme (after Balint 1977).
**Structural Geology**

Banding and trachytoidal texture attitudes within the enclosing coarse grained syenite have a north trend and are steeply dipping to the east or nearly vertical and parallel to each other. The composite dikes have an irregular northwest trend and widths may exceed 1 m. The breccia mass cutting the coarse grained syenite has a north of east trend and appears to pinch out to the east. The intrusive breccia may or may not widen westward beneath Lake Superior. Balint (1977) related the diatreme to block faulting within the Port Coldwell complex, however he did not cite evidence to support this interpretation. The present level of exposure of the Port Coldwell complex is relatively high, there being miarolitic cavities, abundant xenolithic inclusions and a sharp cross cutting contact with the enveloping Early Precambrian rocks. The author has also observed hornfelsed Early Precambrian rocks overlying rocks of the complex. The author considers the Neys diatreme to be a reflection of this relatively high level of exposure of the complex. The structure likely results from the accumulation of volatiles within the alkalic magma in a manner perhaps similar to that proposed by Norton and Cathles (1973). Norton and Cathles (1973) propose that volatiles collect (in an apical region) beneath a cooled rind of an intruding magma and later pierce this rind forming an intrusive breccia. Consequently the author does not consider the Neys diatreme as similar in origin to others discussed in this summary and would interpret it as a shallow feature with no great depth extension.

**Economic Geology**

In 1976 the author examined and collected a large sulphide-bearing sample (0.3 by 0.2 m) from this breccia. A 32 element spectrographic analysis of the sample failed to detect anything of economic interest. During the past field season the author tested the structure with a scintillometer and no radioactivity was detected. The diatreme appears to have little direct economic interest.

**Slate Islands Diatremes**

**Location and Access**

The Slate Islands (2 on Figure 1) lie approximately 11 km off the north shore of Lake Superior directly south of the town of Terrace Bay, Ontario. The islands are approximately 32 km southwest of the Port Coldwell alkalic complex. The islands are located at 48°39'30" N Latitude and 87°00'00" W Longitude. Easiest access to the islands is by boat from Terrace Bay.

**Mineral Exploration**

The islands were extensively explored for gold around 1898 and considerable trenching was completed and two adits driven on the northwest corner of Patterson Island (Parsons 1918). Sometime after this early work persons unknown drove an adit on a sulphide showing at Lambton Cove on Mortimer Island. Between 1960 and 1963 Kimberly Clark Canada Limited stripped and drilled the area north of Horace Cove on Patterson Island for gold. These showings were previously known and reported by Parsons (1918). The company also located a previously unknown gold showing designated as the “Cosen’s showing” in the interior of Patterson Island. The gold occurs in milky quartz veins and along the foliation planes of schist marginal to the veins. Assays in excess of several ounces per ton (private files donated to the Ministry by Kimberly Clark Canada Limited) were not rare, but short lengths and narrow widths discouraged additional work at that time. Patterson Island represents a fold nose in the Early Precambrian stratigraphy and the gold mineralization appears to display a preferential occurrence along the fold axis. The islands were mapped by the author in 1974 (Sage 1974, 1975).

**General Geology**

The general geology of the islands is described by Sage (in preparation). The islands are dominantly composed of Early Precambrian metavolcanics intruded by massive gabbro to diorite bodies, feldspar porphyry, and quartz feldspar porphyry. On the west shore of Patterson Island a thin (approximately 21 m in width) hematite, chert, and argillite unit of Middle Precambrian Gunflint iron formation unconformably overlies the Early Precambrian. This exposure appears to be the presently known eastern limit of the Gunflint Formation. The unit has been extensively broken up by diatreme activity. Overlying the Gunflint in angular unconformity are Late Precambrian amygdaloidal mafic flows with interbedded red siltstone and argillites. These Late Precambrian rocks have been correlated with the Osler Formation (Halls 1974). The Late Precambrian rocks have been broken up at the base of the section by diatreme activity. The sequence is approximately 120 m thick. The islands and the base of the Late Precambrian section have been intruded by an extensive swarm of diabase dikes. Cutting the southwest corner of Patterson Island is a dike displaying carbonatitic affinities containing olivine phenocrysts up to 1 cm in maximum dimension. The dike has been dated by K-Ar techniques as 282 ± 11 my and 310 ± 18 my by Watkinson (1977 personal communication). The dike therefore represents the youngest dated alkalic event in this region and within the alkalic petrogenetic province north of Lake Superior. The Slate Islands diatremes represent a still younger undated event. Cutting all rock types, including the carbonatite dike, are intrusive breccias. The breccias are most common on Patterson Island but examples can be found on most of the
islands within the group. Along the west coast of Patterson Island the breccias may display a preferential occurrence along the Late — Early Precambrian contact and form a completely ramifying pattern which may enclose large blocks of Early Precambrian rocks in relatively unrotated position. The ramifying pattern of breccia development in a highly fissile rock implies explosive rather than passive emplacement. Shock metamorphic features accompany the diatremes in the form of shatter cones in exposed outcrop and microscopically as deformation lamellae on quartz grains within the breccia matrix (Sage in preparation). The author considers diatreme emplacement and shock metamorphism to be identical events related to the petrologic and evolutionary history of the alkalic rock province north of Lake Superior and not the product of meteoric impact as suggested by Halls and Grieve (1976). The breccias consist of fragments up to 4 by 4 m in size in a comminuted matrix derived from the clasts. Except for one breccia unit the breccia clasts are unsorted and lack visual evidence of hydrothermal alteration. Thin sections of one breccia dike which cuts an alkalic diabase dike indicate microscopically the development of an albite-epidote hornfels facies rank contact metamorphism marginal to the breccia dike which is largely the result of hydration. The red color of the diatreme along the west shore of Patterson Island is believed to be due to comminuted Gunflint ironstone in the breccia, however a slight reddening of the breccias on the east side indicate a minor introduction of hematite into the breccia. The breccias break easily when hammered and have not been extensively altered by hydrothermal events. One dike on Spar Island displayed a pronounced zoning of clast sizes with coarse towards the centre and one large breccia dike on the east shore of Patterson Island displayed zoning of clastic debris over widths of several centimetres marginal to larger fragments. This observation implies local laminar flow perhaps during the waning phase of gas discharge. An intrusive breccia lying on top of a diabase sill cutting Late Precambrian rocks on the west shore has a diabase matrix and is the only breccia possessing an igneous matrix. Rounded chert fragments (Gunflint) coated with chilled diabase and fragments of the diabase occur within the breccia. The author considers this to be the leading edge of igneous rock accompanying diatreme formation.

**Structural Geology**

The structural geology of the islands is as complex as the lithology. The islands represent a southwest plunging (approximately 60 degrees) fold nose on which minor folds have been superimposed by shearing between Mortimer and Patterson Islands (Sage in preparation). The circular pattern of the islands is thus a function of bed rock geology and not meteoric impact as suggested by Halls and Grieve (1976). The islands occur along a southwest-striking ridge projecting southwestward from the west flank of the Port Coldwell complex through Ashburton Bay (Sage in preparation). Extensive Early (gabbro and diorite) and Late Precambrian (diabase) mafic intrusions have helped shield the fissile Early Precambrian rocks from glacial erosion and preserve the circular patterns (Sage in preparation). Such pervasive Early and Late Precambrian mafic intrusion has not been observed on the mainland by the writer. The penetrative schistosity found in the Early Precambrian is not present within the Middle Precambrian implying that deformation of the Early Precambrian was pre-Gunflint. Undoubtedly the Early Precambrian structures were reactivated during later events. The intrusive breccia with diabase matrix found on the west shore is faulted indicating at least minor adjustments as recent as 300 my.

The reader should refer to the structural geology section for the Dead Horse diatreme for additional data indicating the regional setting of the islands.

**Economic Geology**

During mapping in 1974 the author routinely checked rock samples collected during mapping with a geiger counter without detecting radioactivity. Because of recent developments on the mainland the author decided to re-check the major intrusive breccias with a scintillometer. Most of the larger structures were checked and no radiation was detected. While texturally and structurally similar to the mainland breccias, the Slate Islands breccias lack the extensive hematization and silicification found within the mainland breccias which are radioactive. The lack of extensive hydrothermal activity within the Slate Islands breccias has undoubtedly preserved the shock fractures found within the matrix and in part explains their lack of mineralization. Sulphide mineralization was not observed within the Slate Island structures whereas sulphides are common in the radioactive mainland breccias. Other than dusty hematite, carbonate appears to be the only mineral that is recognizable as being introduced.

While the Slate Islands are composed of other rock suites of potentially high economic value the breccias appear to be of only academic interest.

**McKellar Creek Diatreme**

**Location and Access**

The McKellar Creek diatreme (4 on Figure 1) is located at approximately 48°49'03"N Latitude and 86°42'40"W Longitude. The intrusion can be reached easily by a trail leading north from Highway 17 just west of the bridge over McKellar Creek. The structure is located approximately 300 m north of Highway 17. The complex consists of essentially two outcrops located in its southwest corner and numerous patches of radioactive rubble derived from weathering of the complex and exposed in recent logging operations.
R.P. SAGE

LEGEND

LATE PRECAMBRIAN
5 Breccia
4 Lamprophyre
3 Diabase

INTRUSIVE CONTACT

EARLY PRECAMBRIAN
2 Metasediments, argillite and siltstone
1 Mafic to intermediate metavolcanics

A. Scattered angular boulders of radioactive breccia; source unknown.
B. Large fragments of Sibley Group (?)

NOTES
1. Age relations of lamprophyre to diabase and breccia unknown.
2. Age relations of breccia to diabase and lamprophyre uncertain.
3. Age relation of diabase to lamprophyre and breccia is unknown.

SYMBOLS
- Strike and dip of bedding, tops unknown; vertical; inclined.
- Strike and dip of bedding, tops known.
- Schistosity; vertical, inclined.
- Glacial striae with direction of ice movement indicated.
- Geologic contact, inferred.
- Rock outcrop.
- Area of weathered bedrock rubble.
- Logging skid trail.
- Stream with direction of flow indicated.
- Point outcrop.

Figure 4—Geology of McKellar Creek diatreme. Geology by R.P. Sage.
Precambrian — Diatremes

Mineral Exploration

The breccia was found by Walker (1967) who interpreted it as an Animikie conglomerate. The author examined the exposure in 1975 after completing work on the Slate Islands and concluded the breccia was a diatreme (Sage in preparation). In 1977 Mitchell and Platt (1977) prepared a brief description of this intrusion along with the Dead Horse Creek structure. The diatreme was recognized as being radioactive by J. Scott (Resource Geologist, Ontario Ministry of Natural Resources, Thunder Bay) in 1976 following staking activity on the Dead Horse Creek structure. The mineral potential of this structure has not been determined.

General Geology

On the basis of limited exposure the diatreme has a north-south long axis of approximately 240 m and a maximum width of approximately 60 m. The site of the breccia is enclosed within extensive outcroppings of Early Precambrian fine grained schistose argillite and siltstone. These metasediments are rather homogeneous, and rarely show good bedding. The rocks commonly contain a visually estimated 20 percent or more biotite and on weathered surface the occasional bluish quartz grain less than 1 mm in diameter can be seen. The metasediments have been intruded by north-trending diabase dikes which were not observed to cut the breccia. Several lamprophyre dikes were encountered in mapping of the metasediments, however the relationship of these dikes to the breccia is also unknown.

The breccia consists of rounded to angular clasts of pink and white quartzite, metasediments, and rarely quartz syenite. The clasts generally do not exceed 0.3 m in maximum dimension but one clast of quartzite 2 by 3 m in size was located in a small outcrop immediately east of the two main outcrops.

The quartzite clasts were considered to be from the Sibley Group by Mitchell and Platt (1977) and the author agrees with this interpretation. The clasts of quartzite are more rounded than the clasts of Early Precambrian metasediments and on weathered surface chalky white specks derived from the weathering of feldspar is visible indicating the rock is an arkosic quartzite. The rounding of the clasts is likely due to milling of the fragments during emplacement of the breccia. The presence of these clasts within the breccia suggests that the Middle Precambrian Sibley Group once covered this area but has been subsequently removed by erosion. The presence of these clasts at a stratigraphically low level has been described and explained experimentally by McCallum et al. (1976) and McCallum (1976). The clasts represent sloughing of the overlying rocks accompanying collapse of the gas column during the waning phase of emplacement. The slate clasts are of local origin derived from the enclosing metasediments. The clasts are reddened (hematized) and silicified. The larger clasts may display a tendency of greater alteration along the rims than within the cores. This reddening and hardening (silicification) of the metasediments rapidly disappears away from the breccia-wallrock contact indicating the hydrothermal effects were restricted to the breccia. The width of visible alteration of the enveloping rocks is estimated to be a maximum of 3 to 6 m.

The quartz syenite to granite is structureless, medium to coarse grained, massive and a rather scarce clast type. This rock type may be a dike phase of the Port Coldwell complex.

The breccia is harder to break than the Slate Islands breccias but not as hard as the Dead Horse Creek breccias. The Slate Islands breccias break around the clasts while the McKellar Creek breccias break around and through the clasts. The Dead Horse breccias commonly break through the clasts. This feature is undoubtedly related to the degree of hydrothermal alteration.

Structural Geology

The diatreme occupies a topographic low and occurs within a north-trending linear. The breccia may be emplaced within a shear or fault zone, however geologic data supporting this possibility is lacking. The rather homogeneous lithologies east and west of the structure have prevented the identification of any offset across the topographically low ground. There is no apparent zonation of clast size, however this may be a function of a lack of exposure. The reader should refer to the Dead Horse Creek structural geology section for additional structural data of regional interest.

Economic Geology

The breccia is always radioactive but highly variable in relative amounts. Thorium is dominant over uranium and readings up to 6 and 7 times background were obtained. Reddish brown carbonate veinlets cutting argillite in the first outcrop west of the trail leading to the diatreme on Highway 17 are 1 to 2 times background. The breccia was staked in 1977 by L. Kaye, however no evidence of prospecting activity was seen by the writer at the time of completion of field work in June. The body warrants careful testing to determine the distribution of radioactive mineralization.

Dead Horse Creek Diatreme

Location and Access

The Dead Horse structure (3 on Figure 1) occurs approximately 3.2 km north of Highway 17 along the Dead Horse Creek access road. This is at approximately 48°50’30”N
Latitude and 86°40'25"W Longitude. Access to the complex east and west of Dead Horse Creek is easy from the road. For simplicity the author has divided the complex into subcomplexes however there is no difference in age between the subcomplexes and all are considered to represent the same event.

Mineral Exploration

Walker (1967) mapped the area but did not recognize the presence of a diatreme structure. Mitchell and Platt (1977) published a brief report on the structure. The Dead Horse Creek diatreme was discovered in 1977 and staked on behalf of Gulf Minerals Canada Limited. The author has obtained scintillometer readings 10 times background in some areas. Thorium appears to dominate over uranium.

In 1977 pitting had been completed on the Dead Horse-west structure. During 1978 Gulf Minerals Canada Limited completed line cutting over the breccia and detailed geologic mapping was begun.

General Geology

The breccia consists of angular to subrounded clasts of locally derived rocks (Figure 5) in a matrix of comminuted rock debris which has been locally extensively altered. Clasts up to 1 m have been seen but most frequently are 0.3 m or less. Mitchell and Platt (1977) reported the presence of Sibley-like clasts similar to those found in the McKellar Creek structure but the author has not observed such clasts. The alteration is extremely variable within the breccia. The first indication of alteration is reddening of clast margins. Weathering of these clasts may develop a dish shaped structure with a rim standing in relief and depressed core which reflects less alteration of the core. Sili
cification accompanies the hematalization. With increasing alteration dark green amphibole may develop along the rim of the clast and this is closely associated with carbonate. Where carbonate is present in the clast matrix weathering may produce clasts weathering in relief over the matrix. As alteration continues the entire clast will become bright brick red and is hard to break. When such extensively replaced clasts are broken they display a crude conchoidal fracture. Disseminated fine-grained pyrite is common in the matrix of some samples. These extensively altered breccias are generally highly radioactive. In the southwest corner and at the west contact of the Dead Horse south subcomplex isolated highly radioactive outcrops of breccia with a carbonate matrix were noted. These outcrops consist dominantly of fine-grained grey carbonate with isolated red clasts weathering 4 to 5 cm in relief. The clasts have an open framework supported by the carbonate matrix. A carbonate dike was observed cutting the breccia in the face of a breccia cliff within the southwest corner of the complex. The author considers the carbonate to be of magmatic origin.

The style of breccia and type of alterations are identi
cal to altered and fenitized breccias observed by the author marginal to some carbonatite complexes. Within the northeast corner of the south subcomplex an extensive zone of scapolite replacement is present. The clasts are not red as previously described but extensive replacement of the clasts is visually obvious. The zone is appreciably more radioactive than the highly altered red breccia. Sca
polite is visually identifiable on the weathered surface as white prismatic fibres and on the fresh surface as greenish brown fibres that blend into the matrix. The replacement tends to display a preference for the more siliceous metasedimentary clasts. The scapolite weathers out of the clasts giving a wormeaten appearance to the clasts. The scapolite zone is a more intense zone of alteration than that represented by the red breccias. Carbonate, amphi
bole, and disseminated pyrite are common in the matrix of the scapolite zone and form part of the replacement mineralogy.

The complex has been observed to be cut by carbon
cate dikes, diabase dikes, porphyritic trachytoidal diabase dikes, and syenite aplite.

Starting in 1976 the author has done a limited amount of reconnaissance work within the Port Coldwell complex. This work has disclosed dikes cutting the Port Coldwell complex identical to the porphyritic trachytoidal diabase and syenite aplite that cut the Dead Horse brecci
as. The syenite aplite dikes are nearly always radioactive and within the Port Coldwell complex they have been prospected for their uranium and niobium content (private records, Noranda Mines Limited). Along the east flank of the diatreme structure Walker (1967) mapped granitic rocks as monzonite and quartz monzonite and considered them to be part of the Port Coldwell alkalic complex. Assuming this interpretation is correct, Rb-Sr isochron dating by Chaudhuri and Brookins (1971) indicates an isotope age of 1052 ± 15 my or 1265 ± 20 my for the Port Coldwell complex, establishing a maximum age for the dia
treme since monzonite occurs as clasts within the breccia.

On the basis of field observations the author considers the Dead Horse Creek diatreme to be the brecciated and altered top of an unexposed carbonatite intrusion, perhaps younger than the main period of alkalic rock emplacement at Port Coldwell but older than some diking of that complex. The structure is thus an integral part of the alkalic rock—carbonatite petrogenetic province located north of Lake Superior.

Structural Geology

Mapping by the author has outlined a breccia structure approximately 1100 m long and up to 750 m wide. This structure was subdivided into three subcomplexes: north, central, and south. West of the south subcomplex a small subcomplex approximately 60 m long and 15 m wide is present which is referred to as Dead Horse-west. The main breccia zone has a trend east of north, however the small
Figure 5—Geology of the Dead Horse Creek diatreme. Geology by R.P. Sage.
western structure is elongated in a northwest direction. This small structure may occupy a small fault crosscutting the Early Precambrian rocks subsidiary to the main structure.

The main structure appears to cross Dead Horse Creek at a shallow angle with most of the structure lying east of the north-south trending creek. The author was not able to correlate lithologies across the creek and would concur with Walker (1967) that the creek is occupied by a fault. This fault is referred to as the Dead Horse Creek fault and may represent the structure controlling the emplacement and northeast trend of the diatreme intrusion.

A number of small faults occur marginal to the breccia. It is uncertain whether these faults cut the breccia or existed prior to breccia emplacement and exerted control on the emplacement. The author suspects that these faults were pre-breccia in origin and that reactivation of earlier structures may have occurred, however no fault has been traced completely through the breccia. Within the south subcomplex the limited number of more centrally located outcrops appear to be less brecciated and less altered than more marginal exposures. The core of the structure may therefore be less brecciated and altered than the periphery. The author has obtained more intense and consistent radioactivity readings on the scintillation meter in a similar spatial distribution. Within the central and northern subcomplexes less intense brecciation and alteration may be located towards the margins.

Shearing and brecciation are present along the south margin of the Dead Horse west structure and locally sheared and brecciated rock hosts the high grade uranium-thorium mineralization of this subcomplex. While some breccia-wallrock contacts are sharp, others are more gradational as brecciation and alteration fade into unaltered rock.

**Regional Structural Setting**

The following discussion pertains to the Slate Islands and McKellar Creek diatremes as well as the Dead Horse Creek diatreme. The relationship of the Gold Range diatreme to regional geology is uncertain. The Neys diatreme is considered by the author to represent an entirely different set of conditions of formation. The Neys diatreme is considered by the author to represent the release of high level accumulation of volatiles in a crystallizing alkalic magma while these other structures represent mantle-derived volatiles which in the case of the Dead Horse structure display carbonatic affinity.

The Slate Islands occur at the junction of two regional faults (Figure 6) identified on the basis of geophysical data by Hinze et al. (1966). The Michipicoten Island fault passes south of the island and up along its west side and is likely a curvilinear feature marginal to the Lake Superior basin. The Big Bay—Ashburton Bay fault crosses the Lake Superior basin on a northeast trend intersecting the Michipicoten Island fault immediately south of the Slate Islands and continuing northeastward intersecting the

![Figure 6—Major carbonatite-alkalic intrusions and major regional faults.](image-url)

Note: the Prairie Lake carbonatite has been dated by Rb-Sr methods at 1033 ± 59 m.y. (Bottriell 1975), and the Killala Lake alkalic complex by K-Ar methods at 1185 ± 90 m.y. (Coates 1970). Scale 1:1,584,000 or 1 inch to 25 miles.
shoreline in the area of Ashburton Bay along the west flank of the Port Coldwell complex. On the basis of air-photo interpretation and topographic maps the author has postulated the extension of the fault northward to the Killala Lake alkalic rock complex and then beyond to the Chipman Lake fentes and carbonatite dikes (Sage in preparation). Subsidiary faults possibly controlled the emplacement of the Prairie Lake carbonatite (Sage in preparation). At Chipman Lake the fault has a left lateral offset of approximately 0.8 km. South of Lake Superior this structure has been traced into Michigan and Wisconsin (Klasner et al. 1973, 1975). The Big Bay — Ashburton Bay structure is the site of considerable crustal thickening (Smith et al. 1966; O'Brien 1968), and divides the Lake Superior basin into sub-basins indicating that the structure was a topographic high in Late Precambrian time (White 1972). At the site of the Slate Islands the trend of the Big Bay — Ashburton Bay fault swings east and in proximity of the Port Coldwell complex it swings west. Perhaps these deviations in trend would create points of dilatancy during movement thereby controlling the site of the Slate Islands diatremes and Port Coldwell alkalic rock complex (Sage in preparation). North to northeast trending fractures parallel and subsidiary to the main structure likely control the emplacement of the McKellar Creek and Dead Horse Creek diatremes and account for their long axis orientation being north to northeast. The Killala Lake alkalic rock complex occurs at the point of intersection of the extension of the Big Bay — Ashburton Bay fault and a southwest trending lineament in part lithologic. (Coates 1970) between the Killala Lake alkalic rock complex and Prairie Lake carbonatite. Most of the alkalic rock - carbonatite intrusive events are Late Precambrian in age, however, the middle Paleozoic age for the Slate Islands carbonatite dike suggests alkalic magmatism along this trend spans at least 700 my.

Economic Geology

Mapping by the author disclosed two areas within the south subcomplex that possibly warrant drilling. One area occurs in the southwest corner and the second occurs in the northeast corner. Both areas represent extensive alteration and relatively high radioactivity with readings up to and locally exceeding 10 times background. Drilling of some areas for geologic data may be advisable. Remaining areas of the diatreme warrant close and systematic prospecting. Within the Dead Horse-south subcomplex uranium and thorium mineralization may be concentrated towards the periphery of the complex in a manner similar to some occurrences at Hopi Buttes (Shoemaker et al. 1962) and the Orphan mine (Gornitz and Kerr 1970). Both deposits occur in diatreme structures in Arizona.

The Dead Horse-west structure contains uranium-thorium mineralization in association with shearing along its southern flank. In one trench the mineralization is tentatively identified as uranothorite (Knapp and Hibbitt, prospectors, personal communication) and occurs as a chocolate brown glassy mineral.

Fenwick and Scott (1978) collected several specimens of breccia from the zone of scapolite alteration in 1976. One of these returned an assay of 149 ppm silver. It is uncertain whether this represents mineralization within the diatreme or a clast derived from one of the Pb-Zn-Ag veins that cut the Early Precambrian rocks marginal to the Port Coldwell alkalic rock complex. The diatreme may have base and precious metal potential.

Recommendations to the Prospector — Regional

On the basis of regional geology the author has indicated three possible areas for the location of additional diatreme structures north of Lake Superior (Figure 7). Success in these areas would suggest that a number of prominent linear structures north of Lake Superior may warrant re-evaluation for uranium-thorium mineralization. The uranium-thorium is likely of mantle origin as suggested in a model proposed by Gabelman (1977), and thus the rocks bordering the diatreme structure have no bearing on whether uranium mineralization is present or absent. Breccias that have undergone the greatest alteration and replacement offer the greatest potential for uranium-thorium mineralization. Within recent years diatremes with kimberlitic affinities have been reported (Hearn 1968; McCallum et al. 1976) and a carbonatite-kimberlite relationship appears partially established (McGetchin and Nickhanj 1973; Dawson and Hawthorne 1973). As a consequence of this inter-relationship prospectors working within the region should be on the lookout for kimberlitic rocks.

The author considers that the mineralized breccias, McKellar Creek and Dead Horse Creek, are coeval structure which on the basis of field geology are Late Precambrian in age. Caution, however, should be used in categorically restricting prospecting of diatremes only to this age group. The Dead Horse structure displays strong carbonatitic affinities and on the basis of rock alteration the McKellar Creek structure is likely to have a similar genesis. The Slate Islands diatremes may have originated from a magma of gabbro (diabasic) origin rather than carbonatitic. This study suggests that all diatremes are not equivalent in genesis and that the origin of any particular structure can be determined only on the basis of field data. The middle Paleozoic isotopic age on the Slate Island carbonatite indicates carbonatitic magmatism much younger than the Dead Horse Creek structure exists along the Big Bay — Ashburton Bay structure and therefore perhaps under suitable conditions uranium-thorium mineralization of Paleozoic age could occur.

Uranium-thorium mineralization found within the diatremes examined may represent the terminal phase of an evolving alkalic petrogenetic cycle related to structures intimately involved with the development of the Lake Superior basin. Uranium mineralization exists in other areas bordering the Lake Superior basin (Nuffield 1956; Carter 1977) and if this mineralization can be determined as be-
which leached silica and iron(?) more proximal to an intruding carbonatite magma and this modified fluid subsequently deposited the silica and iron along with uranium and thorium in a distal setting.

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Introduction

In 1975, field work was begun on a stratigraphic synthesis of the Timmins-Kirkland Lake sheet by D.R. Pyke and the writer (Pyke 1975). Mapping by the writer was confined to the eastern part of the sheet, shown on the location map: Areas 1 and 2, the Kirkland Lake and Larder Lake map-areas, are part of a mapping program at a scale of 1:63,360, which is being conducted concurrently with the more regional mapping of the Timmins-Kirkland Lake sheet. Areas 3 and 4 represent areas of potential future programs which are now being partially investigated to determine the regional stratigraphy and structure of the Timmins-Kirkland Lake area. Previous mapping by the author includes the Ramore area (Jensen 1974, 1975c), the Lightning River area (Jensen 1972, 1973) and townships within the Magusi River area (Jensen 1975a, 1975b, 1978a).

The regional mapping of the Timmins-Kirkland Lake sheet is a joint project involving D.R. Pyke, who is currently mapping in the western half of this sheet (Pyke, this volume), and the writer. Field work for the Timmins-Kirkland Lake project is continuing with emphasis primarily on outlining major rock stratigraphic units and regional struc-
minerals. The integration of known metal deposits into a regional stratigraphic framework will assist in delineating new areas of mineral potential as well as additional targets in areas of known mineralization.

Location and Access

The writer’s main responsibility in the regional stratigraphic and structural program for the Timmins-Kirkland Lake area includes the area between Longitude 80°30'W and the Quebec-Ontario boundary. The area is well served by Highways 11, 66, 101, 112, and 624 and the many logging, concession and recreation roads that extend from these highways. Map-areas where active field mapping is being carried out within the larger area, are as follows:

Area 1—Kirkland Lake map-area, Latitudes 48°00’ to 48°15’N, Longitudes 80°00’ to 80°30’W.
Area 2—Larder Lake map-area, Latitudes 48°00’ to 48°15’N, Longitudes 79°30’ to 80°00’W.
Area 3—Englehart map-area, Latitudes 47°45’ to 48°00’N, Longitudes 79°30’ to 70°00’W.
Area 4—Matheson map-area, Latitudes 48°30’ to 48°45’N, Longitudes 80°00’ to 80°30’W.

Each map-area encompasses an area of approximately 1000 km².

Mineral Exploration

Gold was initially discovered in the vicinity of Larder Lake in 1906 (Thomson 1941, p.40). Shortly, thereafter, several gold mines were brought in to production near Kirkland Lake, 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 activity is described in geological reports on the area by the then 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 Lovell and Ploeger (1977, 1978).

General Geology

Bedrock in the area consists of Early Precambrian (Archean) metavolcanic, metasedimentary 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 overlie the bedrock throughout the area.

Kirkland Lake and Larder Lake Map-Areas

The major geological features of the Kirkland Lake and Larder Lake map-areas are shown on Map 2205 (Pyke et al. 1973) and the major geological features found during the field-mapping in 1976 were described by Jensen (1976a). During the 1977 field season, field work was concentrated on the sedimentary, volcanic and intrusive rocks in Otto, Boston, McElroy, Hearst and Skead Townships south of Kirkland Lake and Larder Lake (Jensen 1977).

In 1978, field mapping was concentrated on extending the major rock stratigraphic units and studying their relationships to one another, particularly in areas of gold mineralization such as the Kerr Addison mine in Virginia-town and the Macassa gold mine in Kirkland Lake. For mapping purposes nine layered assemblages and five intrusive assemblages of Early Precambrian rock and one Middle Precambrian (Proterozoic) layered assemblage are recognized. Their approximate distribution is shown in Figure 1.

Each Early Precambrian layered assemblage constitutes a group of several mappable rock-types called formations. Each formation contains members composed of several distinctive beds or volcanic flows.

The Pacaud Group, previously named the Pacaud Tuffs (Ridler 1970), occurs along the northern margin of the Round Lake Batholith and comprises the oldest rocks of the area. The group consists of calc-alkalic basalt, andesite and dacite mainly in the form of tuff and tuff breccia. The group is tectonically deformed and intruded toward its base by the Round Lake Batholith. The thickness and extent as well as rock units within the group are still largely unknown.

The Wabewawa Group is proposed by the author as a new group to distinguish a sequence of rocks that were formerly included with the Catharine Basalts and the Pacaud Tuffs (Ridler 1970, 1975). The group contains ultramafic and basaltic komatiite and Mg-rich tholeiitic basalt interlayered with calc-alkalic basalt, andesite dacite and rhyolite tuffs and sedimentary rocks of wacke, argillite, ironstone, chert, and sulphide mineralization and minor conglomerate. The komatiitic lava flows predominate toward the top of the group and the group is tectonically deformed and in places cut by the Round Lake Batholith. Where not truncated by the batholith, the Wabewawa Group appears to conformably overlie the Pacaud Group. Layered sulphide mineralization and ironstone 5 to 100 cm thick occurs in a few places. Further work is being done to trace the upper and lower contacts of the group as well as to distinguish rock units, and to determine the metamorphism and structural deformation of the group.

The Catharine Group, previously referred to as the Catharine Basalts (Ridler 1970) is composed of Mg-rich and Fe-rich tholeiitic basalt flows with Fe-rich tholeiitic basalt predominating at the top of the group. The group con-
Figure 1—Stratigraphic units in the Kirkland Lake-Larder Lake area.
Layered assemblages - 1) Pacaude Group, 2) Wabewawa Group, 3) Catharine Group, 4) Shead Group, 5) Unnamed group (5a Sedimentary rocks, 5b Volcanic rocks), 6) Kinojevis Group, 7) Blake River Group, 8) Gauthier Group, 9) Timiskaming Group, 10) Coleman member of the Gowganda Formation.
formally overlies the Wabewawa Group and forms a monoclinal sequence about 8000 m thick in Catharine Township (Area 3, see location map). Further work will be required to trace out its lower contact with the Wabewawa Group and to trace out formations of Mg-rich and Fe-rich tholeiitic basalt.

The **Skead Group**, previously referred to as the Skead Pyroclastics (Ridler 1970), consists mainly of massive calc-alkalic volcanic fragmental rocks of basalt, andesite, dacite and rhyolite composition. Some flows are present in the group. The fragmental rocks range from crystal tuff to tuff-breccia and flow breccia. The coarser fragmental rocks contain a wide variety of felsic fragments. The main source of the volcanic rock appears to have been a large volcanic center in Skead Township as suggested by Hewitt (1949) with numerous other smaller contributing vents. Further work will be carried out to study the distribution of various types of fragments including sulphide fragments.

An unnamed group, possibly correlative with the Piché Group in Quebec (H.L. Lovell, Resident Geologist, Ontario Ministry of Natural Resources, Kirkland Lake, personal communication) occurs conformably to disconformably above the Skead Group. It consists of volcanic and sedimentary rocks over a large area south of Kirkland Lake. The volcanic rocks are calc-alkalic rhyolite tuff-breccia, crystal tuff and cherty tuff and ultramafic and basaltic komatiitic flows with Mg-rich tholeiitic basaltic flows. In many places, the komatitic rocks are metamorphosed to talc-serpentinite-chlorite schist, and are metasomatized to form green and grey carbonate rocks and alkali-rich greenstones. The sedimentary rocks consist of conglomerate, wacke, argillite and green to grey carbonate rocks interlayered with mafic to felsic alkalic lava flows and tuff-breccia and tuff and much redeposited volcanic debris. At its base, the group unconformably overlies the Kinojevis and the Blake River Groups. The rocks underlying the Timiskaming belonging to the Kinojevis and Blake River Groups. The rocks underlying the Timiskaming belonging to the Kinojevis and Blake River Groups have a characteristic alteration suggesting a period of weathering prior to deposition of the Timiskaming. Much of the material in the basal grit (Thomson 1948) is of volcanic rock having this alteration. However, above the basal grit, all the fragmental rocks appear to have been derived from the south and from within the basin itself. No rock fragments of rock types to the north have been identified except in the basal grit.

The top of the Timiskaming is in fault-contact with the sedimentary and volcanic rocks of the unnamed group to the south. This contact has been observed on surface and in drill core and probably represents the main expression of the Kirkland Lake — Larder Lake Fault zone that extends west toward Matachewan (see Pyke, *this volume*).

Further study of the upper and lower contacts of the Timiskaming Group as well as the tracing out of the many distinctive units within the Timiskaming remains to be done particularly to evaluate the uranium and gold potential of the Timiskaming Group.

The intrusive assemblages have similar ages to and are spatially associated with the volcanic rocks of similar composition.

Subalkalic ultramafic to mafic rocks occur as plugs of peridotite (serpentinite) and as sills composed of peridotite, pyroxenite and gabbro intruded into the Wabewawa Group and the unnamed group of komatitic and sedimentary rocks of the Timiskaming. This sequence of tholeiitic lavas extends west and appears to be part of the Kinojevis Group.

The **Blake River Group** conformably to disconformably overlies the Kinojevis Group in the north parts of the Kirkland Lake and Larder Lake map-areas. The group consists of calc-alkalic basalt, andesite dacite, and rhyolite flows and pyroclastic rocks derived from two main vents in Clifford and Pontiac Townships (Jensen 1975a, 1975b). The writer has only partially investigated the lower contact of the Blake River Group and the volcanic units in the Blake River Group in the Kirkland Lake and Larder Lake map-areas.

The **Gauthier Group** is separated from the other layered assemblages because of its distinctiveness and uncertain stratigraphic position. It is composed of fragmental rocks with K-rich calc-alkalic basalt, andesite and dacite composition. Minor cherty rhyolite tuff occurs toward the top of the group. The fragmental character of this group is similar to that of the Skead Group and the two have been correlated by Ridler (1970). However, the volcanic fragments are more rounded and the rocks are 1 to 2 percent higher in potassium than are the sodium-rich Skead-calc-alkalic volcanic rocks. There is some evidence to suggest the Gauthier Group is partly of sedimentary as well as of volcanic origin.

The **Timiskaming Group** consists of fluvioglacial conglomerate, wacke, arkose, sandstone and argillite interlayered with mafic to felsic alkalic lava flows and tuff-breccia and tuff and much redeposited volcanic debris. At its base, the group unconformably overlies the Kinojevis and the Blake River Groups. The rocks underlying the Timiskaming belonging to the Kinojevis and Blake River Groups have a characteristic alteration suggesting a period of weathering prior to deposition of the Timiskaming. Much of the material in the basal grit (Thomson 1948) is of volcanic rock having this alteration. However, above the basal grit, all the fragmental rocks appear to have been derived from the south and from within the basin itself. No rock fragments of rock types to the north have been identified except in the basal grit.
Subalkalic mafic to intermediate intrusive rocks mainly occur in the Kinojevis and Blake River Groups.

Subalkalic felsic intrusive rocks occur as trondhjemite in the Round Lake Batholith and as granodiorite in the Watabeag Batholith. Small stocks of quartz diorite cut the Blake River Group (Jensen 1975a, 1975b).

The alkalic intrusive rocks are ultramafic to felsic in composition and vary from Na-rich syenodiorite to K-rich syenite. The larger more felsic bodies include the Otto Stock, Lebel Stock, and Murdock Creek Stock. They range from quartz-normative to nepheline-normative. Several hundreds of smaller stocks and dikes cut the volcanic and sedimentary rocks of the Kinojevis Group, the Timiskaming Group, and the rocks south of Kirkland Lake. Where many of the intermediate to felsic rocks cut komatiitic rocks, hybrid phases appear to form similar in composition to the host rock except they are high in alkalis and clearly cut the host rocks and other phases of the alkalic intrusive rocks. The ultramafic to mafic alkalic rocks are mainly serpentine-biotite rich lamprophyres.

The volcanic rocks of the Blake River Group are mainly komatiite flows and tuffs. Volcanic rocks of the Blake River Group are mainly komatiite flows and tuffs. The volcanic manifestation of the alkalic intrusive rocks appears to be restricted to the Timiskaming Group where alkalic volcanic flows and tuffs of mafic to felsic trachyte are present. Hence the alkalic intrusions appear to be of the same age as the Timiskaming Group.

Further work is being carried out to distinguish the K-rich and Na-rich alkalic intrusive rocks and to evaluate their gold and uranium potential.

Diabase dikes occur throughout the area, the highest concentrations being in the west part of the Kirkland Lake map-area. They are mainly north trending Matachewan-type quartz diabase dikes.

Shallow dipping to horizontal Middle Precambrian sedimentary rocks unconformably overlie the early Precambrian rocks. They consist of boulder conglomerate, arkose, wacke and argillite of the Coleman member, Gowganda Formation. They occur in the west part of the Kirkland Lake map-area and in the east part of the Larder Lake map-area where they were studied in detail by Mandzuik (see this volume).

A cyclic pattern occurs in the subalkalic volcanic rocks in Kirkland Lake and Timmins area that allows the volcanic rocks to be tentatively correlated between the two areas. The cycle consists of a basal komatiitic sequence associated with sedimentary rocks containing ironstone, a middle tholeiitic sequence and an upper calc-alkalic sequence. In the Kirkland Lake area, the volcanic rocks are preserved in a large east-plunging synclinorium (Jensen 1975a, 1975b, 1978b). On the north limb of the synclinorium, the uppermost cycle is represented by the komatiitic rocks of the Stoughton-Roquemaure Group, tholeiitic rocks of the Kinojevis Group and the calc-alkalic rocks of the Blake River Group (Jensen 1976b, 1978a). Below the komatiitic rocks of the Stoughton-Roquemaure Group is a group of calc-alkalic volcanic rocks, the Hunter Mine Group (Jensen 1978b). The Hunter Mine Group is thought to represent the top of an earlier volcanic cycle (Jensen, in preparation).

On the south limb of the synclinorium, the upper volcanic cycle is represented by an unnamed group, possibly correlative with the Piché Group (Lovell, personal communication), of komatiites overlain by tholeiitic volcanic rocks of the Kinojevis Group and calc-alkalic rocks of the Blake River Group.

Underlying this upper cycle is a lower cycle composed of the Wabewawa Group, Catharine Group and the Skead Group. Below this cycle is the Paucaud Group which possibly represents the top of an older third volcanic cycle.

Younger than the above subalkalic volcanic cycles are two suites of alkalic volcanic rock, the first being located along the Kirkland Lake — Larder Lake Fault zone in the Timiskaming Group and the second, along the Detor-Porcupine Fault zone (Jensen in preparation).

Volcanic rocks of the Kinojevis Group and the Stoughton-Roquemaure Group in the north part of the synclinorium extend west where they form the younger volcanic rocks of the Timmins area (see Pyke, this volume). Here they extend south and east again on the south side of the synclinorium in the Kirkland Lake area.

Thus the unnamed komatiitic group (Piché Group, Lovell, personal communication) appear to be correlative with the Stoughton-Roquemaure Group.

The lower volcanic cycles may or may not be correlative in the north and south parts of the Kirkland Lake area and the Timmins area. Although stratigraphically they appear equivalent to one another, they may be of slightly different ages and derived from separate volcanic sources (see Pyke, this volume).

**Economic Geology**

In the Wabewawa Group and possibly in the Paucaud Group, chalcopyrite is associated with thin pyrite-rich layers in the felsic tuffs and sedimentary rocks as isolated occurrences and on strike with ironstones. In the Catharine Group, minor gold and chalcopyrite occurs associated with quartz veins and feldspar porphyry dikes and in the Skead Group numerous showings of massive to disseminated chalcopyrite, molybdenite, sphalerite with pyrite and minor gold occur in the volcanic breccias and tuffs which contain pyrite fragments in many places.

In the unnamed group of komatiitic volcanic rocks, calc-alkalic volcanic rocks and sedimentary rocks above the Skead Group, gold at the Kerr Addison mine and iron at the Adams mine are the major economic deposits. At the Kerr Addison mine, gold is associated with carbonatized mafic and ultramafic volcanic rocks interlayered with sedimentary rocks that include conglomerate, wacke, argillite and graphite. At the Adams mine, layers of magnetite ironstone alternating with chert form a sufficient thickness and grade to be economically mined. Calc-alkalic dacite and rhyolite tuff along with some pyrite and pyrrhotite occur in the leaner upper and lower parts of the ironstone deposit. Tholeiitic basalt occurs on the footwall and ultramafic komatiite occurs on the hanging wall of the ironstone deposit. Elsewhere in the unnamed group, nu-
merous occurrences of zinc and lead sulphide mineralization with minor chalcopyrite occur with graphitic layers and disseminated chalcopyrite occurs in some limestones and dolostones.

In the Kinlochis Group, as in the Catharine Group, minor chalcopyrite and gold occur associated with quartz veins and feldspar porphyry dikes. Thin layers of ironstone and graphite with minor pyrite, sphalerite, and galena occur in a few places.

In the Blake River Group, massive to disseminated Zn, Cu, Pb, Mo sulphide minerals and minor Au and Ag occur in Ben Nevis and Clifford Townships north of the map-areas (Jensen 1975a).

In the Gauthier Group, gold and chalcopyrite mineralization occurs at the Upper Beaver mine (Thomson and Griffis 1941).

In the Timiskaming Group, gold occurs along fractures filled by quartz-veins and feldspar porphyry in the main mines of the Kirkland Lake mining camp. In addition, above background values of uranium and gold are present in some of the alkalic volcanic lava flows and tuffs.

In the intrusive assemblages, nickel and chrome silicates, oxides and some sulphide occur in the ultramafic to mafic intrusions in the unnamed group, Skead Group, Wabewawa Group and Pacaud Group. Asbestos fiber is also present in some of the larger serpentinitized bodies.

The alkalic intrusions appear to have been responsible for the concentration of Au and Ag in the Kirkland Lake mining camp (Thomson 1948) and the Upper Canada mine in Gauthier Township (Thomson and Griffis 1941).

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Thomson, J.E. and Griffis, A.T.
No. 11 Regional Geology of the Timmins-Matachewan Area Districts of Cochrane and Timiskaming

D.R. Pyke

Introduction

Since 1972, the writer has been involved in regional mapping in the Timmins-Kirkland Lake area, particularly in the area between Timmins and Matachewan. This has largely been confined to five quadrangles, four of which are bounded by Longitudes 80°30' and 81°30'W and Latitudes 48°00' and 48°30'N, and the fifth by Longitudes 81°00' and 81°30'W and Latitudes 47°45' and 48°00'N. The emphasis in this mapping has primarily been to outline the major lithostratigraphic units and regional structures. From this it was hoped that the integration of known metal deposits into a regional stratigraphic framework would assist delineating new areas of mineral potential as well as additional targets in known mineralized camps. Certainly a better understanding of the stratigraphy has evolved; problems, however, still remain and changes will be necessary as more data is accrued.

General Geology

When the region is viewed in a larger perspective than any one of the above mentioned quadrangles, it is seen that what were previously defined as groups (Pyke 1974, 1978a) are in reality supergroups (given that the correlations presented here are correct), and in turn the formations would necessarily be raised to group status. This concept is incorporated in Figure 1, whereby, for example, the Deloro Group within the Shaw Dome of the Timmins area (Pyke 1974) is shown as forming part of the

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Lower Supergroup (in a regional context). The Tisdale Group (Pyke 1974) on the other hand would correspond to the Upper Supergroup. This division of the volcanic rocks into two supergroups follows the subdivision previously presented by Pyke and Jensen (1976).

The division between the Lower and Upper Super groups marks a major change in volcanism, and is the single most important stratigraphic marker in the area. Felsic, calc-alkaline, largely pyroclastic volcanism, with abundant associated iron formation forms the upper part of the Lower Supergroup; the base of the overlying supergroup is dominated by komatiitic volcanism, in large part ultramafic. Interlayering along the contact between the calc-alkaline and komatiitic volcanism is common, as is the intercalation of turbidites, marking the first major encroachment of sediments into the area.

The onset of komatiitic volcanism is taken to represent a common lithostratigraphic horizon throughout the area shown in Figure 1, and thus forms the basic underlying assumption on which much of the stratigraphic interpretation hinges. If incorrect then changes are correspondingly required: for example ultramafic volcanic rocks are known to occur at the base of the Deloro Group in the Peterlong Lake area (Pyke 1978a) and therefore

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**LEGEND**

**EARLY PRECAMBRIAN**
- Porcupine Group

**UPPER SUPERGROUP**
- Calc-Alkaline suite
- Tholeiitic suite
- Komatiitic suite

**LOWER SUPERGROUP**
- Unsubdivided

*Figure 1—Regional stratigraphy of the Timmins-Matachewan area.*
can obviously occur at more than one stratigraphic level. Nevertheless, the particular komatitic volcanic rocks shown to be correlative (Figure 1) do provide a starting point for a stratigraphic frame work which may ultimately aid in further interpretations.

**Lower Supergroup**

The Lower Supergroup is largely a calc-alkaline sequence, tholeiites are only known to be prominent toward the bottom of the supergroup in the Peterlong Lake area (Pyke 1978a). Ironstone is common at or near the top of the supergroup and forms a persistent stratigraphic marker throughout much of the area south of the Destor-Porcupine Fault. In fact, the abundance of ironstone is perhaps one of the most readily noticeable differences between the two supergroups, for by comparison ironstone is virtually absent from the Upper Supergroup. Furthermore, dunitic intrusions are also an entity confined almost solely to the Lower Supergroup.

The Lower Supergroup is confined to domal-type structures such as the Shaw Dome and Pamour Dome (?), or to the margins of granitic plutons (eg. Kenogami batholith) which have pushed up (domed) the surrounding supracrustal rocks.

The interpretation of a domal structure north of Timmins (the Pamour Dome) is based largely on aeromagnetic data (GSC 1970) whereby a series of magnetic highs outline a somewhat oval-shaped, east-west trending structure. Many of these “highs” are known from diamond drilling (Assessment Files, Research Office, Ontario Geological Survey, Toronto) to correspond to ultramafic rocks, some of which are known to be flows, as shown by spinifex texture and flow contacts. A dome rather than a basin is inferred in that the metasediments on the southern flank lie outside the structure and are assumed to be younger. The ultramafic flows at the periphery of the Pamour Dome are interpreted to form part of the komatitic sequence at the base of the Lower Supergroup. If the Pamour sequence of volcanic rocks does not form part of a domal structure but instead the regional structure is a basin, then the volcanic sequence to the north of Timmins is part of the Upper Supergroup or perhaps a higher stratigraphic sequence.

The Kamiskotia area northwest of Timmins is tentatively included in the Lower Supergroup for the following reasons: Firstly, ultramafic volcanic rocks are only known to occur near the top of the main volcanic sequence in the Kamiskotia area (R. Middleton, Rosario Resources Canada Limited, personal communication). Secondly, no large gabbroic complexes, like the Kamiskotia gabbro, are known to occur in the Upper Supergroup, whereas layered gabbroic sills do intrude the Lower Supergroup (for example in the Peterlong Lake area, Pyke 1978a). The third, and perhaps most compelling reason is that the area sits on the western margin of a trondhjemitic complex; similar batholiths to the south (Kenogami and Round Lakes) are bordered by formations of the Lower Supergroup, and it is postulated that a similar situation exists in the Kamiskotia area.

Both the Pamour Dome and the Kamiskotia area could prove to be of a differing age than the supergroups proposed, as the absence of exposure and detailed mapping precludes any direct correlation at this time.

**Upper Supergroup**

The Upper Supergroup is divided into three groups, each characterized by a distinct chemical composition; this subdivision is essentially an extension of the manner in which the Tisdale Group was partitioned in the Timmins area (Pyke 1975). The chemo-stratigraphic breakdown as shown on Figure 1 is largely based on a number of unpublished analyses (Pyke, in prep.).

The base of the Upper Supergroup is composed mainly of basaltic and peridotitic komatiites and magnesium-rich tholeiitic basalts; the komatiitic rocks being most common near the base of the lower group. This basal group is possibly correlative with the Stoughton-Quem趣味 Group, largely a komatitic sequence, described by Jensen (1976). The overlying group is dominantly an iron-rich tholeiitic sequence and is interpreted to form the westward extremity of the Kenojevis Group (Dimroth et al. 1973; Jensen 1976). The upper group is composed almost entirely of volcanic rocks of calc-alkaline chemical affinity, and is interpreted to be part of the Blake River Group of Dimroth et al. (1973) and Jensen (1976).

Given that the above correlations are correct, then there is considerable thinning of the Upper Supergroup from east to west; maximum thickness is approximately 30 000 m near the Ontario-Quebec Provincial boundary (Jensen 1976), and approximately 12 000 m in the Timmins-Matachewan area. Suggested stratigraphic correlations in the Timmins-Kirkland Lake area are shown in Figure 2, and in Jensen (this volume).

**Structure**

Near the Ontario-Quebec boundary the main structure within the Upper Supergroup is an easterly plunging synclinorium (Jensen 1976). The Timmins-Matachewan area is interpreted to be in the nose of this synclinorium. Here, not only are the volcanic strata rapidly thinning, but they have been highly disrupted by batholith contacts. The emplacement of the Kenogami batholith and the resultant updoming of the adjacent volcanic rocks of the Lower Supergroup marks the westward termination of the Upper Supergroup and associated synclinorium.

Two major easterly trending faults, the Destor-Porcupine and Larder Lake, form prominent structures; the westerly extension of the Larder Lake break has not yet been traced with certainty further than the Matachewan area, but is interpreted to extend as far as the Kenogami batholith. In the writer’s opinion these faults formed part of a major fracture system in the Early Precambrian crust, possibly related to rifting, along which komatiitic volcanism and sedimentation was prominent. In a more regional context than even that of the Timmins-Matachewan area this would aid in explaining the intimate associa-
tion of ultramafic volcanics and a variety of different rock types. An alternate interpretation to rifting would be that the fault zones represent high angle faults along the margins of the main synclinorium, their formation being concomitant with the subsidence of the central portion of the synclinorium; this however is considered less likely.

Regional Economic Considerations

Once an interpretation of the regional stratigraphy is formulated it is then practical to relate this to known mineral deposits in the area. In the writer's opinion some of the more obvious generalizations are:

1) Known Cu-Zn deposits are within the felsic calc-alkalic volcanic rocks at the top of the Lower Supergroup. The Kamiskotia deposits are a few thousand feet below the top of the Lower Supergroup, the Kidd Creek deposit is at the interface of the two Supergroups.
2) South of the Destor-Porcupine Fault, ironstone units seem to occupy the same stratigraphic position as the Cu-Zn deposits north of the fault.
3) Nickel deposits are in the peridotitic komatites at the base of the Upper Supergroup.
4) Asbestos deposits are within the ultramafic intrusions, not the ultramafic flows. Virtually all the dunitic intrusions are within the Lower Supergroup.
5) Magnesite and talc-magnesite deposits of commercial importance are confined to carbonatized dunitic intrusins and not ultramafic flows.

Figure 2—Suggested stratigraphic correlations in the Timmins-Kirkland Lake area. Note the rapid thinning of the Upper Supergroup from east to west. Also see Jensen (this volume).
6) Gold deposits are spatially and (probably) genetically related to the carbonatized portions of the komatiitic suite of volcanic rocks forming the lowermost group of the Upper Supergroup. Furthermore, a strong structural control is evident as virtually all the deposits are close to major east-west-trending fault zones, the Destor-Porcupine and Larder Lake breaks. In Timmins all the deposits are located within 6 km of the fault zone, a stratigraphic thickness of approximately 3000 m, and all but one of the many economic deposits is located north of the fault. In Matachewan both former producers are a hundred metres or so north of the Larder Lake break. In the writers opinion further gold exploration is warranted in both the Timmins and Matachewan camps. Virtually all the deposits were found from surface exposures, the deposits appear to be in a large part stratigraphically controlled, thus extensive areas of overburden overlying areas of favourable stratigraphy may mask prime target areas. For example, examination of the following is suggested: (i) the area between the Aunor-Delnite mines and the DeSantis mine and westward to the Mattagami River fault; (ii) the gold properties south of the Destor-Porcupine Fault, especially those in or near zones of extensively carbonatized komatiites such as (a), the area of the former Balmoral Porcupine property in north Adams Township, now known to be overlying carbonatized ultramafic flows at the margin of the Shaw Dome or (b) carbonatized ultramafic flows in the vicinity of Goose Lake in north Shaw Township—this zone is also spatially associated with a large quartz-porphyry stock (Mt. Logano) or (c) the Tetrault property in McArthur Township (Pyke 1978b), again gold mineralization related to carbonatized ultramafic flows and porphyry intrusions at the contact of the two supergroups.

As a general exploration guide it appears that the contact of the two supergroups is of special significance. Certainly the contact represents a dramatic change in volcanism, from felsic (calc-alkalic) to ultramafic (komatiitic). The nickel and gold deposits are related to the komatiites, whereas the Cu-Zn deposits are found within the underlying calc-alkaline sequence. Furthermore many of the quartz-feldspar porphyries were emplaced along or near this general contact, and the porphyries have been postulated as sources for the gold, Cu-Zn, and Cu mineralization. Indeed, regardless of one’s bias as to the origin of much of the sulphide and precious metal mineralization in the Timmins-Matachewan area, one cannot avoid the observation that a significant proportion of the producing mines, past producing mines and significant prospects are spatially related to the contact of the two supergroups. This would encompass a general stratigraphic thickness in the order of 1000 to 3000 m. In the writer’s opinion it is this general contact zone which warrants the most rigorous exploration. In conjunction with this stratigraphic zone the superposition of one or more of three additional elements would appear to warrant special consideration. These are: (1) major fault or shear zones, for example the Destor-Porcupine Fault in the Timmins Camp, the Larder Lake break at Matachewan, and the Burrows Benedict (?) at the Kidd Creek mine; (2) quartz-feldspar porphyries as in the Timmins gold camp, Kamiskotia area Cu-Zn deposits, and Kidd Creek (porphyry is present northeast of Kidd Creek in southwest Prosser Township, and some porphyry is known to be present in underground workings at Kidd Creek R. Walker, Texasgulf Canada Limited, personal communication, 1974); and (3) extensive alteration in the form of carbonatization, sericitization and chloritization.

References


1978a: Geology of the Peterlong Lake area, Districts of Timiskaming and Sudbury; Ontario Geol. Survey, Rept. 171, 53p. Map 2345, scale 1:50,000.


No. 12 Geology of the Burntbush-Detour Lakes Area District of Cochrane
G.W. Johns

Location
The map-area is bounded by Latitudes 49°00' and 50°04'N and the Quebec border and Longitudes 80°00'W and comprises 4030 km² in northeast Ontario. That portion of the map-area which comprises surveyed townships is in the Larder Lake Mining Division and the unsurveyed portion to the north is in the Porcupine Mining District. The map-area is north of Lake Abitibi and its centre is 169 km northeast of Timmins.

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Access
The southern portion of the map-area is easily accessible by the Abitibi Power and Paper Company Limited’s trans-limit road and auxiliary haulage roads. The trans-limit road connects with Highway 652 from Cochrane, 93 km to the west and directly with the mill in Iroquois Falls 96 km away. La Sarre, Quebec, is 63 km east via the trans-limit road connecting with the highway through St. Lambert Desmelozoies, Quebec.

The northern part of the map-area can be reached by float equipped aircraft and helicopter from Timmins and float equipped aircraft from both Cochrane and La Sarre, Quebec. From Cochrane and La Sarre it is 134 km and 131 km respectively to Detour Lake in the north-central part of the map-area. From Detour Lake to Timmins it is 200 km.

Mineral Exploration
A gold discovery was reported on the Patten River in 1912 (Tanton 1919). The subsequent rush of prospectors failed to find any valuable deposits. Following the initial discovery, in 1925, of copper and zinc at the Normetal Mine which lies 37 km to the east in Quebec, the metavolcanics in Steele Township were prospected (Lumbers 1962). In the early 1930s Cyril Knight did some prospecting for gold on a group of claims that were staked along the Burntbush River (Thomson 1936).

Exploration for base metals occurred mainly in the late 1950s, mid-1960s and recommenced in the early 1970s. Exploration has increased since 1974 with the announcement of a gold discovery by Amoco Canada Petroleum Company Limited in the vicinity of Sunday Lake.

Much assessment work has been filed within the map-area since 1957 and Table 1 is a listing of that work which is on file in the Assessment Files Research Office, Ontario Geological Survey, Toronto. During the field season the following companies and individuals held claims within the map-area: Amoco Canada Petroleum Company Limited, C. Bertrand, Dex Limited, Dome Exploration (Canada) Limited, Geophysical Engineering Limited, Hollinger Mines Limited, Hudson Bay Exploration and Development Company Limited, D. Maillet, Noranda Exploration Company Limited and Sarafand Developments Company Limited.
### TABLE 1

**ASSESSMENT WORK FILED FOR THE BURNTBUSH-DETOUR LAKES AREA.**

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G.W. JOHNS
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<td>Noranda Explor. Co. Ltd.</td>
<td>2.2040</td>
<td>Sunday L.</td>
<td>geophys</td>
<td>ground mag, EM</td>
</tr>
<tr>
<td>1975</td>
<td>Noranda Explor. Co. Ltd.</td>
<td>2.2019</td>
<td>Sunday L.</td>
<td>geophys</td>
<td>ground mag, EM</td>
</tr>
<tr>
<td>1975</td>
<td>Noranda Explor. Co. Ltd.</td>
<td>2.1911</td>
<td>Sunday L.</td>
<td>geophys</td>
<td>ground mag, EM</td>
</tr>
<tr>
<td>1976</td>
<td>Noranda Explor. Co. Ltd.</td>
<td>2.1880</td>
<td>Sunday L.</td>
<td>geophys</td>
<td>ground mag, EM</td>
</tr>
<tr>
<td>1975</td>
<td>Noranda Explor. Co. Ltd.</td>
<td>2.1881</td>
<td>Sunday L.</td>
<td>geophys</td>
<td>ground mag, EM</td>
</tr>
<tr>
<td>1975</td>
<td>Noranda Explor. Co. Ltd.</td>
<td>2.1879</td>
<td>Sunday L.</td>
<td>geophys</td>
<td>ground mag, EM</td>
</tr>
<tr>
<td>1975</td>
<td>Noranda Explor. Co. Ltd.</td>
<td>2.2076</td>
<td>Sunday L.</td>
<td>geophys</td>
<td>ground mag, EM</td>
</tr>
<tr>
<td>1974</td>
<td>Amoco Canada Petroleum Co. Ltd.</td>
<td>DDH rpt 10</td>
<td>Sunday L.</td>
<td>DDH</td>
<td>53 holes, 13,235 m</td>
</tr>
<tr>
<td>1974</td>
<td>Amoco Canada Petroleum Co. Ltd.</td>
<td>DDH rpt 11</td>
<td>Sunday L.</td>
<td>DDH</td>
<td>2 holes, 234 m</td>
</tr>
<tr>
<td>1974</td>
<td>Amoco Canada Petroleum Co. Ltd.</td>
<td>DDH rpt 12</td>
<td>Sunday L.</td>
<td>DDH</td>
<td>3 holes, 491 m</td>
</tr>
<tr>
<td>1976</td>
<td>Amoco Canada Petroleum Co. Ltd.</td>
<td>DDH rpt 13</td>
<td>Sunday L.</td>
<td>DDH</td>
<td>1 hole, 320 m</td>
</tr>
<tr>
<td>1976</td>
<td>Amoco Canada Petroleum Co. Ltd.</td>
<td>DDH rpt 14</td>
<td>Sunday L.</td>
<td>DDH</td>
<td>2 holes, 289 m</td>
</tr>
<tr>
<td>1974</td>
<td>Amoco Canada Petroleum Co. Ltd.</td>
<td>DDH rpt 15</td>
<td>Sunday L.</td>
<td>DDH</td>
<td>62 holes, 14,281 m</td>
</tr>
<tr>
<td>1975</td>
<td>Noranda Explor. Co. Ltd.</td>
<td>2.1807</td>
<td>west of Sunday L.</td>
<td>geophys</td>
<td>ground mag, EM</td>
</tr>
<tr>
<td>1975</td>
<td>Ogrzylo, S.P.</td>
<td>2.2006</td>
<td>west of Sunday L.</td>
<td>geophys</td>
<td>ground mag, EM</td>
</tr>
<tr>
<td>1971</td>
<td>Canadian Nickel Co. Ltd.</td>
<td>DDH rpt 10</td>
<td>west of Sunday L.</td>
<td>DDH</td>
<td>1 hole, 145 m</td>
</tr>
<tr>
<td>1971</td>
<td>Canadian Nickel Co. Ltd.</td>
<td>DDH rpt 11</td>
<td>west of Sunday L.</td>
<td>DDH</td>
<td>2 holes, 230 m</td>
</tr>
<tr>
<td>1974</td>
<td>Amoco Canada Petroleum Co. Ltd.</td>
<td>DDH rpt 12</td>
<td>west of Sunday L.</td>
<td>DDH</td>
<td>1 hole, 106 m</td>
</tr>
<tr>
<td>1974</td>
<td>Amoco Canada Petroleum Co. Ltd.</td>
<td>DDH rpt 13</td>
<td>west of Sunday L.</td>
<td>DDH</td>
<td>1 hole, 109 m</td>
</tr>
</tbody>
</table>
General Geology

The map-area lies in the northern part of the Early Precambrian Abitibi Belt of the Superior Province. Tanton (1919) mapped the eastern part of the area in 1914 and 1915. In the fall of 1917, Hopkins (1918) made a track survey of the La Reine (Oikidosik) and Patten Rivers and produced a geologic map. Thomson (1936) undertook a reconnaissance geological survey of the Burntbush River area in 1934. The townships of Steele, Bonis and Scapa were mapped by Lumbers (1962) at a scale of 1 inch to ¼ mile (1:15 840) in 1959. Hepburn Township and parts of Sargeant, Adair and Abbotford Townships were mapped by Lumbers (1963) in 1960 at the same scale. In 1966, Bennett et al. (1967) mapped 71 680 km² which included the whole of the Burntbush-Detour Lakes area.

The rocks in the map-area have undergone regional metamorphism of almandine-amphibolite facies rank. The metavolcanic-metasedimentary rocks appear to be part of a single folded supracrustal sequence separated by intermediate to felsic intrusive bodies. This sequence, the base of which is not exposed, commences with mafic and ultramafic flows and mafic pyroclastic rocks, and progresses upwards through intermediate to felsic flows, tuffs, lapilli tuffs and minor interbedded metasediments intercalated with the mafic metavolcanics. The top of the metasedimentary portion is capped by more mafic flows. Conformably overlying the metavolcanics is a belt of metasediments called the Scapa metasediments in the south by Lumbers (1962, 1963). Overlying these metasediments are the Steele metavolcanics (Lumbers 1962) which are mafic flows with very minor intermediate tuffs. The Steele metasediments (Lumbers 1962) overlie these metavolcanics. The Steele metavolcanics and metasediments are only found in the extreme southwest portion of the map-area. This volcanic-sedimentary sequence was cut by concordant and discordant gabbro intrusions. The whole sequence was then folded and intruded by quartz monzonite and granite batholiths and plutons. Later two sets of diabase dikes intruded the “greenstone” belt assemblage. The northeast-trending dikes post-date the north-trending dikes by at least 1255 million years (Fahrig et al. 1965).

The mapping during this field season has resulted in revision to rock types and distribution of some of the units from those portrayed by Bennett et al. (1966a,b). The intermediate to felsic metavolcanic horizon that was found in parts of St. Laurent, Bradette, Noseworthy, Hurtubise, and Hobilitzel Townships (Bennett et al. 1966a) has been reduced in extent. It was found to extend from the Quebec border to the Burntbush River but it is not as wide as previously interpreted. The geology in the vicinity of Detour Lake in the north part of the area has been changed substantially from that known previously. The mafic metavolcanics depicted to stop on the south shore of Hopper Lake and just north of Lower Detour Lake (Bennett et al. 1966b) have been extended northwards to incorporate Sunday Lake. Between those mafic metavolcanics and the granitic batholith there may be a band of metasediments. The circular exposure of “foliated granites” noted on the west side of Lower Detour Lake (Bennett et al. 1966b) could not be found and has been remapped as mafic metavolcanic flows.

Structural Geology

The metavolcanic-metasedimentary rocks in the map-area lie at the noses of two anticlinal which extend west from the main body of the Abitibi volcanic belt in Quebec. The southern anticlinorium is centered on the surveyed townships and the northern anticlinorium is centered on Lower Detour Lake. That portion of the southern anticlinorium found south of the Mistawak Batholith appears to be a south facing homoclinal sequence. The northern part of the anticlinorium above the Mistawak Batholith, may be a more complex series of anticlines and synclines as proposed by Wilson et al. (1977). Bennett et al. (1966b) proposed a series of three synclines and anticlines within the northern anticlinorium. Even though information is scarce the author suggests there may be more folds, and that the felsic and sedimentary stratigraphy previously mapped (Bennett et al. 1966b), may be repeated between Lower Detour Lake and Sunday Lake.

No major faults or lineaments have been proposed for the map-area since the poor outcrop exposure precludes detailed interpretation. The glacial fluting within the map-area masks any lineament that may otherwise be visible.

Economic Geology

The Burntbush-Detour Lakes map-area has been the subject of intense exploration for base metals since 1974. The areas of interest are the felsic metavolcanics centered on Bradette and Noseworthy Townships and the felsic metavolcanics centered on Vandette Lake. The homoclinal sequence in the extreme south has not received much recent attention.

Lumbers (1962, 1963) has described the mineral occurrences found in the extreme southern portion of the map-area and the reader is referred to his reports.

Gold

The most interesting property in the area is the Amoco Canada Petroleum Company Limited's gold discovery 15 km north of Detour Lake. The deposit was discovered late in 1974 as the result of a diamond drill hole testing an electromagnetic conductor indicated by an airborne geophysical survey. Since 1974, over 50 000 m of diamond drilling has outlined a deposit of 10 million tons grading approximately 6.86 ppm gold (Northern Miner, 1976). In 1976 a 758 m decline was sunk to the 120 m level and a 100 t bulk sample was removed from three cross-cuts into the deposit.

The main zone of mineralization is irregular in width, varying from 1 m to 45 m and incorporates the basal por-

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tion of a mafic flow sequence, the upper part of a talc-carbonate zone and an intervening intermediate tuff horizon. The mineralized zone is up to 900 m long and has been proved to a depth of 150 m. The deepest diamond drill hole intersected mineralization at a depth of 545 m.

The gold mineralization is found in discontinuous quartz filled fractures; as well as the host rock. The mineralization is believed to be of epigenetic origin and is the result of remobilization during tectonic activity (D. Deem, Senior Mining Engineer, Amoco Canada Petroleum Company Limited, Mining Division, personal communication, 1978).

The only other reported gold occurrence was a showing on the east side of the Burntbush River (Thomson 1936). Here the Cyril Knight Prospecting Company did stripping and trenching in a 1.8 m wide shear zone in rhyolite tuff. The grade was reported to be 1.71 ppm gold (Thomson 1936).

Iron

A number of small occurrences of Algoma-type ironstone (iron formation) have been reported in the map-area (Shklanka 1968). The most interesting is the Kenning prospect situated in the southeast corner of Kenning Township. It is classed by Shklanka (1968) as an Algoma type, oxide facies iron formation. It is a highly folded, magnetite-quartz-mica-hornblende-grunerite ironstone with a strike length of 727 m and an average width of 61 m. It has an average grade of approximately 25 percent iron and an estimated tonnage of 133 000 t per vertical metre (Shklanka 1968). This was deemed by Cliffs of Canada Limited in 1957 to be too small to be of economic interest.

Base Metals

Exploration for base metals has been active in the map-area. Areas of interest are the intermediate to felsic metavolcanics found throughout the map-area. Significant amounts of pyrrhotite and pyrite have been found in Abbotsford and Adair Townships and in the vicinity of Vandette, Atkinson and Nash Lakes (Assessment Files Research Office, Ontario Geological Survey, Toronto). Even though only traces of economic minerals were found it is the authors opinion that those areas have economic potential. The reader is referred to Springer (1978) for a broader outline of these areas of economic interest.

References

Bennett, G., Brown, D., and George, P.

Bennett, G., Brown, D.P., George, P.T., and Leathy, E.J.

Fahrig, W.F., Gaucher, E.H. and Larochelle, A.

Hopkins, P.E.

Lumbers, S.B.


Northern Miner Press

Shklanka, Roman

Springer, Janet

Tanton, T.L.

Thomson, Robert

Wilson, B.C., Arenji, J. and Peacock, J.
No. 13  Benton and Mallard Townships, District of Sudbury
G.M. Siragusa¹

Location and Access

The two contiguous townships of Benton and Mallard are bounded by Latitudes 47°40' and 47°45'30"N and by Longitudes 82°13' and 82°28'W. A narrow and locally poor bush road connects the southern tip of Rush Lake (northeastern Mallard Township) with the gravel road formerly owned by Eddy Forest Products Limited which was opened to the public in 1978 and connects Highways 129 and 144. The distance from Rush Lake to Chapleau is about 139 km. The Wakami, Woman, and Opeepeesway Rivers offer good canoe routes within the area and were constantly used as baselines for traversing. The area has low relief and is covered by extensive swamps particularly in Benton Township.

Mineral Exploration²

Mallard Township

In 1933 Mallard Township was actively prospected for gold. Woman River Gold Mines Limited held a group of 14 claims which were staked in 1931 following the discovery of gold values in a shear zone located in the northwestern part of the township. These claims were surveyed in 1933, and development work consisted of a series of test pits and shallow trenches which exposed the shear zone for a length of 40 m with average width of 3 m, and lesser trenching in other parts of the property. Presumably some trenching was carried out on this property also during the following year. Gold occurrences were found also in three other properties one of which, known as the Ferland-Gauldie-Mogridge claims, was located in central Mallard Township adjacent to the eastern bank of the Opeepeesway River. This property consisted of 18 claims in which stripping and trenching exposed a shear zone for a length of about 140 m, and a width ranging from 5 to 10 m. In September of 1933 N.A. Timmins Corporation optioned the claims, completed four diamond drill holes for a total of 150 m, and subsequently dropped the option in 1934. The other two properties consisted of two groups of claims, known as the Herriston-Hammerstrom claims and the Maltby claims, which were located adjacent to and to the west of the Ferland-Gauldie-Mogridge claims, and within a short distance southeast of the latter, respectively. An unspecified, although presumably small amount of stripping and trenching was apparently the only devel-

¹ Geologist, Precambrian Geology Section, Ontario Geological Survey, Toronto.
² Unless otherwise specified, information from Assessment Files Research Office, Ontario Geological Survey, Toronto.
opment work carried out on these two properties. From the geological descriptions of the above properties (Laird 1935), it is apparent that quartz veins in sheared and silified volcanic rocks and the presence of small bodies of "porphyry" or "felsite" (i.e. subjacent felsic volcanic rocks) are the favourable environment for gold mineralization in Mallard Township.

In more recent times the emphasis of exploration has shifted toward search for base metal deposits. Following the discovery of copper in southwestern Genoa Township (Northern Miner, July 23, 1970) which adjoins Mallard Township to the north, a staking rush occurred in Mallard Township. Recorded data on exploration other than drilling, and on drilling, are summarized in chronologic order in Tables 1 and 2, respectively.

**Benton Township**

In the past Benton Township has attracted less exploration activity than Mallard Township; there is little doubt that the poor access and the expanse of flat and swampy terrain over most of Benton Township have been negative factors. Recorded data on exploration other than drilling, and on drilling, are summarized in Tables 3 and 4 respectively.

During the summer of 1978 a crew of Noranda Exploration Company Limited was in the area. Drilling equipment was noted on the winter road leading west of Garnet Lake (Garnet Township) into Cunningham Township.

---

**TABLE 1**

**SUMMARY OF EXPLORATION WORK OTHER THAN DRILLING IN MALLARD TOWNSHIP.**

<table>
<thead>
<tr>
<th>Year</th>
<th>Company</th>
<th>Surveys*</th>
<th>Number of claims in claim groups covered by surveys, and their general location within Township</th>
</tr>
</thead>
<tbody>
<tr>
<td>1970/71</td>
<td>Panacea Mining and Exploration Ltd.</td>
<td>M, EM</td>
<td>12 Northeastern</td>
</tr>
<tr>
<td>1972</td>
<td>Claw Lake Molybdenum Mines Ltd.</td>
<td>AM</td>
<td>39 Northern</td>
</tr>
<tr>
<td>1975</td>
<td>Noranda Exploration Company Ltd.</td>
<td>M, EM</td>
<td>8 Southern</td>
</tr>
<tr>
<td>1975/76</td>
<td>U.S. Steel International Ltd.</td>
<td>EM, TMFG, G, RC, SC</td>
<td>15 Northwestern</td>
</tr>
<tr>
<td>1977</td>
<td>Noranda Exploration Company Ltd.</td>
<td>M, EM</td>
<td>4 Southern</td>
</tr>
</tbody>
</table>

*Abbreviations:

M ground magnetic survey
EM ground electromagnetic survey
AM airborne magnetometer survey
TMFG total magnetic field gradient study
G geological mapping
RC rock geochemistry
SC soil geochemistry

**TABLE 2**

**SUMMARY OF DRILLING DATA IN MALLARD TOWNSHIP.**

<table>
<thead>
<tr>
<th>Year</th>
<th>Company</th>
<th>Claim</th>
<th>Number of D.D. holes</th>
<th>Total length, metres</th>
</tr>
</thead>
<tbody>
<tr>
<td>1933</td>
<td>N.A. Timmins Corp.</td>
<td>S24797 (?)</td>
<td>4</td>
<td>153</td>
</tr>
<tr>
<td>1963</td>
<td>Anaconda American Brass Ltd.</td>
<td>S118285</td>
<td>1</td>
<td>120.7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>S118287</td>
<td>2</td>
<td>169.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>S118291</td>
<td>8</td>
<td>959.8</td>
</tr>
<tr>
<td>1976</td>
<td>Gulf Canada Minerals Ltd.</td>
<td>P451699</td>
<td>1</td>
<td>151.7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>P451691</td>
<td>1</td>
<td>151.4</td>
</tr>
<tr>
<td>1976</td>
<td>W.G. Wahl Ltd.</td>
<td>P428943</td>
<td>1</td>
<td>145.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>P428944</td>
<td>1</td>
<td>111.5</td>
</tr>
</tbody>
</table>

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### TABLE 3
**Summary of Exploration Work Other Than Drilling in Benton Township**

<table>
<thead>
<tr>
<th>Year</th>
<th>Company</th>
<th>Surveys</th>
<th>Number of claims in claim groups covered by surveys, and their general location within Township</th>
</tr>
</thead>
<tbody>
<tr>
<td>1974/75</td>
<td>Noranda Exploration Co. Ltd.</td>
<td>M, EM</td>
<td>18 North-central</td>
</tr>
<tr>
<td></td>
<td></td>
<td>M, EM</td>
<td>2 Southeastern</td>
</tr>
<tr>
<td></td>
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<td>M, EM</td>
<td>20 South-central</td>
</tr>
<tr>
<td></td>
<td></td>
<td>M, EM</td>
<td>14 South-central</td>
</tr>
<tr>
<td></td>
<td></td>
<td>M, EM</td>
<td>6 Northeastern</td>
</tr>
<tr>
<td>1975</td>
<td>U.S. Steel International Ltd.</td>
<td>EM, TMFG, G, RC, SC</td>
<td>15 North boundary</td>
</tr>
</tbody>
</table>

### TABLE 4
**Summary of Drilling Data in Benton Township**

<table>
<thead>
<tr>
<th>Year</th>
<th>Company</th>
<th>Claim</th>
<th>Number of D.D. holes</th>
<th>Total length, metres</th>
</tr>
</thead>
<tbody>
<tr>
<td>1948/49</td>
<td>Blackstein &amp; Kanowsky</td>
<td>S40249</td>
<td>9</td>
<td>338</td>
</tr>
<tr>
<td></td>
<td></td>
<td>S40250</td>
<td>9</td>
<td>341</td>
</tr>
<tr>
<td>1976</td>
<td>W.G. Wahl Ltd.</td>
<td>P428954</td>
<td>1</td>
<td>152.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>P428951</td>
<td>1</td>
<td>152.7</td>
</tr>
<tr>
<td>1977</td>
<td>Granges Exploration AB</td>
<td>P451299</td>
<td>1</td>
<td>111.8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>P450979</td>
<td>1</td>
<td>104.8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>P450945</td>
<td>1</td>
<td>110</td>
</tr>
<tr>
<td></td>
<td></td>
<td>P450952</td>
<td>1</td>
<td>79.5</td>
</tr>
<tr>
<td>1977</td>
<td>Noranda Exploration Co. Ltd.</td>
<td>P410863</td>
<td>1</td>
<td>137.7</td>
</tr>
</tbody>
</table>

### General Geology

Metamorphosed mafic volcanic flows which at the time of writing are interpreted as high-magnesium tholeiitic basalt extend uninterruptedly throughout Benton Township and over most of Mallard Township. The mafic metavolcanics trend NW to WNW, are locally pillowed, vesicular and/or amygdaloidal, and have generally undergone greenschist rank metamorphism. Evidence of primary features, notably selvage margins of pillows, is widespread even in foliated and sheared flows. As was previously mentioned with reference to Cunningham and Garnet Townships (Siragusa 1977) the pillows have mostly lobate or irregular outlines which cannot be used for reliable top determinations. Porphyritic layers characterized by conspicuous presence of plagioclase phenocrysts are locally found in metabasalts but can not be traced laterally for significant distances owing to lack of outcrops. The groundmass of these layers is basaltic and at one locality vesicular basalt.

Narrow northwest-trending layers of variably sheared felsic, metavolcanics shown by previous mapping as metasediments (Laird 1935) are locally interbedded with mafic metavolcanics particularly in western Benton Township. These units which consist of porphyritic and/or tuffaceous rhyolite and dacite are offset by northeast-trending faults and by the intrusion of gabbro and diorite. The porphyritic felsic metavolcanics exhibit variable size, frequency and proportions of feldspar and quartz phenocrysts, and where relatively undeformed are megascopically similar to the porphyritic rocks spatially associated with the base metal bearing ironstone units in central Cunningham Township (Siragusa 1977).

A prominent northwest-trending unit of pyroclastic metavolcanics containing strongly deformed clasts consisting dominantly of porphyritic and tuffaceous rhyolite, and minor chert, is partially exposed in southwestern Mallard Township. The clasts are embedded in an aphanitic to tuffaceous groundmass of andesitic or basaltic composition. This unit is the outstanding feature of an otherwise rather monotonous basaltic sequence of the area, and in Mallard Township it has a thickness of 2400 m and a maximum ascertainable length of about 3700 m. Despite the thickness of the unit the determination of its western extent into Benton Township is problematic owing to lack of
outcrops in an extensive area along strike of the unit. Smaller lenses of pyroclastic metavolcanics similar to the main unit just mentioned were also located northeast of the latter.

Three occurrences of ferruginous chert were mapped in Benton Township. One of these is located in the northeast corner of the township, strikes northwest and has estimated maximum length and width, within Benton Township, of about 1830 and 45 m, respectively. This unit corresponds to a pronounced aeromagnetic pattern (Map 2261G ODM-GSC 1963) and is found within foliated to nearly massive and pillow basalts. Foliated to sheared metabasalt is also the host of a small northwest-trending layer of ferruginous chert found along the east bank of the Woman River in southeastern Benton Township; this second occurrence is probably the least important based upon its low aeromagnetic relief. The third occurrence consists of a west-striking layer of ferruginous chert having exposed length and width of about 5 and 1.5 m respectively, found along the north side of the Wakami River about 460 m east of the western boundary of Benton Township. It is flanked to the north by a small lens of sheared felsic metavolcanics, and a prominent aeromagnetic ridge underlies the area (ODM-GSC 1963). This ridge trends WNW and has peaks of 61 500 gammas in the Yarwood Lake area of Cunningham and Garnet Townships, and of 60 500 gammas in central Benton Township where it ends abruptly. It has been previously suggested that the unit of ironstone and associated ferruginous chert of the Yarwood Lake area may extend considerably to the southeast (Siragusa 1977). The location of the Wakami River chert occurrence lends support to this possibility and suggests that this unit may extend, although intermittently and with variable thickness, as far east as Benton Township, a distance of about 16 km. From field evidence observed in Garnet Township (1977) the intermittent character of the unit is explained by its partial obliteration by intrusions of diorite and gabbro; however this is also the case for the cherty units in central Cunningham Township for which a potential 1.0 million t of 1.2 percent copper and 1.28 percent zinc mineralization has been indicated (Siragusa 1977, p.92).

Mafic intrusive rocks in bodies of irregular shape and variable size which display quasi-concordant intrusive relationships with respect to foliation in the metavolcanics, and which contain xenoliths of the latter, are locally found within and marginal to the metavolcanics. These rocks comprise types varying in textural and compositional features which were mapped by empirically subdividing them into two broad dioritic and gabbroic categories. As the distinction of domains of Middle to Late Precambrian diabase within unmetamorphosed mafic intrusive rocks is problematic, the gabbroic category may include rocks of widely different ages. The largest mafic intrusion found in the map area is an elongated northwest-trending, dominantly dioritic body located in the eastern half of Mallard Township. This body is about 6.8 km long, has average width of 1.3 km, contains large deformed xenoliths of metabasalt, and tuffaceous rhyolite, and is in contact to the southwest with basalt underlying central Mallard Township; and to the northeast with the regional granitic rocks.

Ultramafic rocks are also present as a few outcrops of peridotite located in northwestern Benton Township; no peridotite occurrences were found in Benton and Mallard Townships.1

The regional granitic rocks underlie the northeast corner of Mallard Township and are, as a whole, poorly exposed. They consist of biotite potassic types (i.e. granodiorite, quartz monzonite), contain a little hornblende as groundmass component and/or inclusions close to the largely inferred contact with the metavolcanics and the diorite body just mentioned, and are intruded by diabase. Very minor granitic intrusions are also found in a few localities within the volcanic belt.

Structural Geology

The trend of metamorphic foliation in the metavolcanics varies from WNW in Benton Township to NW in Mallard Township where it parallels the granite contact. The dips are commonly subvertical or steep to the south and the strain is larger in the felsic rocks, particularly those with primary heterogeneous fabrics (i.e. porphyry, tuff, lapilli-tuff). The outcrop pattern and the structural features of a few occurrences of felsic metavolcanics in western Benton Township indicate the presence of a small fault in this area, and owing to the thick overburden which veeners the latter, the fault can not be inferred from evidence other than the offset in the felsic units intersected by it. The fault trends NNW and is normal to the trend of foliation and shearing in the metavolcanics. Similar relationships may exist in other parts of the present map-area and are well documented in Cunningham Township where they indicate that faulting along northerly directions post-dated the emplacement of granite within the metavolcanics at the southern margin of the Swayze belt. The scarcity of outcrops in the present map-area, the lack of reliable top indicators in the metavolcanics, and the intensity of deformation in the basaltic and pyroclastic metavolcanics in southern Mallard Township prevent, at the time of writing, formulation of valid general statements on folding and stratigraphy of the area.

Economic Geology

The drilling carried out by N.A. Timmins Corporation on the Ferland-Gauldie-Mogridge property (see "Mineral Exploration, Mallard Township") intersected a 3 m section yielding an average 3.77 ppm of gold; selected grab samples (collected by H.C. Laird) of mineralized schist from the surface yielded from 0.34 to 3.77 ppm of gold, and from 49 to 166 ppm of silver (Laird 1935, p.25). A

1 The log of the drill hole by Noranda Exploration Company Limited in claim P410863 (see Table 4) indicates the presence of peridotite under 10.6 m thick overburden at one locality of western Benton Township.
selected grab sample collected by Laird from a pit located 15 m south of the main shear zone on the Woman River Gold Mines property yielded 6.51 ppm of gold (Laird, 1935, p.28). H.C. Rickaby (in Laird 1935, p.28) reported that two grab samples from the Hermiston-Hammerstrom property assayed 7.19 and 9.59 ppm gold. A selected grab sample collected by Laird from the Maltby property yielded negligible gold values and a trace of silver (Laird 1935, p. 28).

The drilling logs from Benton and Mallard Townships (see Tables 2 and 4) show that although minor disseminations and/or stringers of one or more of pyrite, pyrrhotite, magnetite and hematite with or without traces of chalcopyrite and/or sphalerite are not uncommon in the metavolcanics underlying the tested areas, nothing of economic significance has apparently being intersected. However, assay data on sulphide mineralization, if any, are not found in the records.

References

Laird H.C.

ODM-GSC

Siragusa G.
No. 14  Hemlo Area, District of Thunder Bay
T.L. Muir

Location
The Hemlo Area is almost 415 km² in area and is bounded by Latitudes 48°33'N and 48°45'N and Longitudes 85°52'30"N and 86°07'30"W. Most of Lecours and Bomby Townships (formerly Townships 74 and 73 respectively) and a small part of Cotte Township (formerly Township 75) are contained within the boundaries of the area. The remainder of the area is unsurveyed territory. Highway 17 (Trans-Canada Highway) and the Canadian Pacific Railway both run east-west across and provide access to the northern third of the area. Hemlo, a former pulp and paper, and railroad settlement is located central to the area and lies less than 1.5 km south of Highway 17, being approximately 350 km from Thunder Bay and 430 km from Sault Ste. Marie by road. Most of the remaining part of the area can be reached by float-equipped airplanes on several relatively large lakes, by canoe on parts of the Black and White Rivers, or by helicopter.

Mineral Exploration
Although limited exploration in the surrounding areas to the west was carried out as early as the 1870s, the first assessment work recorded for the Hemlo area was in 1945 (which probably reflects accessibility problems) although reference was made by Bartley and Page (1957) to work carried out in the early 1920s by J. Lecour on a gold prospect near Hemlo. In 1945 a group of 11 claims near Cedar Creek and Highway 17 was staked, stripped, and trenched by Messrs. Ollmann and Williams. Follow-up drilling (15 holes of unknown length) of a shear zone that gave low gold values returned a maximum value of 5.5 ppm Au over 1.1 m.

Although reference is made to work in 1944, the first work recorded on the area was done in 1945 on a group of 33 claims (which adjoined the Ollmann-Williams group) held by Lake Superior Mining Corporation Limited. Drilling carried out by this company from 1947 to 1959 totalled approximately 3656 m (The Northern Miner, p.26, Nov 8, 1973) and returned low gold values from sheared, feldspar porphyry dikes that vary in thickness from 0.6 to 60 m. A group of nine claims lying just east of the Lake Superior Mining Corporation Limited property was staked in 1947 and held by W.M.C.Thoms. Some stripping and trenching was undertaken and rock samples collected returned low gold values.

In 1973, Ardel Explorations Limited staked 12 claims which covered part of the ground previously held by Lake Superior Mining Corporation Limited. Diamond drilling was undertaken in 1973 but the results did not outline a significantly larger body than previously indicated (see "Economic Geology"). Further work was not recorded.
In 1977, R.G. Newman held a block of eight contiguous claims which lie north of Rule Lake (near Highway 17) and to the west of and approximately along strike from the claims originally held by Lake Superior Mining Corporation Limited. An electromagnetic survey revealed no interesting conductors. A geochemical soil survey for several elements pinpointed one highly anomalous (single-station) gold value and a small area (underlain by feldspar-quartz porphyry) for potential further work.

Reference was made to the Hemlo occurrence (Lang 1952) on the gold property held by Lake Superior Mining Corporation Limited in 1949 that gave mildly anomalous total radioactivity values from five, parallel radioactive zones. A more exact reference to the location could not be found.

In 1965, Keevil Mining Group (under R.M. Butler, Barrett option) undertook airborne magnetic and electromagnetic surveys over parts of the southern metavolcanic-metasedimentary belt largely in the Heron Bay map-area but extending about 2 km into the Hemlo Area. Several magnetic anomalies were outlined (which are probably the result of the presence of ultramafic rocks, but no ground follow-up was recorded.

In 1975, Noranda Mines Limited held two groups of claims, a 31 claim group immediately north-northwest of Rous Lake, and a four claim group about 5 km west of the former. Magnetometer and electromagnetic ground surveys were undertaken on both properties and a few small discontinuous conductors were outlined. One relatively long, narrow conductor on the second claim group was investigated and interpreted to be the result of a fault. Follow-up work in 1976 on a four-claim group north-north-east of Rous Lake outlined a few small anomalies that were not investigated further.

General Geology

Approximately half of the Hemlo map-area was mapped in 1930 by Thompson (1931) as part of a much larger area, at which time he outlined the ‘greenstone’-’granite’ contacts. Subsequently published compilation maps (P 494, P. 541, and Map 2220) incorporated some significant changes in these contact positions which could not be corroborated by the present mapping survey. The Hemlo area lies adjacent to the east boundary of the Heron Bay map-area which was mapped by Muir and Barnett (1977). Approximately 60 percent of the area is underlain by granitoid rocks that can be subdivided into four batholiths, none of which lie entirely within the map-area. The remainder of the area is underlain by Early Precambrian metavolcanics and metasediments except for some Middle to Late Precambrian subalkalic diabase and alkalic (?) lamprophyre dikes. Preliminary investigations suggest that the rocks have undergone medium-grade metamorphism as defined by Winkler (1976).

The metavolcanics lie in two, east to east-northeast trending belts. The southern metavolcanics are a continuation of the belt that extends from Lake Superior, about 13 km to the west to Mussy Lake in the east where it termi-nares. The rocks consist mostly of amphibolitized tholeiitic mafic flows. Minor amounts of thinly bedded intermediate to felsic calc-alkaline tuff lie along the northern edge of the belt or are intercalated locally. Minor ultramafic rocks (herzolite and hornblendite) and related gabbro occur as sills in the western part of this belt and represent a continuation of a ‘zone’ of numerous sills discovered in the Heron Bay area to the west (Muir in preparation, Muir and Barnett, in press). In the Hemlo area they show strong magnetic contrast with other rock types (ODM-GSC 1963).

The northern belt broadens from west to east and extends from the Heron Bay map-area across the Hemlo map-area, paralleling Highway 17. It consists mostly of poorly bedded to well laminated (thin) intermediate to felsic calc-alkaline tuff and lapilli tuff with minor amounts of pyroclastic breccia and intercalated argillite, siltstone, ironstone, and wacke. The small proportion of pyroclastic breccia to tuff (compared to the Heron Bay area) as well as other field relations suggest that these rocks are distal deposits from a source that was most likely centred in the area ranging from Heron Bay to Lake Superior (offshore). Most of these rocks are composed of water-deposited material and could be interpreted as sediments. However, nomenclature restraints and an attempt by the writer to distinguish between erosional material and air-borne tuff deposited in water have resulted in the use of pyroclastic terms. Pillowed and variolitic mafic flows of various degrees of amphibolitization are present, particularly along the Highway 17 section.

The southern third of the area is underlain by the Puskawa Gneissic Complex which consists of foliated to massive, quartz diorite to granodiorite as well as some quartz monzonite. These rocks vary considerably in texture on a large and small scale and in mafic mineral content (generally hornblende predominant) and locally are cut by relatively few pegmatite and aplite dikes. Large xenoliths of mafic to intermediate composition are found locally. Some amphibolitized mafic to intermediate (volcanic and sedimentary) migmatises are located south of Hayward and Herrick Lakes in a poorly defined narrow belt trending northeast to east-northeast. The west-central part of the area is underlain by the Heron Bay Batholith which consists mainly of massive, medium-grained, biotite-hornblende granodiorite. The rocks are locally foliated and locally contain potassium feldspar phenocrysts. Sparse, small, mafic inclusions are locally present. The northwest part of the area is underlain by the Pic Batholith which consists mainly of massive to linedated, medium-grained, hornblende quartz monzonite with about equal proportions of potassium-feldspar porphyritic phases and equigranular phases. Small mafic inclusions are commonly present and are locally abundant. The northeast part of the area is underlain by the Cedar Lake Batholith which consists mainly of massive, medium-grained, biotite hornblende granodiorite, not unlike the rocks of the Heron Bay Batholith. The Cedar Lake Batholith is poorly exposed and a good approximation of its extent in the map-area could not be made.

Tholeiitic diabase dikes cut all of the Early Precambrian rocks and generally trend north, northeast or north-
west. Thicknesses range from less than a metre to 60 m. A few, small, Late Precambrian lamprophyre dikes were located; some contain biotite phenocrystals, others have olivine and/or pyroxene phenocrysts. The dikes may be related to the Port Coldwell Alkaline Complex which lies to the west.

Bedrock exposure in much of the area is fair to poor. Many outcrops do not show on air photographs due to the extensive deciduous tree cover in some areas; these outcrops are small and commonly consist of vertical, moss covered faces. A significant proportion of other outcrops are largely covered by a layer of soil and grass or moss and lichen. Many of the larger lakes have some good shoreline exposure. Locally relief is moderately rugged and changes rapidly in the order of 60 m or so. The Black River valley is filled with glaciofluvial sand, silt, and clay deposits that have been dissected by tributaries and streams. Rock exposure in the valley is nil over large areas. These deposits would restrict the effective use of ground geophysical surveys in many cases.

Structural Geology

The overall structure of the area appears to be relatively simple although sparse critical information was obtained. In the northern, east to east-northeast trending metavolcanic-metasedimentary belt beds are generally steeply north-dipping although steep southerly dips are locally present. Exposure along Highway 17 is locally very good but in no case could a top direction be conclusively determined. A minor, overturned, synformal structure is present in the east part of the area and is exposed on Highway 17. This could not be related to any larger scale structures. Pillows are uncommon and are too deformed for top determinations. In the southern east-trending belt, bedding is either absent (the belt is mostly composed of flows) or not positively recognizable due to the degree of amphibolitization.

Foliation, and bedding where present, are generally concordant with the outlines of the granitic batholiths. Foliation within the batholiths, and to a lesser extent in the Pukaskwa Gneissic Complex is largely restricted to the marginal zones of each batholith (being widest in the gneissic complex) and is generally concordant to the batholith outlines in the immediate contact zone. Further from the contacts in the Pukaskwa Complex gneissosity and foliation are commonly shallow dipping and in many cases the fabric approximates a lineation rather than a foliation.

Numerous lineaments are present throughout much of the area. A major north-trending lineament extends from the west end of Hayward Lake to north of Cache Lake. Several east-trending, subparallel lineaments are present in the volcanic rocks of the northern belt from Cache Lake to beyond the east boundary of the map area. They appear to be parallel to bedding for the most part. ERTS (Earth Resources Technology Satellite) images show that the Heron Bay lineament extends eastward into the Hemlo Area, and passes north of Rous Lake to a point north of Hemlo where its identity is lost.

Economic Geology

Exploration for gold has been the main interest in the Hemlo map-area. Numerous showings of pyrite-bearing zones and feldspar porphyry dikes have been tested and have returned very low gold values for the most part. Minor occurrences of pyrite, pyrrhotite, sphalerite, chalcopyrite, tourmaline, gold, and silver were reported near Highway 17 between Hemlo and Cedar Creek (Bartley and Page 1957). The most noteworthy occurrence comprises a number of pyrite-bearing feldspar porphyry dikes located north of Highway 17 about 2 km west of the east border of the map-area near Cedar Creek. This area has held the interest of several exploration companies from about 1944 to the present. The current figures reported in the assessment files which are a compilation of drilling results give an average of 7.20 ppm Au across 2.2 m over a strike length of 370 m for 12 shallow holes, and 7.54 ppm across 1.7 m over a strike length of 120 m for seven deeper holes. Calculations reported in the assessment files show that the mineralized body would be about 150 000 t at 7.20 ppm Au above 18 m (The Northern Miner, Feb. 14, 1974, p.9). The mineralization is within metasediments and is associated with feldspar porphyry dikes in a shear zone which has been traced for over 460 m, with a variable strike ranging from N68W to N64W and dipping an average of 62° north.

Several rusty gossan zones are well exposed along Highway 17. One lies to the east of the gold occurrence described above and is in garnet-staurolite-mica schist (metasediment). The garnets are not of industrial grade. Other numerous, small, rusty-weathering, pyrite-bearing zones occur throughout the rest of the Hemlo area. Samples from a number of the gossans returned negative values of Au, Ag, and base metals. A few small specks of molybdenite were found in a poorly exposed amphibolitized rock just north-northwest of Mussy Lake but the mineralization observed was minor and the host rock character uncertain.

Judging from known occurrences and past exploration activity the best prospects for exploration particularly in relation to gold probably lie within a zone that parallels Highway 17 for about 1.5 km on either side.

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Winkler, H.G.F.
No. 15 Grey Owl Lake Area, District of Algoma
E.C. Grunsky

Location

The Grey Owl Lake map-area is bounded by Latitudes 47°15' to 47°22'30", Longitudes 84°05'00" to 84°19'00" and is located in the District of Algoma approximately 90 km north of Sault Ste. Marie. The map-area is approximately 250 km² and includes parts of Loach, McAughhey, McParland, Runnalls, Raflaub, and Running Townships. Access is possible by float-equipped aircraft, via the Montreal River reservoir which divides the map-area from east to west. Access into many of the smaller lakes such as Doyle, Dyer and East Lakes, requires the use of a helicopter. The map-area is also accessible by boat from Montreal Falls, at the west end of the Montreal River reservoir, approximately 11 km from the west end of the map-area boundary. Montreal Falls can be reached via the Algoma Central Railway at mile 92 (kilometre 148) or by a private road maintained by the Great Lakes Power Company which is approximately 14.5 km from Montreal Falls to Highway 17.

Mineral Exploration

The earliest record of mineral exploration in the map-area dates back to approximately 1950 when J.E. Gimby located a uranium occurrence in the southwest corner of McAughhey Township. Two samples submitted by Gimby are reported to have contained 0.063 and 0.081 percent U₃O₈. No further work has been reported on this occurrence since that time.

In 1953, the Jalore Mining Company Limited conducted an airborne magnetic survey over several townships in the Batchawana area including the present map-area. Ground follow-up of magnetic anomalies revealed the presence of banded ironstone and numerous diabase dikes throughout the area. No further work was reported.

In 1956, Technical Mine Consultants performed an airborne electromagnetic and magnetic survey over seven townships controlled by the Algoma Central Railway including Running and McParland Townships. No ground work was performed on these townships within the present map-area boundary.

During the early 1960s the Algoma Central Railway had F.R. Joubin and Associates Limited investigate the map-area in an attempt to locate base metal deposits. Regional geological, geophysical, and air photo interpretation maps were prepared and are available from the Assessment Work Files of Algoma Central Railway in Sault Ste. Marie. Rio Tinto Canadian Exploration Limited, through H.O. Seigel and Associates Limited took an option on the
Algoma Central Railway project and commenced work throughout the area. Loach, Raflaub, McParland, and Running Townships are part of the Algoma Central Railway land grant and no claims were staked on occurrences located in these townships at that time. McAughey and Runnalls Townships are held by the Crown and 107 claims were staked in these townships within the present map-area. An airborne electromagnetic and magnetic survey was carried out by Rio Tinto Canadian Exploration Limited followed by geological mapping, trenching, and ground geophysics over 15 conductors located on Algoma Central Railway lands and Crown land claim groups. Minor sulphide mineral occurrences were located within metasediments and felsic metavolcanics, mostly around the Doyle Lake area. Assay results for copper, zinc, lead, silver, and gold were low and no drilling was performed.

In 1966, Canex Aerial Exploration Limited, in an option with the Algoma Central Railway, diamond drilled a 50 m hole in a conductor approximately 1800 m north of Doyle Lake. The conductor consists of graphite with minor sulphides and assay results were nil. No further work was performed by the Algoma Central Railway on its properties within the present map-area and the claim groups on Crown land were allowed to lapse.

In 1974, Asarco Exploration Company of Canada Limited conducted an airborne geophysical survey in an area to the east which included Running Township. Ground follow-up work resulted in seven trenches and one drill hole within mafic metavolcanics however, all of the conductors examined are east of the present map-area boundary.

In 1975, Geophysical Engineering Limited investigated two sulphide mineral occurrences east and south of Doyle Lake. Geological mapping, trenching and drilling are reported on both occurrences consisting of four claims each. The occurrence east of Doyle Lake consists of three sulphide mineralization zones intersected by a diamond drill hole at a depth of 10, 16 and 20 m and varying from 0.3 to 2.0 m in width. Assay values of copper, lead, zinc, and silver from these zones were very low. The occurrence south of Doyle Lake consists of a sulphide mineralization zone in tuffaceous felsic metavolcanics in which a 37.5 m hole was diamond drilled. A sulphide zone about 3.0 m wide was intersected which yielded very low copper, zinc, and silver values. No further work was reported and the claims were allowed to lapse.

No work is presently being carried out in the map-area.

General Geology

The Grey Owl Lake area consists of an Early Precambrian (Archean) metavolcanic-metasedimentary sequence within the Batchawana belt of the Superior Province that has been deformed, metamorphosed and intruded by later quartz monzonite stocks and plutons. Part of the map-area was first mapped by Moore (1925) during a general geological survey of the Missisagi Reserve and the Goulais River Iron Range. McAughey, Runnalls, McParland and Running Townships were covered and most of the supracrustal rocks were mapped as a variety of metasediments. The supracrustal sequence is a continuation of a metavolcanic-metasedimentary sequence that extends southward and has been mapped by Siragusa (1975, 1976) and Grunsky and Arengi (1977). The area has also been covered by regional mapping done by the Algoma Central Railway which includes magnetic, electromagnetic, air photo interpretation, bedrock geology, and Pleistocene geology maps which are available from the Algoma Central Railway office in Sault Ste. Marie.

The map-area can be divided into two distinct regions: an Early Precambrian felsic intrusive complex comprised of migmatite and trondhjemite, and a supracrustal succession that has been deformed, metamorphosed, and intruded by later quartz monzonite stocks and plutons.

The lowest unit of supracrustal rocks is a mafic to intermediate metavolcanic sequence of flows with intercalated metasediments occurring along the shore of the Montreal River, striking east, dipping subvertically to the south, and thickening eastward past the map-area boundary. In the west part of the map-area the surface width of the sequence is less than 500 m but increases to a width of at least 1300 m in the east part of the map-area. The mafic to intermediate metavolcanics consist of fine to coarse grained hornblende-plagioclase schist in which most primary features have been obliterated due to deformation and recrystallization. The associated interflow metasediments consist of thin units of biotite-hornblende-plagioclase schist (wacke) derived from the metavolcanics. In the southeast corner of McAughey Township, a locally discontinuous sequence of interbanded mafic to felsic ironstone and chert occurs within the metavolcanics.

In the southwest corner of the map-area a sequence of mafic to intermediate metavolcanics, interflow wacke, and conglomerate form part of a small synform which is probably tectonically derived by the intrusion of the Grey Owl Pluton. Siragusa (Geologist, Ontario Geological Survey, 1978, personal communication) reports that some of these mafic metavolcanics are komatitic in composition.

Overlying the mafic to intermediate metavolcanics, in the east part of the map-area, is a sequence of fine-grained banded quartz-plagioclase-muscovite schist that has been interpreted by the author as felsic to intermediate tuff. This sequence strikes east to southeasterly, dips subvertically to the south, and is approximately 1600 m wide in the east part of the map-area, thinning westward. Westward the tuff grades into and is interbedded with wacke and conglomerate. The lowermost felsic metavolcanic units are primarily composed of lapilli tuff, crystal tuff and ash tuff. Due to lack of outcrop, recrystallization, and deformation, felsic flows can not be distinguished from the fine grained tuff. The tuff grades upward (southwestward) and westward into metasediments that have been derived from tuff, with an increasing frequency of wacke and pelitic interbeds which represents a facies change from a pyroclastic to epiclastic derivation of the units.
The epiclastic rocks extend from the southeast corner of the map-area (Doyle Lake) westward as far as the western boundary of the map-area. In the Doyle Lake area the metasediments are a sequence of thinly bedded quartzite, arkose with minor wacke and mudstone interbeds. These metasediments strike northwesterly towards the Montreal River where the strike changes to a westerly direction. Westward the metasediments grade into wacke and conglomerate and grade up sequence into finer-grained biotite-quartz-plagioclase-hornblende schist. The metasedimentary sequence is approximately 3200 m wide in the central portion of the map-area, thinning southeastwardly where it grades into the felsic pyroclastic rocks. In the west part of the map-area the sequence exhibits irregular strikes and dips in the bedding. This may be due to the presence of an underlying near-surface quartz monzonite intrusive complex that occurs as small stocks throughout the west part of the map-area.

Massive felsic intrusive rocks south of the Montreal River consist of granodiorite to quartz monzonite stocks and plutons that occur in the central and west portions of the map-area. Numerous small stocks occur west of Dyer Lake and north of Alvin Lake, representing a complex of quartz monzonite, granodiorite, and syenodiorite that has intruded the metasediments. The Grey Owl Pluton is a larger body of porphyritic and non-porphyritic quartz monzonite that has intruded the metasediments. The quartz monzonite-granodiorite-syenodiorite complex, north of Alvin Lake, may partially reflect assimilation of the supracrustal sequence or differentiation of the felsic intrusion itself.

North of the Montreal River the felsic complex consists of foliated to gneissic trondhjemite that grades into a migmatitic complex. The paleosome of the migmatitic rocks is predominantly a biotite-quartz-plagioclase gneiss, and the neosome is typically a quartz-plagioclase-microcline coarse-grained assemblage. The migmatite is highly variable in its occurrence, ranging from metatexite near the supracrustal rocks, to diatexite (Mehnert 1968, p. 270) towards the trondhjemitic masses. The variety of migmatites reflects progressive anatexis away from the supracrustal rocks into the trondhjemitic complex. Pegmatitic dikes and pods are common throughout the migmatitic assemblage.

Porphyritic and non-porphyritic quartz diabase dikes occur throughout the supracrustal and felsic intrusive rocks. The dikes are commonly 10 to 20 m across although some were observed to be up to 200 m across. The larger dikes form high ridges in the area and are aeromagnetically distinct. The porphyritic and non-porphyritic phases can be observed grading into each other and are of the same magma source. The trend of the dikes appears to be structurally controlled, striking N30W. This direction corresponds to the regional foliation and faults, respectively, in the map-area.

### Metamorphism

Regionally, metamorphism varies from low grade (upper greenschist) to high grade (upper amphibolite) facies (Winkler 1976, Miyashiro 1973). The mafic metavolcanics are hornblende-plagioclase schists and the more pelitic metasediments are characterized by biotite-garnet, biotite-hornblende, and biotite-staurolite assemblages.

Anatexis of the supracrustal rocks occurs north of the Montreal River, and high grade metamorphism south of the Montreal River is in part the result of contact metamorphic aureoles around the numerous quartz monzonite stocks and the Grey Owl Pluton.

### Structural Geology

South of the Montreal River the supracrustal rocks are characterized by a well developed schistosity, locally gneissic in places, whereas north of the Montreal River a pronounced gneissosity occurs within the migmatitic assemblage. The trondhjemitic masses contain a vague to pronounced foliation striking approximately east.

South of the Montreal River the schistosity strikes easterly and wraps around the Grey Owl Pluton to a strike of N30W in the Doyle Lake area. Field evidence indicates that the Grey Owl Pluton intruded by deforming the supracrustal rocks, rather than assimilating them.

The dip of the foliation in the supracrustal rocks throughout most of the map-area is nearly vertical or steeply dipping to the south with an exception northwest of Union Lake. In this area, the bedding and schistosity is irregular and it appears that the supracrustal rocks are draped over an underlying felsic intrusive complex.

Foliation and bedding were observed to be parallel in outcrops where these features could be examined; however, this may not apply everywhere within the map-area. East of Alvin Lake a synform occurs in the mafic to intermediate metavolcanics with intercalated wacke and conglomerate. Top determinations from graded beds in the metasediments south of the Montreal River indicate tops are to the south. Flow top determinations from the mafic to intermediate metavolcanics in the east part of the map-area indicate tops are to the south as well.

The Montreal River is an expression of late faulting, closely coinciding with the intrusion of the diabase dikes. The fault varies from easterly to northeasterly in strike and is actually a series of en-echelon fractures. Numerous faults trending N30W occur throughout the felsic intrusive complex north, and the supracrustal rocks south of the Montreal River. Many of these faults appear to have little or no displacement along them, and in fact may be sheared fractures related to the development of the Lake Superior basin.
Economic Geology

There are no past or present mineral producers in the Grey Owl Lake area. The area hosts a variety of mineralization in minor quantities which include: uranium, base metals, gold, silver, and iron.

An occurrence of uranium was discovered in the southwest corner of McAughey Township, just north of the north shore of the Montreal River, around 1950 by J.E. Gimby. Two samples were assayed at that time; one from a pegmatite at 0.063 percent U3O8, and one from a biotite gneiss at 0.081 percent U3O8 (Source Mineral Deposit Records, Ontario Geological Survey, Toronto). No further information was recorded and presently it is an unclaimed parcel of land. During the course of field work the author located additional radioactive areas, using a scintilometer, along the Montreal River fault. Readings up to 30 times normal backround were encountered in biotite schist near the supracrustal granitic boundary, and a grab sample was submitted for assay (results not received at time of writing). The width of this radioactive zone along the Montreal River fault is unknown however, isolated pockets occur along the fault for a length of about 2000 m.

The supracrustal rocks of the map-area are cut by numerous quartz veins, most of which are barren. Two grab samples of quartz veins collected by the author during the field season showed only trace amounts of gold or silver. Other grab samples are still awaiting assay. In the early 1960s quartz veins were routinely examined by the Algoma Central Railway exploration project however, none proved to show any significant amounts of either metal. In a conductor south of Doyle Lake, Rio Tinto Canadian Exploration Limited reported 0.69 ppm gold (SSM File 638, Regional Geologist’s files, Ontario Ministry of Natural Resources, Sault Ste. Marie) in a pyrite-pyrrhotite zone, striking northwesterly, dipping 40 to 70 degrees northeast, within metasediments. The dimensions of the zone are not given. Other conductors that were examined failed to indicate gold in excess of 0.3 ppm. Geophysical Engineering Limited, in 1975, diamond drilled two holes east and south of Doyle Lake and assay results for gold were less than 0.15 ppm and less than 1.4 ppm for silver.

Several base metal occurrences in the form of sulphide mineralization occur within the map-area, however, none to date are of economic significance. Most base metal exploration in the map-area occurred in the early 1960s when the Algoma Central Railway covered the area. Three occurrences of minor significance in the Doyle Lake area, were the only occurrences examined in any detail. Rio Tinto Exploration Limited under an option with the Algoma Central Railway in 1964 reported 0.3 percent copper over 8 m and 0.12 percent copper over 6 m in one trench from three conductors that were examined north of Doyle Lake. Subsequent drilling of an anomaly 1800 m north of Doyle Lake, by Canex Aerial Exploration Limited in 1966, indicated minor pyrrhotite and pyrite in graphite as the cause of the anomaly. East of Doyle Lake, Geophysical Engineering Limited diamond drilled a hole 40 m in length in a sulphide showing in 1975 and intersected 0.01 percent copper and 0.01 to 0.02 percent zinc over four zones, all less than 1.0 m thick. In the same year, south of Doyle Lake, Geophysical Engineering Limited diamond drilled another hole 37.5 m long into a sulphide zone yielding less than 0.01 percent copper and 0.012 to 0.021 percent zinc over approximately 2.0 m.

Iron occurs as interbanded magnetite ironstone and chert in the southeast corner of McAughey Township. The geophysical expression of this unit extends eastward from the Montreal River into McParland Township for a length of about 6 km and appears to be discontinuous either through lenticular deposition or through tectonic dislocation. Only isolated outcrops were observed in the field and the ironstone thickness could not be determined. It is probably at least 50 m thick with many interbedded metavolcanic flows and clastic units. A 2.0 m rusty zone with some pyrite has been reported south of the west part of the ironstone, in the mafic metavolcanics. This unit has never been drilled or thoroughly investigated.

The north shore of the Montreal River, particularly in the southwest part of McAughey Township, requires further work to outline the extent and nature of the radioactivity that is present. Further examination of the sulphide zone south of the ironstone in McAughey Township may be warranted.

References

No. 16 Lake Matchinameigus Area, District of Algoma

M.J. Downes

Introduction

The centre of the map-area is located some 50 km northeast of Wawa, and covers an area of 236 km². It lies within the Sault Ste. Marie Mining Division and is bounded to the west, north and east by the boundaries of Dolson Township (formerly Township 25 range 25) and Echum Township (formerly Township 43), and to the south by Latitude 48°05'5. Topography is flat to moderately hilly with elevations around 360 m, the highest point being 575 m. Within the eastern Township of Echum, access is good from Highway 651, the main Canadian Pacific railway, and Lakes Matchinameigus and Shikwamka. Within the western Township of Dolson access is more difficult because there are no roads or waterways. Two Lakes, Noranda and Dingham can be reached by float-equipped aircraft from Wawa. The remainder of the area is accessible by helicopter, where lakes are too small for access by fixed-wing aircraft.

Minor Exploration

During the 1890s the then Michipicoten Mining District was bustling with prospectors in search of gold (Willmott 1898). Though gold has been actively investigated in that area in more recent years the present map-area has received little attention. A gold showing in Echum Township was trenchcd and sampled by J.P. Davies in 1973 (SSM 1696) but remains untested by drilling. Two major periods of base metal exploration occurred, in the late 1950s and in the late 1960s. In 1955 MacFie Exploration Limited, diamond drilled five holes totalling 280.6 m, within the metavolcanics in the south-central part of Dolson Township, of which the best intersection returned 0.07 percent copper and 0.03 percent nickel over 2 m (SSM 2392). In 1956 Belmine Exploration Limited contracted G.G.I. Surveys to cover nine 16 ha claims located in the north-central portion of Dolson Township with 12.8 line km of resistivity survey, and immediate follow-up of five diamond drill holes totalling 620.4 m (SSM 236). No significant sulphide mineralization was found, and the major conductors were a zone containing magnetite ironstone and some disseminated pyrrhotite zones.

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An airborne magnetometer and electromagnetic survey done by McPhar Geophysics Limited for Frobisher Limited, in 1956 covered 36 line km over a 72-claim group in central Dolson Township. Subsequent diamond drilling of seven holes totaling 900 m in 1956 and a further seven holes totaling 332.1 m in 1957 was done by the Hopkins group for Frobisher Limited. (SSM 2381). None of their drilling gave encouragement to do further work. Again ironstones were the main conductors intersected.

In 1966 Multi-Minerals Limited drilled a total of 81.7 m in four holes in the same area as MacFie, but nothing of economic interest was reported (SSM 11301). It appears that they were drilling geophysical anomalies whose nature is unrecorded. One of these holes (AW-1) was drilled over 67 m entirely within carbonates.

Questor Surveys Limited conducted an airborne magnetometer and INPUT electromagnetic survey for the Ontario Syndicate in 1970. They covered 1900 line km over much of Echum and part of Dolson Townships. Subsequent ground geophysical follow-up of vertical loop electromagnetic and magnetometer surveys for the Ontario Syndicate covered 14 line km over 14 claims in the east-central portion of Dolson Township. Coincident magnetic and electromagnetic anomalies occurred over the same area that was previously drilled by Belmine Exploration Limited. Though these areas were delineated for drilling, none were tested (SSM 16391).

**General Geology**

Metavolcanics, metasediments and granitic plutonic rocks of Early Precambrian age (Archean) comprise the bedrock of the area. These are intruded by Early to Late Precambrian lamprophyre plugs and dikes and numerous diabase dikes. Metamorphic grade is generally upper greenschist to lower amphibolite facies. A Pleistocene cover principally made up of sands and gravels is moderately thick (20 m) in the area of Echum Township. Bedrock exposure is about 20 percent.

A prominent feature within the east-trending metavolcanic-metasedimentary belt is a fairly continuous but thin ironstone-bearing member which gives a strong response on the regional aeromagnetic map (ODM-GSC 1962). This member occurs at the stratigraphic interface of mafic metavolcanics and overlying metasediments and felsic metavolcanics, on the southern limb of a major synclinal fold which characterizes the belt. A very weak magnetic expression at the same stratigraphic level on the northern limb is interpreted by the author as indicating the presence of the same unit. Where best developed the unit is 15 m thick and consists of banded (about 1 cm wide) sucrosic quartzite and magnetite with rare sulphide minerals (siderite facies is absent).

The basal mafic metavolcanic sequence in the southwest of the belt is unusual in that it contains interbeds of quartzite and wacke, and is capped by a bedded limestone or dolostone unit which is exposed over 1500 m strike length and 50 to 100 m thickness. Fine grained intermediate to felsic tuff and metasediments characterize the uppermost portion of the stratigraphy in the core of the syncline.

Foliated gabbro occurs within the basal portion of the mafic metavolcanics in the northern part of the belt and correlates with a low to moderate response on the aeromagnetic map. Strong magnetic anomalies are associated with isolated plugs and dikes of lamprophyre within both the supracrustal rocks and granitoid gneisses.

Non-foliated granitic rocks to the north of the belt (Murray Lake granite) are characterized by a potassic composition and the presence of $\beta$-quartz. Granitic rocks of similar composition, but weakly foliated occur in the southwest. Well banded trondhjemite gneiss forms much of the southern margin of the belt with the development of a 100 to 300 m wide (hybrid) diorite zone along the margin, which is in parts agmatitic.

**Structure**

The metavolcanics and metasediments form an east-trending synclinal belt the axial trace of which has the configuration of a V, closing to the south. The western arm is 12 km across whilst the eastern arm is only 3 km wide. The greater width in the west is in part due to shallow dips of 30° to 60° to the northeast compared to near vertical dips for the rest of the belt. The higher proportion of metasediments within the mafic metavolcanics in the western part is a contributory factor.

Several lineaments, some of which define faults in the area trend N45E and north. Observed faults appear to have small associated displacements.

**Economic Geology**

**Gold**

The gold showing on Ballard Lake (Echum Township) occurs within a quartz vein 30 to 40 cm wide over 300 m, and striking N40W. It lies within the mafic metavolcanics close to the contact with the Murray Lake granite. Sampling (grab?) by J. Davies (SSM 16961) returned assays of 42.86 ppm gold and 267 ppm silver. The property is currently covered by three claims (G. Longhurst) and no drilling has been done.

A similar quartz vein striking N85W is reported (R.G. Hailes 1955 - SSM 18161) to occur on the southern contact of the belt along Sleeth Lake in Echum Township. It hosts scheelite mineralization and low gold values have been reported, however no assays are available and the showing could not be located by the present survey.

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**Base Metals**

Drilling by MacFie Exploration Limited, (1955) and Belmine Exploration Limited, (1956) centred mainly on magnetic and electromagnetic anomalies associated with the ironstones, but nothing of economic interest was reported. The association of quartz-magnetite generally lacks sulphide mineralization. The fine grained nature of the felsic metavolcanics suggests they are possibly of distal character relative to central volcanism and this may be a less likely host of large sulphide deposits.

**References**

Algoma Central Railway


ODM-GSC

No. 17  McFadden and Rattray Townships Area
District of Timiskaming

Z.L. Mandziuk

Introduction

Mapping at a scale of 1:15 640 was completed during the 1978 field season over areas comprising and immediately adjacent to McFadden and Rattray Townships. The map-area, situated along the Ontario-Quebec interprovincial boundary line, is centered 14 km southeast of the town of Larder Lake and includes areas delimited by Latitudes 47°55'30" to 48°06'00" and Longitudes 79°31'00" to 79°38'00"; an area of approximately 160 km². Geological investigation of this area forms a complementary and integral component of a regional stratigraphic-structural synthesis of the Abitibi Belt in the Kirkland Lake-Larder Lake area by L.S. Jensen (1977), and is of relevance to current lithofacies studies of Huronian sedimentary rocks comprising northern elements of the Cobalt Embayment by J. Wood (this volume).

Access

Eastern portions of the map-area are readily accessible by driving east from the settlements of Kirkland Lake or Larder Lake along Highway 66 and then south along the interprovincial boundary road. Road access to the southern sector of Rattray Township is possible along lot, concession and logging roads from the Englehart-Larder Lake Highway 624. Western and central portions of the map-area can be reached by motor boat on Larder Lake and by canoe and portage from Raven Lake downstream to Corset and Ward Lakes and the Larder River. Numerous old to recent trails and logging roads of variable surface condition penetrate interior portions of the area.

Mineral Exploration

Widespread prospecting activity stimulated by the discovery of rich silver ores at Cobalt in 1903 eventually led to an important gold find near the northeast arm of Larder Lake in August 1906 and generated the Larder Lake gold rush. The initial discovery was to become the major gold producing Kerr-Addison mine at Chesterville in 1936; the site is situated approximately 4.3 km north of McFadden Township. Undoubtedly, many of the old pits, trenches, and drill holes occurring in the map-area attest to the early unrecorded exploration for gold in the vicinity of known occurrences along the favourable Larder Lake-Cadillac Fault.

Data filed at the Kirkland Lake Resident Geologist's
office' indicate that the first recorded mineral exploration in the map-area was carried out for gold by Lucky Girl Mines Limited. In 1947 this company put down four diamond drill holes at the south end of Island ‘CC’ on Larder Lake, and single holes on the southern and eastern shores of the lake also. In 1948, P. Wojcieszyn conducted further exploratory diamond drilling for gold on Island ‘CC’ and in 1951-1952 and 1968 E. Lipasti diamond drilled several sites on the east and west sides of Big Pete Island in Larder Lake to assess economic potential of intrastratal volcanogenic sulfide mineral occurrences. Diamond drilling of five holes performed by Kerr-Addison Mines Limited in 1956 explored a showing of copper mineralization on the west side of Icefish Lake in Rattray Township. More recently, in 1976 Geophysical Engineering Limited contracted airborne magnetometer and electromagnetic surveys which included coverage of the northwest corner of McFadden Township, and in 1977 Colex Explorations Incorporated conducted airborne magnetometer and electromagnetic surveys over west-central portions of the map area and ground magnetometer, electromagnetic and soil geochemical surveys over islands Big Pete and ‘CC’ and adjacent lake areas. Although several anomalies have been detected by the various methods and low grade mineralization of gold, copper and zinc occurs in some of the drill cores, there have been to date no favourable results which would encourage economic mining development. However, approximately 50 active mineral exploration claims are held in the area and the possibility of economic ore mineralization has not been ruled out for a large portion of the map-area.

General Geology

The map-area lies at the boundary between the south-central part of the Superior Province and the Cobalt Embayment of the Southern Province some 130 km north of the Grenville Front. Bedrock formations consist chiefly of Early Precambrian (Archean) metavolcanic, metasedimentary, and plutonic rocks, and Middle Precambrian (Huronian) sedimentary rocks, belonging respectively to the Abitibi Belt and the Cobalt Plate (or Embayment) structural subprovinces which are separated by a profound angular unconformity. Small isolated occurrences of, often linear northeast-trending, mafic intrusive rocks have been classified as Late Precambrian (Keweenawan) diabase. Pleistocene deposits of lodgement and ablation till, sand and gravel, varved lacustrine clays, and esker sand, together with Recent deposits of muskeg and alluvium make up the surficial deposits overlying the bedrock.

Early Precambrian rocks are of limited areal extent within the map-area and occur mainly on the large islands in the south of Larder Lake and along a narrow belt in low-lying largely drift covered areas to the south of the lake (see Maps 2205, Pyke et al. 1973. Map 1947-1, Thomson 1947). The metavolcanic sequence consists of structurally complex, interlayered or successive, massive and pillowved, mafic to ultramafic lava flows occasionally grading into coarser differentiated mafic to ultramafic rocks which are massive and often serpentine-bearing or peridotitic. Minor interbeds of derived proximal fine grained to coarse grained metasediments and mudflows display intimate and obscured spatial relationships with their source metavolcanic lithologies. A few thin layers of felsic metavolcanics occur within the flow piles and on Island ‘CC’ a distinctive pyroclastic volcanic breccia is intimately mixed with coarse poorly sorted conglomerate. The mixed breccia-conglomerate is composed of angular to rounded fragments of quartz-feldspar porphyry, rhyolite porphyry and minor mafic metavolcanics in a rubbly, spiny-textured, amygdaloidal, ultramafic matrix and appears to be stratigraphically related to one or more volcanic centers occurring to the southeast in Skead Township (Thomson 1947, Hewitt 1949). The metavolcanic sequence is unconformably overlain by Early Precambrian metasediments consisting of steeply dipping wacke, siltstone, slate, argillite and minor conglomeratic lenses. In southern parts of Rattray Township small inliers of Pontiac-type metasediments such as occur in Pense and Brethour Townships to the south (Lovell 1977) consist of quartz-feldspar-biotite-amphibole schist with lesser intercalated and fragmented black slaty beds. Further east towards the Quebec border, the Early Precambrian Pontiac-type metasediments become more metamorphosed and gneissic in the vicinity of a wide lit-par-lit contact zone with Early Precambrian Algoman-type felsic intrusive rocks comprising a large granitic batholith or massif (Chagnon 1968, Wilson 1912). On the west side of the map-area another Early Precambrian intrusive body composed of differentiated syenite re-intruded by granite cuts through the previously described metavolcanics and metasediments. Small sills, dikes and irregular-shaped intrusions of varitextured gabbro, diorite, and lamprophyre are also present.

More than 75 percent of the map-area is underlain by a substantial thickness of Middle Precambrian Coleman member sedimentary rocks which unconformably overlie the Early Precambrian and comprise the lowest unit in the Gowganda Formation of the Cobalt Group, Huronian Supergroup sedimentary rocks. These flat-lying to gently dipping, low grade to unmetamorphosed, epilastic rocks outcrop along a prominent series of northeast-trending ridges bounded by steep terraced bluffs which rise some 50 to 150 m above the level of Larder and Raven Lakes and represent the erosional remnants of extensive and thick deposits of sediment laid down in a steep-sided elongate trough interpreted by the author as a zeugogeosyncline or block-faulted rift structure marginal to an intracratonic autogeosynclinal depression to the south (the Cobalt Embayment). The lowest exposed portions of Coleman member rocks consist of generally bedded to laminated rhythmic sequences of fluvialite and turbidite graded arkose interbedded with grey, blue-grey and minor maroon argillite with rare dropstones. Sedimentary
structures including current bedding, ripple marks, and load casts are well developed. Argillaceous units tend to increase in volume up the section to the level where a disconformity is reached. Above this disconformity there occurs a massive to poorly bedded heterogeneous assemblage of vertically and laterally intergraded sedimentary rocks. The most abundant rock type above the disconformity is a very poorly sorted to nonsorted polymictic matrix-supported paraconglomerate with predominantly felsic intrusive pebbly to cobbly clasts and fewer metavolcanic and metasedimentary fragments derived from underlying Early Precambrian rocks. Volume percentage of clasts is generally less than 15 percent and often less than 5 percent. Much of the rock is till-like in appearance and contains matrix materials generally consisting of very fine grained sand, rock flour, or mud-silt which is well indurated, saccharoidal, blue-grey, subarkose to lithic and rarely bedded. Interbedded and intergraded with the paraconglomerate are lesser volumes of irregularly distributed argillite and arkose with rare intact framework orthoconglomeratic lenses. Compositional and textural maturity and sorting generally increase in the upper levels of the exposed Middle Precambrian section where occurrences of light grey and green medium to fine grained orthoquartzites were observed.

Structural Geology

The belt of Early Precambrian metavolcanics and metasediments in the map-area makes up part of a large arcuate fold belt extending into Hearst, Skead and McVittie Townships. Lava flows in the area generally strike north; however several phases of tight folding, numerous faults, and contact zones with intrusive bodies give rise to local variations.

The prominent faulting in the area occurs in two main trends; northeastward and northwestward, with the latter group (Lake Timiskaming Rift System, Lovell and Caine 1970) offsetting the northeastward trending faults, and the former being more prominent in effecting strike displacement, shear, schistosity and jointing. Thomson (1947) has described some of the major fault structures in the area, and a major lineament designated as the Larder River Fault in Bayly Township (Lovell 1974) extends along the northeast-trending water course into the map-area. The major structural element which controlled deposition of Middle Precambrian Coleman rocks is an elongate depression which extends northwards from the Cobalt Embayment. The depression, referred to by the author as the Larder Lake Trough, is interpreted as a rift valley bounded by a system of steeply inclined faults which underwent periodic displacements throughout the Middle Precambrian. Variations in the dips of Coleman rocks reflect the control of bedrock topography and the steepening effect of compaction during diagenesis of sediments on the flanks of the subsiding trough.

Economic Geology

Lovell and Ploeger (1978), Ridler (1970) and Savage (1964) have described various ore-types of gold mineralization occurring in the Kirkland Lake-Larder Lake camp and have given guidelines for exploration. In the map-area, greatest potential for exploitable concentrations of gold lies within Early Precambrian rocks subjected to subsidiary branch faulting off the main Larder Lake-Cadillac Fault (e.g. the southwest trending Northeast Arm—Benson Creek Fault and Milky Creek Fault Thomson 1947). Other favourable exploration targets are intratral sulphide-bearing cherty tuff horizons within the metavolcanic sequence such as occur on Big Pete Island and in the west-central part of the map-area. Numerous quartz veins of variable dimension and continuity pervade the Coleman rocks and have been proven by early prospecting to be barren of significant gold. Lava flows in the area generally strike north including several samples from pink hornblende granite in McFadden Township described by Hopkins (1924, p.7) as being similar to gold-bearing granite occurring two miles to the southwest in Skead Township.

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No. 18 Huronian Volcanism
Districts of Sault Ste. Marie and Sudbury

G. Bennett

Introduction

The 1978 field season was spent examining Huronian volcanic rocks and Elliot Lake Group sedimentary rocks between Sault Ste. Marie and Sudbury.

Geological mapping of specific areas coupled with the result of whole-rock chemical analyses of samples collected during the 1977 field season allows some preliminary conclusions regarding the internal volcanic stratigraphy of the Thessalon Formation and correlation with other Huronian volcanic rocks. It was found that a three-channel, portable scintillometer was a useful mapping tool for distinguishing between some types of basaltic rocks.

General Geology

Thessalon Formation

Field relationships and available petrochemical data suggest that the term Thessalon Formation (Frarey 1961) be applied to all known Huronian volcanic rocks west of the east end of the Quirke Lake syncline.

Rocks Underlying The Thessalon Formation

The Thessalon, Duncan and Aberdeen belts of the Thessalon Formation are underlain by a fine-grained grey, cross-beded sandstone and granite cobble conglomerate of the Livingstone Creek Formation (Frarey 1967).

Throughout most of its length the Dollyberry Lake belt lies directly upon the granitic basement.

Bottrill (1971) reported a grey sandstone under the Crazy Lake volcanic belt which he compared with the sandstones below the Thessalon belt, i.e. the Livingstone Creek Formation. Following examination of these sandstone outcrops, the writer agrees that they almost certainly belong to the Livingstone Creek Formation. This allows a correlation of the Crazy Lake belt and therefore the
Rocks Overlying The Thessalon Formation

The Duncan belt of the Thessalon Formation is overlain mainly by a unique, thick sequence of volcanic and polymictic conglomerate and sandstone which are probably equivalent to members of the Hough Lake Group (Bennett et al. 1975). However, the internal stratigraphy of this assemblage is so atypical and complex that the term Averes Formation of McConnell (1926) should be retained.

The volcanic rocks of the Thessalon belt and locally those of the Duncan belt are overlain by up to 125 m of grey to distinctly yellow-green sandstone which is probably stratigraphically equivalent to the Matinenda Formation (Bennett 1977a, 1977b). Diamond drill holes bored from islands and through the ice on Lake Huron have shown that 6 km south of the town of Thessalon this yellow-green sandstone unit contains grit and dispersed, quartz-pebble conglomerate, and lies directly upon the granitic basement. The thickness (900 m) of the volcanic rocks under Lake Huron suggests that the Thessalon belt volcanic rocks occupies a pre-Matinenda fault-bounded trough at its southern boundary under Lake Huron.

The Crazy Lake belt and most of the Dollyberry Lake belt are overlain by polymictic conglomerate of the Ramsay Lake Formation. It is evident from Figure 1 that the Ramsay Lake conglomerate was deposited upon the deeply eroded surface of the Thessalon Formation in that area. This erosion probably took place prior to the deposition of the Matinenda Formation (otherwise the volcanic rocks should be thicker where they are found below the Matinenda Formation). In a few places the writer found evidence of a regolith over the Huronian volcanic rocks of the Dollyberry Lake belt. A similar yellowish bleaching of the volcanic rocks was noted in diamond drill core at the upper surface of the Pecors Lake volcanic belt where it is overlain by the Matinenda Formation.

Nowhere has the writer seen, in outcrop or diamond drill core, evidence of intercalation of the Thessalon Formation volcanic rocks and rocks of the overlying formations. Bottrell’s (1971) correlation of Huronian volcanic rocks in the Elliot Lake area with the main ore-bearing members of the Matinenda Formation would appear to be incorrect because there is no evidence of any volcanic activity during or following the deposition of the Matinenda Formation in the Elliot Lake area. As earlier stated by Barnes (1972), the Huronian volcanic rocks of the Quirke Lake syncline were reduced to erosional remnants prior to the deposition of the Matinenda Formation.

Most of the upper boundary of the Aberdeen belt is obscured by a thick drift cover and the waters of Aberdeen Lake. At the east end of the belt a few outcrops of volcanic-rich polymictic matrix-supported conglomerate, probably the Ramsay Lake Formation, was found just south of the most southerly volcanic outcrop. Diamond drill logs indicate up to 150 m of grey sandstone overlies the volcanic rocks and underlies the conglomerate (subsurface) in Galbraith Township. These sandstones are correlated with the Matinenda Formation.

Aberdeen and Duncan Belts

Geological mapping during the 1979 field season and past field seasons (Bennett et al. 1975, 1977; Bennett 1977a,b) coupled with recently acquired chemical analyses, (All chemical analyses are by the Geoscience Laboratories, Ontario Geological Survey) indicates that the Aberdeen and Duncan belts of the Thessalon Formation have a similar, relatively simple internal volcanic stratigraphy consisting of a lower member (up to 500 m thick) of very dark green, dark brown and black amygdaloidal and massive mafic flows which are overlain by up to 500 m of amygdaloidal to massive medium to pale grey-green mafic flows. The lower member is generally found to contain significantly less Cr, Ni and MgO and more K₂O, TiO₂ and P₂O₅ than the overlying mafic flows. Many, if not most, of the samples analyzed give evidence of soda enrichment, so that much of the volcanic sequence consists of soda spilites. A tentative classification using apparently “immobile” elements suggests that the lower member has an original composition of basaltic andesite with an alkalic aspect, possibly of the hawaiite-mugearite series. The low Cr and Ni contents (= 5 ppm) suggest the magma was not “primary” but had undergone some crystal fractionation under crustal conditions.

The upper member has a range of chemical compositions consistent with continental tholeitic basalt.

Thessalon Belt

The internal stratigraphy of the Thessalon belt is more complex than that of the Duncan and Aberdeen belts. A lower basaltic andesite — andesite sequence and an upper tholeite sequence of flows can be discerned; however, the geological picture is complicated by faulting and relatively shallow dips in many areas.

From 60 to 150 m of amygdaloidal, grey to pink dacite and rhyolite flows, with intercalated felsic volcanic breccia and welded tuff outcrop just east of the town of Thessalon and where intersected in diamond drill holes drilled from the ice on Lake Huron, within a few kilometres of the town. These felsic volcanic rocks occur within the lower (andesitic) volcanic member of the Thessalon Formation. No felsic volcanic rocks are found along the northern edge of the Thessalon belt.

A distinct pale green flow up to 15 m thick with thin amygdaloidal zones at its top and base was mapped for a distance of 5 km along the northern boundary of the Thessalon belt. A single chemical analysis indicates the flow is a high magnesium tholeiite or basaltic komatiite (Brooks and Hart 1974).

Figure 1—Geology of the Ten Mile Lake area.
**Dollyberry Lake Belt**

The Dollyberry Lake belt of the Thessalon Formation outcrops more or less continuously for about 15 km along the northern edge of the Quirke Syncline between the northwestern end of Dollyberry Lake southeastward to north-central Bouck Township.

Throughout most of this length the predominant volcanic lithology is very dark grey-green to almost black massive to amygdaloidal, locally porphyritic mafic flows. A few well developed pillow structures are found near the base of the sequence. A bed of mafic volcanic breccia 3 to 10 m thick is found within the flows in the eastern part of the belt.

Presently available chemical analyses (18 in all) indicate the presence of mafic flows with chemical compositions (basaltic andesite) similar to those of the lower member of the Thessalon Formation between Thessalon and Sault Ste. Marie.

On the north shore of Ten Mile Lake the volcanic rocks are predominantly mafic to intermediate flows, megascopically similar to those along the north shore of Dollyberry Lake. Intercalated within the flow sequence are several units of volcanic breccia and at least three pale pink, grey to red rhyolitic flows. Some of the rhyolite flows display planar laminated zones at the base and coarse quartz-filled amygdules (up to 20 cm across) at the top. Rhyolite is most abundant in the southeast end of the belt and in each case the rhyolite is underlain by a more extensive unit of felsic volcanic breccia and overlain by intermediate to mafic flows. The Huronian age of these volcanic rocks, earlier recognized by Bottrill (1971) was confirmed by observed field relationships between the volcanic rocks and the granitic basement.

**Crazy Lake Belt**

A relatively minor Huronian volcanic belt is located on the south shore of Crazy Lake, Nicholas Township (Robertson 1969a). The volcanic rocks of the Crazy Lake belt are entirely mafic dark flows which megascopically resemble those at the base of the Thessalon Formation. The Crazy Lake belt is only about 6 km west of, and along strike with, the Dollyberry Lake belt.

**Pecors Lake Belt**

A narrow Huronian volcanic belt lies under the Matinenda Formation west of Pecors Lake in Joubin Township. A basal conglomerate unit separates the Early Precambrian metasediments from the almost flat-lying Huronian volcanic rocks (Robertson 1961). The volcanic rocks are very dark grey-green to black with a distinctive porphyritic flow resembling one in the Dollyberry Lake belt north of the Quirke Mill.

**Thessalon Formation Sedimentary Rocks**

Although very subordinate in terms of volume, detrital sedimentary rocks are widely distributed among the basal flows of the Thessalon Formation, and constitute a megascopically distinct lithological assemblage. In the Duncan and Aberdeen belts a few siltstone and argillite beds are reported (Bennett 1977a, 1977b). However, the characteristic detrital lithology of the Thessalon Formation is a coarse, poorly sorted, pink arkose and associated quartz-pebble conglomerate (Bennett 1977a, 1977b). The sandstones and conglomerates commonly contain abundant, distinctly pink to red angular feldspar, but little of the yellow-green sericite matrix characteristic of the Matinenda Formation.

Diamond drilling by the Hanna Mining Company Limited south of Crazy Lake intersected a thin unit of uranium-oous (0.005 percent U₂O₃) quartz-pebble conglomerate at the base of the Thessalon Formation in that area (Regional Geologist’s files, Ontario Ministry of Natural Resources, Sault Ste. Marie). During the 1978 field season 3 to 7 m of pink, coarse arkose and quartz pebble conglomerate were found at or near, the base of the Crazy Lake belt. These detrital rocks are megascopically similar to those found elsewhere near the base of the Thessalon Formation.

A metre or less of poorly sorted pink arkose, grit and quartz-pebble conglomerate was found at four locations at the base of the Dollyberry Lake belt. Although these arkose units display even less internal stratification than the arkose referred to above, they are similar in most respects. Robertson (1969b) reported minor radioactivity in a similar unit (considered by him to be a regolith) north of Dollyberry Lake.

**Salmay Lake Formation**

The Salmay Lake Formation (Robertson and Siemiatkowska 1971) is a sequence of Huronian volcanic rocks up to 500 m thick extending from Sailer Township near Massey in a northeast direction into Baldwin Township, a distance of about 30 km.

The volcanic and associated sedimentary rocks dip about 70 degrees to the southeast and are metamorphosed to the upper greenschist or almandine-amphibolite facies.

North of the Murray Fault zone the Salmay Lake Formation consists predominantly of intermediate to felsic volcanic rocks and minor mafic flows. Some medium-grained, massive, mesocratic units are probably related sills. In general these rocks display few clearly volcanic features such as amygdules, volcanic breccia or pillow structures, but the presence of interbedded sericitic sandstone and quartz-pebble conglomerate indicates the supracrustal nature of much of the Salmay Lake Formation.

South of the Murray Fault system, the apparently fault repeated upper part of the Salmay Lake Formation contains more mafic volcanic rocks. These are commonly amygdaloidal, with interflow volcanic breccia and Matinenda-type sandstone and conglomerate.

Available chemical analyses (Robertson 1976) indicate much of the sequence consists of andesitic and dacitic rocks and some tholeiitic basalt. A preliminary comparison of these chemical analyses with those of the
G. BENNETT

Thessalon Formation does not reveal any obvious chemical similarity.

Sedimentary Rocks of the Salmay Lake Formation

The Salmay Lake Formation, particularly the upper half of the sequence contains interbeds of pale grey to yellow-green sandstone and quartz pebble conglomerate. Workers in the area have considered these interflow sedimentary rocks to be comparable to the Matinenda Formation (Robertson 1976), or state that the Matinenda Formation is intercalated with the volcanic rocks (Card and Palonen 1976).

A similar intercalated relationship between Huronian volcanic rocks and the mainly overlying Matinenda Formation is present in the Sudbury area (Card 1968; Innes 1972, 1977).

The intercalation of the Salmay Lake and Matinenda Formations indicates that the Salmay Lake Formation is stratigraphically superior and probably younger than the Thessalon Formation.

The volcanic rocks of the Sudbury area show similar interbedded relationships with the Matinenda Formation.

A further tentative conclusion is that the erosion surface over the Thessalon Formation is equivalent to that separating the gabbro-anorthosite intrusions from the Salmay Lake Formation. More extensive uplift in the Massey-Sudbury area may have resulted in the erosion of any pre-existing Huronian volcanic rocks (Thessalon Formation) and exposure of subjacent related intrusions of gabbro-anorthosite. Renewed volcanism (Salmay Lake, Elsie Mountain, Stobie and Copper Cliff Formations) was accompanied by sedimentation from the craton (Matinenda Formation) while sedimentation without accompanying volcanism took place in the Elliot Lake—Sault Ste Marie area.

Rocks Underlying the Salmay Lake Formation

In a few places the volcanic rocks of the Salmay Lake Formation lie directly upon the Early Precambrian granitic rocks; however, for most of its length the Salmay Lake Formation is underlain by a complex but distinctive group of diabasic, gabbroic and anorthosite rocks which are spatially related to the Early Precambrian—Middle Precambrian boundary.

The gabbro-anorthosite intrusions are apparently unconformably overlain by the volcanic rocks (Card et al. 1972, p.360). During the 1978 field season the writer found boulders of mafic rocks in a polymictic conglomerate lying upon the granitic basement in Shakespeare Township. These boulders are coarse, gabbroic and anorthositic rocks with cumulate textures typical of the nearby gabbro-anorthosite bodies.

Pater Volcanic Belt

The Pater volcanic belt is about 400 m thick and extends for about 10 km along the north shore of Lake Huron westward from the mouth of the Serpent River.

It is composed mainly of medium-grained, foliated to schistose amphibolite. Local amygdaloidal zones and interbedded conglomerate and sandstone reveal its volcanic origin.

The high metamorphic grade (almandine amphibolite facies) and its isolated position south of the Murray fault prevents any unquestionable correlation. However, the type of interbedded sediments and its geographic position suggests a correlation with the Salmay Lake Formation.

Correlation of Volcanic Rocks

The Matinenda Formation is in most cases readily distinguishable by its characteristic yellow-green colour throughout the Huronian succession of Ontario. This suggests that it was laid down under widespread and unique (climatic?) conditions.

The intercalation of the Salmay Lake and Matinenda Formations indicates that the Salmay Lake Formation is stratigraphically superior and probably younger than the Thessalon Formation.

The volcanic rocks of the Sudbury area show similar interbedded relationships with the Matinenda Formation.

A further tentative conclusion is that the erosion surface over the Thessalon Formation is equivalent to that separating the gabbro-anorthosite intrusions from the Salmay Lake Formation. More extensive uplift in the Massey-Sudbury area may have resulted in the erosion of any pre-existing Huronian volcanic rocks (Thessalon Formation) and exposure of subjacent related intrusions of gabbro-anorthosite. Renewed volcanism (Salmay Lake, Elsie Mountain, Stobie and Copper Cliff Formations) was accompanied by sedimentation from the craton (Matinenda Formation) while sedimentation without accompanying volcanism took place in the Elliot Lake—Sault Ste Marie area.

Economic Geology

Copper

Chalcopyrite is commonly observed as fine, disseminated grains and thin concentric layers in amygdules of mafic flows in the Thessalon Formation.

The Pater copper mine, a past producer in the Spragge area, is located within a fault or shear zone in volcanic rocks of the Pater belt (Robertson 1970).

A few significant copper prospects and a past producer are found within volcanic rocks of the Salmay Lake Formation in the Massey area (Robertson 1976). Innes (1972) described thin, low grade strata-bound sulphide-bearing interflow sedimentary units in the volcanic rocks of the Elsie Mountain and Stobie Formations of the Sudbury area.

Disseminated pyrite and chalcopyrite are common in the volcanic breccias north of Ten Mile Lake. A few iron stained pits 10 to 20 cm across and 10 cm deep were noted in a few of these breccias, but in all cases any sulphide minerals present had been weathered out.

A few percent of disseminated pyrite and chalcopyrite are found in a rusty zone about 0.5 to 1 m thick at the top of a volcanic breccia unit between Hyphen and Ten Mile Lake.

Uranium and Thorium

Several occurrences of uraniferous quartz-pebble conglomerate intercalated with basalt flows of the Thessalon Formation have been tested by diamond drilling and surface prospecting. To date none have yielded grades or thickness to warrant further development. These deposits are widespread areally and restricted stratigraphically. Their presence shows that conditions favourable to the concentration of uranium and thorium existed during ini-
tial Thessalon volcanism.

The major uranium deposits of the Elliot Lake area were deposited on the deeply eroded surface of the Thessalon Formation. Volcanic processes could not have been a factor in their genesis. However, it is possible that some of the components of the Matinenda Formation or the ore zones may have been derived from Huronian volcanic rocks.

Changes in the paleoslope, due to faulting or differential erosion, along the margin of the volcanic belt may have been a factor in localizing the coarse, ore-bearing facies of the Matinenda Formation.

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Robertson, J.A. and Siemiatkowska, K.M.
No. 19 Mackelcan Township and Southern Wanapitei Lake Area, District of Sudbury

B. Dressler

Introduction

Mackelcan Township is located northeast of Lake Wanapitei, about 45 km northeast of Sudbury and is bounded by Latitudes 46°47'54" and 46°53'06"N and Longitudes 80°34'00" and 80°41'35"W. The southern Wanapitei Lake area is about 24 km northeast of Sudbury and includes most of Maclennan and Scadding Townships and parts of Capreol and Davis Township. It is bounded by Latitudes 46°38'00" and 46°42'42"N and Longitudes 80°33'00" and 80°50'00"W.

Access to Mackelcan Township is by float equipped aircraft or by boat via Matagamasi Lake. Access to this lake is provided by a good gravel road, the Kukagami Lake Road, from Highway 17 east of the village of Wanapitei.

The Kukagami Lake Road also provides access to Scadding Township and, via secondary bush roads, to Davis Township. Access to Maclennan Township and eastern Capreol Township is via Highway 54, from Sudbury and a network of gravel roads.

Mineral Exploration

Mackelcan Township

Little exploration has been reported in Mackelcan Township. A. Jerome presently holds two claims at Wolf Lake in central Mackelcan Township where a pyritiferous arkose of the Lorrain Formation is exposed. Nearby, at the north shore of Jones Lake, a similar, rusty weathering arkose was found by the author.

Southern Wanapitei Lake Area

In the southern Wanapitei Lake area exploration has been carried out for nickel, copper, uranium and gold.

Nickel and Copper

Three past-producing mines are located west and south of southern Lake Wanapitei: The Nickel Rim mine of Falconbridge Nickel Mines Limited, the Victor mine and Maclennan mine of Inco Limited. All the ground underlain by or bordering the nickel irruptive is covered by patented and leased claims. The main claim holders are Falconbridge Nickel Mines Limited (about 85 claims) and Inco Limited (about 20 claims). Several other companies and individuals hold another 40 patented or leased claims.

Exploration activity in these claimed areas has gone on since the early days of Sudbury mining activity. It includes geological and geophysical surveys, and numerous diamond drill holes have been drilled. During the 1978 field season Inco Limited diamond drilled near Blue Lake and Falconbridge Nickel Mines Limited conducted a detailed geological mapping program south of the village of Skead.

In 1968 Questor Surveys Limited performed a combined magnetic and electromagnetic survey for Kennco Explorations (Canada) Limited over an area of approximately 673 km². This survey included almost all of Scadding Township, Davis Township and part of Maclennan Township. The purpose of the survey was to investigate...
occurrences of base metal mineralization within the area. The company discovered three groups of electromagnetic anomalies in the southeast corner of Scadding Township and six weak anomalies in southeastern Lake Wanapitei. In southwestern Scadding Township three 5- to 6-channel anomalies were detected very close to and northeast of Moose Rapids, i.e. at the southern border of the map area. The two other groups of (3-channel) anomalies occur 2.1 km northwest and 1.7 km north-northeast of Moose Rapids. Kennco Explorations (Canada) Limited stated that the 3-channel anomalies in southwestern Scadding Township may be due to small quantities of sulphide mineralization or rather deeply buried sulphide bodies and that the good 5- to 6-channel response anomalies appear likely to be caused by sulphide mineralization. The weaker anomalies in Lake Wanapitei are believed by the company to be due most likely to conductive overburden in the bottom of the lake. In 1969 and 1970 as a result of the geophysical survey and of geological field work the company diamond drilled three holes for a total length of 395 m in southern Scadding Township near the Wanapitei River. The drill encountered only minor disseminated sulphide mineralization. The company did not report any further work and the claims were allowed to lapse.

**Uranium**

An uranium discovery in quartz pebble conglomerate was made on the west shore of Massey Bay of Lake Wanapitei. In 1959 Picton Uranium Mines Limited diamond drilled three holes for a total of 162 m. In 1975 M. Burtondiamond drilled a 38 m deep hole and in 1976 Hollinger Mines Limited a 174 m deep hole near the discovery showing (for results see “Economic Geology” below.)

The ground along the western shore of Massey Bay and the bay itself is presently covered by about 40 unsurveyed claims (see claim map, Maclean Township, Plan No. M84).

**Uranium and Gold**

In 1972, Gulf Minerals Canada Limited conducted an airborne radiometric, electromagnetic and magnetometer survey over a group of 79 claims in Scadding Township to map the distribution of radioactive material and subsurface conductors and to obtain structural information on the geological formations. As a result of this work the company driller 41 holes for a total length of 2669 m in an area 1.2 km west of the westernmost end of Ashigami Lake. In January 1978, D. R. Watt drilled another 8 holes totalling 492 m. Gulf Minerals Canada Limited and D.R. Watt did not report any uranium discovery. On the investigated ground, however, gold mineralization in chloritized quartzite breccia was discovered (personal communication, P.C. McLean, North Bay, 1978). P.C. McLean presently holds a group of 24 claims and D.R. Watt a group of 64 claims in central and southern Scadding Township.

**Gold and Gold-Copper**

There are several gold and gold-copper occurrences associated with quartz and quartz-carbonate veins in Maclean and Scadding Townships. They have been known for a long time and no work known to the author has been done on them in recent years. In many places old surface trenches, test pits and shafts were observed by the author during the 1978 field work.

The Skead gold mine is located just east of the village of Skead. The property is owned by Falconbridge Nickel Mines Limited. J. E. Thomson (1961) stated that prior to 1946 a shaft had been sunk and drifting done on the 50 m level. There is no record of when the work was done. In 1946 Falconbridge Nickel Mines Limited dewatered and sampled the mine. Assays from 3.02 to 13.37 ppm gold and up to 0.62 percent copper were reported.

The Bonanza mine (Slaght 1894) is located on the west side of Bonanza Lake in Maclean Township. A shaft was sunk to about 15 m and a little lateral work was done. In 1956 the occurrence was examined by Falconbridge Nickel Mines Limited as a possible source of smelter flux and two holes were drilled. Surface chip samples of the quartz vein contained 90 to 95 percent SiO₂ and from traces to 1.37 ppm gold. A group of four leased claims at northwestern Bonanza Lake, including the quartz-gold occurrence, is presently held by E. Blanchard.

The Red Rock mine is located in central Scadding Township. Between 1923 and 1925 The McMillan Development Company Limited sank a shaft to a depth of about 50 m and did 340 m of drifting and crosscutting (Kindle 1933). McMillan Gold Mines Limited is the present owner of the property. In 1931 Mid-Continent Gold Fields Limited carried out considerable trenching and pitting to test gold mineralizations just north of the Red Rock mine where McChesney Gold Mines Limited presently holds seven claims. Gold Nugget and Development Company two claims and Tower Financial Corporation Limited another two claims.

About 1.6 km east of the Wanapitei River in central Scadding Township lies another gold occurrence, property of J. and G. Alkins. Fairbairn (1939a, b) reported that after several years of inactivity work was resumed on this property in 1939. No production and no more recent work has been reported. The old workings, pits and trenches, were observed by the author.

At southern Kakagami Lake in Scadding and Davis Township several copper, gold and lead bearing quartz veins are known to occur. In 1960 and 1962 Midas Mines Limited diamond drilled 14 holes for a total of 437 m to test the occurrence. In 1967 Kayyon Minerals Limited diamond drilled two holes for a total of 350 m. Midas Mines Limited reported a gold and silver rich (387 ppm gold, 298 ppm silver and 1.95 percent copper) 15 cm long core section in one of its drill holes and Kayyon Minerals Limited’s drill encountered five mineralized zones containing 0 to 22.3 ppm gold, 1.37 to 12.3 ppm silver and 0.02 to 0.07 percent copper (analyses of 1.5 m long core sections).
E.J. Plexman presently owns a group of four claims in the area.

East of the J. and G. Alkins property, in lots 5 and 6, concession II of Scadding Township, Glade Exploration Limited, a now defunct company, carried out a geological survey of twelve claims. The company reported (1972) several occurrences of visible gold in quartz veins.

In northern Scadding Township, about 1.8 km east southeastward of Scadding Bay (Lake Wanapitei) another gold and copper occurrence is located. In 1950, 1956 and 1959 Alwyn Porcupine Mines Limited diamond drilled 14 holes for a total of 1406 m to test the occurrence. No further work has been reported and the claims were allowed to lapse.

General Geology

Mackelcan Township

Mackelcan Township is underlain by wacke of the Gowganda Formation, arkose and quartz-sandstones of the Lorrain Formation and a little Nipissing-type gabbro. An olivine diabase dike occurs in the southwestern corner of the township.

Southern Wanapitei Lake Area

Early Precambrian mafic metavolcanics, metasediments, biotite-plagioclase gneiss, granitic rocks and diabase underlie part of western Scadding Township and part of eastern Capreol Township.

Middle Precambrian sedimentary rocks of the Huronian Supergroup unconformably overlie the older rocks or are in fault contact with them. Quartz-pebble conglomerate, in places radioactive, arkose and quartz-sandstones of the Mississagi Formation are the oldest Huronian rocks in the area. They were observed at Massey Bay of Lake Wanapitei, near the village of Skead and in southern Macclennan and Scadding Townships. Pebbly wacke of the Bruce Formation is common in eastern and central Scadding Township. It is overlain by limestone and siltstone of the Espanola Formation. This formation is, in turn, overlain by arkose of the Serpent Formation, which outcrops in central Scadding Township. Large areas of central and northern Scadding Township are underlain by wacke of the Gowganda Formation. The Lorrain Formation appears to be absent from the southern Wanapitei Lake area.

Nipissing-type gabbro intrudes all the foregoing rock formations. The medium- to coarse-grained gabbro forms irregularly shaped bodies, sills and dikes. The largest gabbro mass in the southern Wanapitei Lake area is located between Massey and Outlet Bays of Lake Wanapitei. Intermediate to acidic phases of the Nipissiing intrusions were observed in several places, mainly at the south shore of Lake Wanapitei.

Tuft-breccia of the Onaping Formation, the only formation of the Whitewater Group observed in the area, outcrops in the western part of Scadding Township and in Capreol Township. The tuft-breccia is intruded by rocks of the Sudbury Nickel Intrusive, the norite and micropegmatite.

All the foregoing rocks are intruded by Late Precambrian olivine diabase dikes. They strike northwesterly and were observed in many places.

Sudbury-type breccia is present throughout the map-area but is found mainly west of Lake Wanapitei and south of the village of Skead. The breccia consists of rounded or angular rock fragments that are a few millimetres to several tens of metres in size and that are set in a fine-grained or aphanitic dark coloured matrix. Pseudotachylite is common and is of the same age as the Sudbury-type breccias, i.e. it was formed after the Nipissing-type gabbro intruded and shortly before the intrusion of the rocks of the Sudbury Nickel Intrusive.

Cenozoic deposits comprise sand and gravel. They are found mainly south of Lake Wanapitei near the Sudbury airport.

Structural Geology

In Mackelcan Township the Huronian rocks are only weakly deformed. In general, they form a large syncline, the synclinal axis striking approximately north and plunging gently northward.

In the southern Wanapitei Lake area the Early Precambrian rocks do not exhibit an obvious structural trend due to a strong tectonic deformation probably related to the Sudbury event, i.e. endogenic forces or the impact of a meteorite.

The rocks of the Huronian Supergroup and the Nipissing-type gabbro are weakly deformed in the northern part of the southern Wanapitei Lake area. In general the rocks trend east-southeast. Towards the south, i.e. toward the Grenville Front Tectonic Zone the degree of deformation increases and south of Skead—Bonanza Lake—Ashigami Lake the rocks exhibit fracture cleavages or are schistose.

Shatter cones have been observed in a few places along the shore of Lake Wanapitei, and on Howie Island. These structures are possibly suggestive of a meteorite impact origin for Lake Wanapitei. However, no other field geological evidence has been observed by the author that would support an explanation of the Wanapitei Lake structure as a meteorite impact crater.
Economic Geology

Mackelcan Township

The pyritiferous arkose of the Lorrain Formation in central Mackelcan Township forms gossans up to about 100 m2 in size. No assays are known to the author and no information from drilling or geophysical surveys is available. Therefore nothing is known by the author about the thickness and lateral extent of the pyritiferous arkose.

Southern Wanapitei Lake Area

Nickel and Copper

Detailed geological information on the Mackeninnan open pit and the Victor mine of Inco Limited is not available. Ore samples found by the author at the two mines consist of common Sudbury copper-nickel ores. J.E. Thomson (1961) gave a description of the Nickel Rim mine:

Mineralization at the mine is confined mostly to the band of quartz diomite breccia and is concentrated in irregularly-shaped bodies... The sulphides occur in a series of irregular, disconnected bodies... There does not seem to be any definite structural control in the occurrence of the sulphide bodies. The ore shows typical Sudbury mineralization and consists of pyrrhotite, pentlandite, chalcopyrite and lesser amounts of pyrite.

Little is known of the economic potential, character, extent and thickness of the disseminated sulphide mineralization encountered by Kennco Explorations (Canada) Limited in its drill holes in southern Scadding Township. In the drill records the company described coarse tuff-conglomerate that occasionally contain up to 5-10 percent pyrite and pyrrhotite. Assay values range from traces to 0.04 percent copper and from traces to 0.02 percent nickel.

Uranium

Radioactive quartz-pebble conglomerate is exposed at a few places along the west shore of Massey Bay of Lake Wanapitei. At the discovery site the conglomerate can be traced for a distance of about 180 m along the lakeshore. However, it is exposed at a few more places south of the discovery pit. In 1959, Picton Uranium Mine Limited encountered 2.8 m of slightly radioactive quartz sandstone interlayered with siltstone that is underlain by 3.25 m of radioactive, pyritiferous pebble conglomerate in diamond drill hole No. 1. Another radioactive conglomerate bed, about 8.7 m thick occurs deeper in the hole, i.e. from 24.7 to 33.4 m in depth. Eight assays from the 3.25 m thick radioactive zone ranged from 0.01 to 0.04 percent U3O8.

Suggested radioactive zones were indicated in the quartzite and pebble conglomerate in two other drill holes. J.E. Thomson (1961) reported an assay of 0.009 percent U3O8 obtained from a grab sample taken from a conglomerate occurrence opposite the Ministry of Natural Resources Buildings at Bowlands Bay. Hollinger Mines Limited reported a 25 cm thick radioactive pyritic quartz pebble conglomerate bed at 124 m in depth of a vertical diamond drill hole near the discovery showing.

Gold and Gold-Copper

All but two gold or gold-copper occurrences described under "Mineral Exploration" are associated with quartz and quartz-carbonate veins that occur within rocks of the Huronian Supergroup or within Nipissing-type gabbro near or at the contact of the Huronian sedimentary rocks with the gabbro. The veins are a few centimetres to about 18 m (Bonanza mine) thick and strike parallel to the contacts or cut across them. Gold occurs as native gold within the quartz veins. A few veins also contain pyrite, chalcopyrite and in one area, near Kukagami Lake, galena.

In central Scadding Township P.C. McLean (personal communication, 1978) discovered native gold in chloritized quartzite breccia. No detailed information on this gold occurrence is available yet as exploration activity is still going on. The gold-copper occurrence in Scadding Township formerly owned by Alwyn Porcupine Mines Limited is associated with a fault zone that strikes in a north-west direction. J.E. Thomson (1961) stated:

The property is underlain by rocks of the Gowganda Formation, which is cut by dikes of gabbro... The rocks adjacent to the fault zone are greatly altered, brecciated, and fractured, the zone itself is marked by some sulphide mineralization and many quartz-carbonate veins... The geometrical average of vein intersections to date is 0.022 ounces of gold per ton and 0.42 percent copper...

Suggestions for Future Exploration

Further detailed work on the contact zones of the Nipissing-type gabbro with the Huronian rocks should be carried out to investigate the possibility of gold and gold-copper quartz-carbonate vein mineralization.

Detailed radioactivity surveys over areas underlain by rocks of the Mississagi Formation, for instance south of Ashigami Lake in Scadding and Davis Townships, are needed to determine the uranium potential of the quartz pebble conglomerate and the pyritiferous arkose found in this formation.

Exploration of the Nipissing gabbro within the Wanapitei Lake Area and on a regional basis is probably warranted in view of large tonnage, low-grade, copper-nickel deposits possibly associated with the Nipissing gabbro.

1 All information, if not otherwise stated, from Assessment Files Research Office, Ontario Geological Survey, Toronto and Resident Geologist's Files, Ontario Ministry of Natural Resources, Sudbury.
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Thomson, J.E.
No. 20  Cobalt Area, District of Timiskaming

John Wood

Introduction

Reconnaissance compilation mapping of the Cobalt area bounded by Latitudes 47° 15' N and 47° 30' N and Longitudes 80° 00' W and the Quebec Border, an area of some 1000 km² was carried out in the 1978 field season. The approximate geographic centre of the area is the town of Latchford. Access to most of the area is by road or water, in the west aircraft are required if long portages are to be avoided.

About one-third of the area, around the town of Cobalt has been mapped recently (Thomson 1956, 1963a, 1963b, 1963c, Lovell and de Grijs 1976) and one sixth mapped in 1925 (Todd 1926). The remainder had not previously been mapped. The mapping done in 1978 is intended as the first phase of further detailed studies in the Cobalt area.

Mineral Exploration

Since the discovery in 1903 of silver in what is now the town of Cobalt, mineral production and exploration have been continuous. Petruk et al. (1971) estimated that 19 million kg of silver, 20.4 million kg of cobalt, 7.3 million kg of nickel and 2.3 million kg of copper had been mined. Details of mineral exploration in the area are voluminous.

General Geology

Cobalt Group (Huronian) sedimentary rocks of Middle Precambrian age underlie most of the map-area. They unconformably overlie Early Precambrian rocks comprising: mafic to felsic metavolcanics; interflow metasediments that are usually fine grained, finely bedded, and siliceous but locally are carbonaceous; conglomerates and sandstones of the Timiskaming ‘Series’; granitic stocks such as the Lorrain Granite; migmatitic complexes of metavolcanics and granitic rocks; and mafic intrusive rocks. The Huronian rocks are intruded by the Middle Precambrian Nipissing Diabase and Late Precambrian (Keewanian) diabase.

The Early Precambrian rocks are exposed in the southwestern, and eastern parts of the area (see Card and Lumbers Map 2361).
The younger Early Precambrian supracrustal rocks, conglomerate and sandstone of the Timiskaming Series, outcrop in the northeastern part of the area. Stratigraphic top determinations from crossbedding indicate that they have been tightly folded, bedding dips in the order of 80 degrees are common. These metasediments overlie metavolcanics ("Keewatin") that change composition from north to south. The most northerly or stratigraphically highest exposures are felsic, and consist of flows and tuffaceous rocks. Thomson (1963a) considered some of these rocks to be of sedimentary origin. The felsic rocks are interdigitated with and overlie pillowed and/or porphyritic intermediate and mafic metavolcanic flows. Siliceous and carbonaceous metasediments occur between the flows. These metavolcanics occur in and a few kilometres around the town of Cobalt, and comprise the basement where silver mineralization occurs. Further to the south the intermediate and mafic metavolcanics become more massive (Lovell and de Grijs 1976).

The supracrustal rocks are intruded by mafic dikes and sills, generally referred to as "Haileyburian". In the southern part of the eastern occurrence of Early Precambrian rocks the Lorrain Granite, consisting of granite, quartz monzonite, syenite and aplite (Lovell and de Grijs 1976) intrudes the Early Precambrian supracrustal rocks. There are some inclusions in the peripheral parts of the granite body (Lovell and de Grijs 1976). However overall the intrusion has sharp contacts and is inclusion free.

All of the Early Precambrian supracrustal rocks in the eastern part of the map-area are of low metamorphic grade. In contrast those in the southwestern part of the area are part of a migmatite complex. The granitic component of this complex has a range of composition from mafic to felsic, and many compositions may be represented on one outcrop. Mafic rock is the recognizable non-granitic component of the complex, however it is not clear whether the original mafic rock was intrusive or extrusive in nature.

If these felsic rocks in the migmatitic complex are part of the same sequence as those in the eastern part of the area, they have been eroded to a much deeper level than those to the east and northeast, and may therefore be older.

The flat lying to gently dipping Middle Precambrian sedimentary rocks of the Huronian Supergroup overlie Early Precambrian rocks with profound unconformity. The erosional level of the Early Precambrian rocks is essentially the same now as when the Huronian Supergroup rocks were deposited. Topographic relief must have been at least 300 m. As a result facies changes are abundant in the Huronian rocks, and inliers of Early Precambrian rocks are common.

The lowermost part of the Huronian succession is a sequence of clast supported conglomerate, matrix supported conglomerate, sandstone and mudstone. Some of the matrix supported conglomerates are spectacular in that they contain large boulders, up to 3 m in diameter set in a sand and mud matrix. Coarsening upward sequences are common. The rocks are considered to be of fluviolacustrine origin. These rocks form an extensive mappable unit which has been named the Coleman Formation by Thomson (see Thomson 1956, 1963a,b,c).

Overlying, apparently conformably, the conglomerate sequence is a sequence of fine-grained mudstone and sandstone. The basal part of this sequence is a black shale. This passes upwards into grey-black shale, then grey shale, finely interbedded grey silt and green-grey shale, finely interbedded red brown shale and grey-green very fine-grained sandstone. The red-brown shale and grey-green sandstone constitute the bulk of the sequence, at the top of which the shale disappears, the sand becomes red and coarser grained, and the sequence passes into the overlying Lorrain Formation. Ripple-marks are common. This sequence of shale, siltstone and sandstone can be identified and mapped over an extensive area and has been classed as the Firstbrook Formation by Thomson (1956, 1963a,b,c). Robertson et al. (1969) suggest that the name Gowganda Formation be retained for the conglomeratic, and the finely bedded fine grained, sequences together.

The general distribution of the Gowganda Formation is given on Map 2361 (Card and Lumbers 1977), however 1978 fieldwork has shown many changes in detail. Two large scale changes are in the northwestern part of Barr Township and in eastern Brigstocke Township where the Gowganda Formation is less extensive than shown. In the vicinity of Anima-Nipissing Lake a white to cream weathering subarkose to arkose unit occurs within the upper part of the finely bedded Firstbrook sequence.

The contact with the overlying Lorrain Formation is conformable. The contact relationship varies from a simple transition to a complex interbedding of rocks typical of both formations. The Lorrain Formation is a sequence of arkose, subarkose, quartz arenite, and mudstone. Outcrops may be white, cream, grey, flesh coloured, red, or light green. Cross-bedding is common. The composition of the rocks in the Lorrain Formation is dependant on basement topography and composition; thus there is no straightforward stratigraphic subdivision. The distribution of the Lorrain Formation is more extensive than shown on Map 2361 (Card and Lumbers 1977), it is present south of Highway 558 in Barr and Firstbrook Townships and also east of Anima-Nipissing Lake.

The Nipissing Diabase occurs as an undulating sheet with dike-like portions. It has intruded the Huronian and Early Precambrian rocks with equal facility. There are two rock-types that constitute these intrusions. The most common is a dark green and grey quartz diabase, the typical Nipissing Diabase; less common is a brown grey weathering hypersthene diabase.

Olivine diabase of Late Precambrian age forms long narrow dikes and is the youngest Precambrian rock type.

Dolomite, limestone and shale of Ordovician and Silurian age that unconformably overlie the Precambrian rocks occur only in the northeastern part of the area.

Quaternary sediments cover much of the area, however they are thickest in the northern third, in the Townships of Barr, Firstbrook and Bucke, and west of Cobalt. There are a number of sand and gravel operations adjacent to Highway 11 just to the north of the intersection of 11 and 11B.
The silver deposits for which Cobalt is famous occur in the metavolcanics suggesting that folding in two directions has affected these rocks. The Lorrain granite is later than the folding whereas in the southwestern part of the area the granitic rocks are intimately intermingled with the supracrustal rocks. The Early Precambrian bedrock in the eastern part of the area may represent a higher crustal level than that in the southwestern part of the area.

The Huronian strata are almost flat-lying, folding is restricted to supratenuous folds.

Faults of at least two ages can be documented. The most obvious belong to the Lake Timiskaming Fault System (Lovell and Caine 1970) and have a northwest strike. On a smaller scale near Cobalt there are a northwest and northeast set of faults which are of Middle Precambrian age and have been of importance in mining at Cobalt (see Jambor 1971).

Economic Geology

The silver deposits for which Cobalt is famous occur in veins, generally only a few centimetres wide, in Early Precambrian rocks, Huronian rocks, or Nipissing Diabase. The bulk of production at Cobalt has come from veins in the Coleman sedimentary rocks. Since the veins occur where Nipissing Diabase has cut the uppermost parts of the metavolcanics and Huronian sedimentary rocks overlying the metavolcanics, further silver mineralization may occur in two areas. These are: a) depth to Early Precambrian basement is not known; b) the composition of the Early Precambrian basement is not known; c) the location of the Nipissing Diabase often is unknown. A program of geophysical techniques allied to drilling could indicate the presence or absence of the trinity and indicate the potential for Cobalt-type mineralization. This assumes that the silver has not been derived from a unique localized source within the Cobalt area.

The potential for base metal mineralization in the Early Precambrian rocks should be considered. Chalcopyrite, sphalerite and galena, disseminated and in stringers occurs in the metavolcanics and interflow metasediments near Cobalt. These rocks could be considered part of the Temagami or Abitibi “greenstone” belts and thereby have equal mineralization potential. Again the capability to explore under the Huronian cover to the west would expand this potential.

The presence of disseminated stratiform sulphide mineralization in the basal Huronian (see Jambor 1971) represents an as yet untapped exploration potential. Although no highly anomalous radioactivity was encountered in the Huronian sedimentary rocks, the potential for this in the area and the Cobalt Embayment in general cannot be ruled out.

The most apparent thriving mineral industry in the Cobalt area is the aggregate industry. There are many sand and gravel pits in the area. The quarries in Paleozoic rocks are now unused, but presumably represent a resource capable of being used at any time.

References


1963b: Geological Map of the Cobalt Silver Area, Northwestern Sheet; Ontario Dept. Mines, Map 2051, scale 1 inch to 1000 feet.

1963c: Geological Map of the Cobalt Silver Area, Southeastern Sheet; Ontario Dept. Mines, Map 2052, scale 1 inch to 1000 feet.

No. 21 Long Lake Area, Frontenac County

J.M. Wolff

Location and Access

The Long Lake area covers about 250 km² and is bounded by Longitudes 76°45'W and 77°00'W and Latitudes 44°37'30"N and 44°45'N. The villages of Arden and Mountain Grove are located in the northern half of the area.

Access to much of the field area is provided by Highway 7 and a good network of secondary roads extending southwards. The Salmon River provides navigable water access to the western part of the area and Long Lake intersects the eastern border.

In 1978 the writer completed detailed mapping of the Long Lake area as part of the continued detailed mapping of the Hastings Basin-Frontenac Axis segments of the Central Metasedimentary Belt (Wynne-Edwards 1972). In the southern Grenville Province. The adjacent map sheet to the west had been mapped by the author in 1977 (Wolff 1978).

Mineral Exploration

Mineral exploration in the map-area has been sporadically active since the turn of the century. In 1897 L. Benn discovered the first zinc at the present site of the Long Lake mine. This particular deposit has been worked at various times since. The chief periods of activity are summarized in Table 1. At present this mine is inactive although most of the mill is still present.

Exploration for copper and nickel was active in the area from 1956 to 1957. The efforts were mainly concentrated west of O'Reilly Lake by Sharbot Lake Mines Limited. Four thousand metres of diamond drilling in 17 holes revealed a sulphide bearing zone 230 m long by 45 m wide to a depth of 312 m. The highest values reported were 0.3 percent for both copper and nickel with 0.14 percent cobalt in a 7.6 m wide zone (Assessment Files Research Office, Ontario Geological Survey, Toronto).

Assorted surface exploration work since 1950 for zinc, uranium and molybdenum in the area have not produced promising results (Assessment Files Research Office, Ontario Geological Survey, Toronto).

Building material was quarried south of Mountain Grove from 1936 to 1942 (lot 11, concession III, Olden Township), in anorthositic gabbro. This material was used for roofing and stucco purposes by Building Products Limited, Montreal (Harding 1947).

General Geology

The bedrock of the map-area is composed of a number of different stratified and massive formations which are divided into three major groups (listed in order of apparent decreasing age).

1) Grenville Supergroup metasediments and metavolcanics group composed of well foliated to gneissic rocks which can be divided into five subunits.
   a) Mafic to silicic gneisses and related anatectites.
   b) Mafic to intermediate metavolcanics.
   c) Clastic siliceous gneisses.
   d) Carbonate metasediments including calc-silicate material.
   e) Amphibole rich gneisses and schists.

2) Syntectonic metamorphosed felsic to intermediate intrusive rocks composed of a number of discrete "granitic" intrusive bodies with fabrics ranging from well lineated to gneissic and divided into four subunits.
   a) The Sheffield and Hinchinbrooke gneiss complex-
TABLE 1

<table>
<thead>
<tr>
<th>Period</th>
<th>Exploiter</th>
<th>Work/Tonnage</th>
<th>Value</th>
</tr>
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<tbody>
<tr>
<td>1897-1913</td>
<td>J. Richardson &amp; Sons</td>
<td>3 497 t Zn ore</td>
<td>$41,500</td>
</tr>
<tr>
<td>1914-1915</td>
<td>optioned by: Long Lake Zinc Co.</td>
<td>dewatered mine, surface exploration,</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>300 m of D.D.H.</td>
<td></td>
</tr>
<tr>
<td>1947-1950</td>
<td>optioned by: Rochette Gold Mines Co. Ltd.</td>
<td>117 t Zn, 9 t Pb</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>25 D.D.H.</td>
<td></td>
</tr>
<tr>
<td>1966</td>
<td>optioned by: Mid-South Explor. Ltd.</td>
<td>surface exploration</td>
<td></td>
</tr>
<tr>
<td>1970-1974</td>
<td>optioned by: Lynx-Canada Explor. Ltd. and</td>
<td>re-opened mine</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Reynolds Metal Co.</td>
<td>10 668 m D.D.H.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>9 618 t Zn</td>
<td>$1,277,000</td>
</tr>
</tbody>
</table>

*t = metric tonne

es: the Sheffield is an interbanded granite-quartz monzonite and trondhjemite-granodiorite gneiss; and the Hinchinbrook is a grey buff quartz-plagioclase-pyroxene gneiss.

b) The Northbrook Batholith is well lineated to foliated and compositionally varies from trondhjemite to granite.

c) The Abbotts Hill intrusion varies from trondhjemite to quartz monzonite with local granite phases and is massive to weakly foliated.

d) The Addington intrusion is a lit-par-lit granite to quartz monzonite body.

3) Late tectonic unmetamorphosed intrusive rocks composed of massive mafic and felsic intrusions which can be divided into three subunits.

a) The Mountain Grove mafic intrusion varies compositionally from gabbro to anorthositic gabbro with local syenite zones.

b) The McLean granitic pluton which is composed of granite to quartz monzonite with minor syenite. Foliation is well developed near the margins but a massive porphyritic interior prevails. Offshoot granite pegmatites are part of this intrusive event.

c) Undifferentiated mafic dikes.

Group 1 and group 2 rocks have been metamorphosed to the medium to high temperature portion of medium-grade metamorphism as described by Winkler (1976). In the southeast corner of the map-area metamorphism reaches the regional hypersthene zone (granulite high grade) as described by Winkler (1976).

New information of importance since Harding (1947) mapped the area includes: the delineation of several intrusive bodies of different ages; the continuity along strike of several metasedimentary and metavolcanic units of the Grenville Supergroup; and the recognition of a major shear zone trending N50E across the map-area.

Pleistocene sand and gravel deposits dot the area with the thickest deposits being found in the shear zone mentioned above.

Structural Geology

The structural setting of the map-area can be divided into two major zones which are separated by the late stage regional shear zone running northeast-southwest through the village of Mountain Grove. The western zone is the northern extension of the Clare River Synform. The synform is part of a second deformation event and has isoclinally folded a pre-existing foliation-gneissosity and schistosity which trends N50E with moderate dips. The synform itself has an axial trace which essentially parallels the foliation of the first deformation. Minor folds in the Clare River Synform close northeasterly and exhibit lineations that generally plunge shallowly S55W.

The eastern structural zone is the northwestern portion of the Frontenac Axis and consists of a large scale synform of metavolcanics and metasediments which has been intruded by late stage felsic and mafic plutonic rocks of group 3 above. This synform, part of the second deformation event, has a northeast-trending axis. Evidence of the first deformation event is presented by a moderately dipping well developed foliation-gneissosity in these rocks which trends N55E, dipping south, and S80W, dipping north, respectively on each limb of the synform.

Faulting in the map-area is chiefly a late stage event. A prominent shear zone separating the two structural zones contains well developed mylonites of all the rock types adjacent to the zone. This prominent shear zone is continuous and often filled with Pleistocene sand and gravel deposits.
Jointing in the area is generally very steep to vertical and can be grouped into three prominent sets trending north, N50E and S50E.

Economic Geology

The area possesses economic potential for the metals zinc, lead, nickel, copper and cobalt plus possible building stone material and aggregate deposits.

Zinc and minor lead were mined successfully at the Long Lake mine until December 1974. Mined to approximately the 65 m level, this deposit likely has more ore at depth as the ore zone is folded in en echelon geometry. The ore bearing host can be followed along strike with some difficulty as it is faulted and two localities have favourable geological settings to warrant further exploration for sphalerite horizons.

The known nickel, copper and cobalt concentrations west of O'Reilly Lake may prove to have future potential but are not presently economic.

Results of the joint Federal-Provincial Uranium Reconnaissance airborne gamma-ray spectrometric maps (GSC 1976) indicated a number of small anomalies in the map-area. None of these yielded any uranium mineralization.

The late tectonic gabbro and granite intrusive bodies (group 3 above) may have some potential as sources of building stone. Deposits of sand and gravel are presently being worked by local operators based in Mountain Grove and Arden.

References

GSC

Harding, W.D.

Shklanka, R.

Thomson, J.E.

Uglow, W.L.

Winkler, H.G.F.

Wolff, J.M.

Wynne-Edwards, H.R.
No. 22  Khartum Area, Renfrew County
S.G. Themistocleous

Location

The Khartum area is bounded by Longitudes 77°00'W to 77°15'W and Latitudes 45°15'N to 45°22'30"N and covers about 250 km². The village of Griffith lies approximately 0.5 km southwest of the map-area, and the town of Renfrew lies approximately 49 km northeast of the map-area. Access to much of the eastern area is provided by Highway 41 and several gravel roads, used for lumbering. Access to the western part of the map-area and to the Highland Lake area is provided by a gravel road from Highway 41 west of the village of Griffith.

Mineral Exploration

Exploration has been carried out for molybdenum and uranium at a number of localities.

Before the turn of the century mineral exploration for molybdenum was carried out at numerous localities, in the eastern part of the area (Satterly 1944). This activity resulted in the discovery and development of economic molybdenum deposits during the early 1910s in the area around Jeffers Lake. Several shafts and trenches are still evident remnants of this activity.

The past producing Spain mine is located in Griffith Township, lot 31, concession IV, about 200 m east of Highway 41. The mine was opened in 1912 and developed in 1915 and 1916; the workings consisted of a large open cut, a shaft and about half a dozen small pits. Between 1916 and 1919, 105 t of ore were treated, yielding 3663 kg of MoS₂ and 270 kg of concentrate (Assessment Files Research Office, Ontario Geological Survey, Toronto). In 1939 the property was acquired by North American Molybdenum Corporation Limited which did some stripping and trenching and diamond drilling totalling 1212 m. Later, the property was sampled and drilled in 1965-1966 by New Far North Exploration Limited (Assessment Files Research Office, Ontario Geological Survey, Toronto). The property is now owned by G.G. Tobias of Williamburg, Dundas County.

Exploration for uranium was carried out by Imperial Oil Limited in Brougham Township in lots 29 to 33, concession XVII, lots 29 to 34, concession XVIII, and lots 28 to 33, concession XIX, in 1976 and 1977. Their work consisted of detailed geological mapping, a radiometric survey and diamond drilling; the company put down three diamond drill holes, located in lots 31, 32, concession XVIII, Brougham Township, totalling 126 m testing radiometric anomalies in granite pegmatites. The highest value obtained was 0.035 percent U₃O₈ over 0.6 m, in a granite pegmatite. Diamond drill logs for five holes located in lot 30, concession V, Griffith Township, were submitted by Conrad Uranium Mines Limited in 1957, for assessment credit. These drill holes totalled 80 m testing granite pegmatites for uranium.
General Geology

The Khartum area lies within the Late Precambrian supracrustal sequence, 10 to 20 km southeast of the boundary between Middle and Late Precambrian supracrustal sequences in the Grenville Province (Ayres et al. 1971). The Late Precambrian supracrustal rocks are a northeast trending belt which structurally overlies the northwest belt is composed of thickly bedded, coarsely recrystallized feldspathic arenite, calcareous shale (amphibole gneiss), wacke, feldspathic arenite and quartzitic arenite. Most of the central portion of the map area is underlain by several large granitic and syenitic plutons which separate the metasediments into two northeast-trending belts: (1) a northwest belt and (2) a southeast belt. These rocks were subjected to regional metamorphism which caused coarse recrystallization, deformation and conversion of these rocks into gneiss. The mineral assemblages are indicative of upper almandine-amphibolite facies temperature and pressure metamorphic conditions.

The northwest belt of metasediments is a sequence of thickly bedded, coarsely recrystallized feldspathic arenite, carbonate and calcareous metasediments. Late tectonic sills and dikes of gabbro, syenite, granite pegmatite, and diabase intrude these metasediments. The southeast belt which structurally overlies the northwest belt is composed of several thick marble units intercalated with feldspathic arenite and calcareous metasediments. This belt of metasediments is intruded by numerous minor metagabbro dikes. The Balvenie syenite as well as late granite pegmatite, diabase and gabbro dikes.

Several alkalic intrusive bodies of various ages were mapped throughout the area. The mafic plutonic rocks in the area are contained mainly within a large metagabbro sill, exposed south of Highland Lake and north of Beaver Lake. This sill is in contact with syenite to the northwest and carbonate metasediments to the southeast. Numerous minor metagabbro dikes intrude the carbonate metasediments parallel to the gneissosity and are boudinaged.

Several metamorphosed mafic to felsic intrusive bodies of various ages were mapped throughout the area. The mafic plutonic rocks in the area are contained mainly within a large metagabbro sill, exposed south of Highland Lake and north of Beaver Lake. This sill is in contact with syenite to the northwest and carbonate metasediments to the southeast. Numerous minor metagabbro dikes intrude the carbonate metasediments parallel to the gneissosity and are boudinaged.

Further Metasedimentary Rocks

Several sets of faults were observed; a major east-trending set with a vertical movement related to the Ottawa-Bonnechere Graben (Kay 1942) north of the map area; a minor north-trending set with a vertical movement; and a minor northeast-trending set of thrust faults which are characterized by the development of mylonite and gouge zones.

Structural Geology

The northwest metasedimentary belt exposed west-northwest of Three Mountains and Waterfall Mountain has a generally northeast-trending gneissosity which for the most part dips to the southeast except north of Tincamp Lake where the metasediments dip steeply to the north. This local deflection is due to the Three Mountains pluton.

Three sets of faults were observed; a major east-trending set with a vertical movement related to the Ottawa-Bonnechere Graben (Kay 1942) north of the map area; a minor north-trending set with a vertical movement; and a minor northeast-trending set of thrust faults which are characterized by the development of mylonite and gouge zones.

Lineations and fold axis plunge shallowly east to southeast.

Economic Geology

Molybdenum mineralization at the past-producing Spain mine in Griffith Township occurs within amphibole-pyroxene-feldspar gneiss which is overlain and underlain by coarsely recrystallized limestone, and cross cut by barren, thick (1 to 8 m) granite pegmatite and thin syenite pegmatite dikes which were intruded along joint surfaces. The mineralization consists of disseminated pyrite-pyrrhotite-molybdenite in veinlets and as disseminations within the amphibole-pyroxene-feldspar gneiss. Brecciated sulphide veins crosscut and parallel the gneissosity. The syenite dikes are also mineralized. Because the better mineralization exposed is confined to shear zones and joint surfaces it is probable that the mineralization was emplaced during...
faulting. The same favourable geology was traced north-east of the Spain mine and west of Jeffers Lake where a rusty sulphide zone is exposed in which a few specks of molybdenite were observed.

A spectrometer (TV-1 McPhar) survey undertaken during the field work indicated that magnetite-bearing granite pegmatites in the area are radioactive. Selected grab samples collected by the field party from Griffith, Sebastopol and Brougham Townships were analyzed by the Geoscience Laboratory, Ontario Geological Survey. These selected samples show that most of the radioactivity is due to the high thorium content except one sample from east of Merchands Lake, lot 34, concession IV, Griffith Township, which returned values of 0.11 percent U$_3$O$_8$, 5.0 percent Th and 4.98 percent K$_2$O. A large (640 by 290 m) radioactive body of granite pegmatite located 2.4 km south of Beaver Lake, has spot areas of 10 to 20 times background radioactivity and warrants further work.

The Spain mine area is another radioactive area of potential economic interest, from which no analytical data are as yet available for the radioactive locations indicated by spectrometric investigation during the 1978 field season. The Spain radioactive mineralization is associated with the sulphide mineralization, the granite pegmatite dikes and the brecciated zones.

References


GSC

Kay, M. G.

Satterly, J.
No. 23   Southern Renfrew County
S.B. Lumbers

Location

During the 1978 field season, geological reconnaissance mapping of Renfrew County south of 45°30'N was completed and some reconnaissance work was carried out in selected areas of the adjacent Counties of Hastings, Lennox and Addington, Lanark, and the District of Nipissing. Most of the area covered was mapped previously at various scales and levels of detail by Satterly (1944), Hewitt (1954), Quinn et al. (1956) Evans (1964), and Livingston et al. (1974). The present work, initiated in 1977 (Lumbers 1977), completed previously unmapped portions of Renfrew County and revises the older mapping to provide an updated geological base for metallogenic and other studies.

Mineral Exploration

The area contains a large variety of mineral deposits, most of which have been described previously by Satterly (1944), and Quinn (1952). Metallic deposits of iron, molybdenum, and uranium and rare earth minerals are numerous and widespread throughout the area; deposits of beryllium, copper, gold, magnesium, lead, strontium, and zinc are also known but restricted in their distribution. Non-metallic deposits consist of apatite, asbestos, clay, corundum, feldspar, fluorite, garnet, graphite, marl, mica, nepheline, peat, pyrite (sulphur), stone, tourmaline, and sand and gravel. Many of the deposits are small and of low economic potential, but some production has been attained from deposits of asbestos, clay (for production of brick and tile), beryllium, corundum, feldspar, graphite, iron, lead, mica, magnesium, molybdenum, pyrite, stone, and strontium. Present production is confined to stone and sand and gravel used for local construction purposes, clay (the Dochart Brick and Tile Company of Arnprior),

LOCATION MAP

Scale: 1:1 584 000 or 1 inch to 25 miles
magnesium produced from dolomitic marble in Ross Township by Chromasco Limited, and rose quartz and beryl obtained from pegmatite bodies in Lyndoch Township by Wal Gem Lapidary Company of Quadeville.

General Geology

Several major aspects of the geology were described previously (Lumbers 1977). Bedrock in the area is dominated by Late Precambrian supracrustal and intrusive rocks of the Grenville Province of the Precambrian Canadian Shield. Except for late dikes of diabase, granite pegmatite, and a few small syenite bodies, all of the Precambrian rocks were deformed and recrystallized into gneisses by a Late Precambrian high rank regional metamorphic event. In the eastern part of the area, Paleozoic strata, consisting of limestone, dolostone, shale, and sandstone, are preserved in down-thrown blocks developed along major faults of the Ottawa-Bonnechere Graben that extends along the eastern and northern parts of the area (Lumbers 1977).

Work during the 1978 field season shows that a large batholith of anorthosite suite rocks, just recently mapped in the Pembroke and Mattawa—Deep River areas (Lumbers 1977), extends southward into the present map-area and underlies northwestern Brudenell, northern Radcliff, Jones, Lyell, and most of Wicklow and Bangor Townships. Both general reconnaissance and more detailed studies suggest that 1) the batholith extends westward beyond the map area to at least Highway 11 in the region between the towns of Burke’s Falls and Huntsville; 2) the batholith underlies much of Algonquin Provincial Park; 3) the batholith extends southward, possibly to known Late Precambrian supracrustal sequences exposed between Maynooth on Highway 62 and Halls Lake on Highway 35 (Ayers et al. 1971); 4) granitic and syenitic rocks dominate the batholith; and 5) the batholith is probably earliest Late Precambrian in age (1.5 to 1.6 b.y., Lumbers and Krogh 1977) and older than Late Precambrian supracrustal and intrusive rocks that constitute the Grenville Province of southeastern Ontario (Ayers et al. 1971).

In the Pembroke area, the batholith is overlain unconformably by a basal arkose unit which forms the lowest part of the Late Precambrian supracrustal sequence (Lumbers 1977). In the present map-area, the batholith is also overlain by a basal arkose unit in northern Brudenell Township, but to the southwest in central Radcliffe, and southern Bangor and Wicklow Townships, this basal unit becomes coarser in grain size and fragmental and consists of coarse grained, feldspathic, micaceous, and pebbly to boudery metasediments, metasediments derived from siliceous and calcareous shales and siltstones, and minor siliceous limestone. The basal unit shows a facies change southeastward across the strike into a carbonate-rich sequence in which marble and calc-silicate metasediments greatly predominate over local units of silt, shale, and moderately to well sorted sandy metasediments.

Outliers of the basal unit occur within the batholith up to 20 km northwest of the main unconformity. Some of these outliers contain thin, intercalated marble units no more than a few metres thick. In southern Raglan and northern Ashby and Denbigh Townships, the carbonate-rich sequence passes into a metagreywacke-rich sequence containing subordinate felsic and mafic metavolcanics.

As outlined previously (Lumbers 1977), a large variety of intrusive rocks were emplaced within the Late Precambrian supracrustal sequence, mainly before the culmination of regional metamorphism. These rocks can be subdivided into about seven distinct groups based upon relative age relationships and lithology (Lumbers 1977), but two of the groups account for most of the intrusive rocks. One of these two groups, symmetamorphic gneissic alkalic syenite and granite, is confined to the northern margin of the Late Precambrian supracrustal sequence where it forms an almost continuous intrusive complex extending for over 160 km southwestward from the Ottawa River in Westmeath Township to at least Glaveng Township west of Bancroft. This group consists mainly of alkalic syenite, iron rich to alkalic granite, locally abundant nepheline syenite, and minor rocks of the anorthosite suite. Locally, massive, undeformed phases of the alkalic syenite and granite are present within the complex. In Renfrew County, late (post metamorphic) veinlets of alkalic pyroxene are common and widespread, and carbonate-rich dikes and late fluorite-potassic feldspar-apatite-calcite pegmatite dikes are present in both alkalic syenite and granite phases. The other most abundant group constitutes a biotite diorite suite (Lumbers 1967) and is marked by abundant granodiorite, trondhjemite, albitic syenite, tonalite, and diorite. This group forms several stocks and batholithic complexes that lie south of the complex of alkalic syenite and granite and is older than the alkalic syenite and granite group. To the southwest of the map-area, the biotite diorite suite is about 1250 ± 25 m.y. old (Lumbers 1967), and the suite is associated in both space and time with metavolcanics.

Late Precambrian high rank regional metamorphism caused most of the supracrustal and intrusive rocks to be coarsely recrystallized and deformed into gneiss. Mineral assemblages indicate that the metamorphism culminated at the temperature and pressure conditions of the upper almandine amphibolite facies throughout most of the area. In the eastern part of the area, particularly in McNab Township and near metavolcanic rich portions of the sequence, the grade of metamorphism decreases (Lumbers 1977). During the waning stage of regional metamorphism, white, pink, and dark red granite pegmatite dikes were emplaced throughout the various gneissic supracrustal and intrusive rocks (Lumbers 1977). In southeastern Renfrew County, particularly in McNab and Bagot Townships, several calcite fissure veins and rare dolomite pyrite fissure veins cut across marble-rich portions of the Late Precambrian supracrustal sequence. The veins are post Middle Ordovician in age and are associated with faults of the Ottawa-Bonnechere Graben. The calcite fissure veins contain a large variety of minerals, chief
among which are barite, celestite, pyrite, pyrrhotite, galena, sphalerite, and hematite.

Structural Geology

Some major aspects of the structural geology were outlined previously (Lumbers 1977). Structural data indicate that during the Late Precambrian high rank regional metamorphism, the batholith older than the Late Precambrian supracrustal sequence was reactivated and possibly rose as a series of small secondary diapirs into the higher density, ductile supracrustal rocks. Both the batholith and the supracrustal rocks are characterized by numerous zones of subhorizontal foliation with intervening zones of shallow to steeply dipping foliation. Recumbent folds are common both within the batholith and the supracrustal rocks. All rocks near the unconformity are markedly strained and exhibit a prominent southeasterly plunging lineation. Some of the larger felsic plutons within the Late Precambrian supracrustal sequence also appear to have undergone diapirism during the regional metamorphism. The structural geology is further complicated by superimposed open folds which probably formed during cooling and uplift stages following culmination of the regional metamorphism. Many of the late granite pegmatite dikes are localized in these late open folds.

Economic Geology

Data are now sufficient to relate most of the mineral deposits in Renfrew County to specific geological environments. Details concerning these relationships will be published upon compilation of all the data. Some major results concerning mineralization are briefly summarized below.

1. Most concentrations of iron occur either as primary magmatic segregations in rocks of the gneissic alkalic syenite and granite group or as contact metasomatic deposits associated with rocks of the biotite diorite suite. Thin units of iron formation are found sparingly in shaly metasediments intercalated with the carbonate-rich sequence. Minor concentrations of iron are found in the post Middle Ordovician calcite fissure veins.

2. Concentrations of uranium and rare earth elements are associated with rocks of the gneissic alkalic syenite and granite group, with late granite pegmatite dikes, and with skarn containing late granite pegmatite dikes. Known concentrations of these elements appear to be small and localized in all of these environments; uranium mineralization in late granite pegmatite dikes is commonly associated with local concentration of biotite and/or pyrite.

3. Most concentrations of molybdenum are associated with skarn and pyrite-pyrrhotitic zones developed at the margins of biotite diorite suite intrusions and with skarns developed at the margins of large late granite pegmatite dikes. Minor molybdenum mineralization is common within late granite pegmatite dikes.

4. Apatite, beryllium, corundum, fluorite, nepheline, and zircon concentrations are confined to rocks of the gneissic alkalic syenite and granite group. This group also contains local concentrations of titanium, chiefly in the form of titanite.

5. Concentrations of lead and strontium are confined to post Middle Ordovician calcite fissure veins.

6. Concentrations of zinc are confined to dolomite marble (Lumbers 1977) or to post Middle Ordovician calcite fissure veins.

7. Concentrations of gold are lacking in the area, and concentrations of copper are rare.

References


Introduction

This report summarizes results of a detailed geological survey of Precambrian rocks within Harvey Township, southern Ontario. The primary objectives of the program were to define regional stratigraphy and structure; concurrently known mineral deposits were examined. The field work outlined and defined a narrow belt of mafic to felsic metavolcanics (previously unreported and/or mapped as metasediments) and located several small occurrences of copper and zinc within this rock succession.

Location

Harvey Township is located in Peterborough County and covers approximately 600 km² of which some 350 km² are underlain by Precambrian rocks. The township is situated between Latitudes 44°27' and 44°44'N, and Longitudes 78°10' and 78°35'W; the small village of Buckhorn is located in the south-central portion of the township whereas the village of Burleigh Falls occupies the southeastern corner. Primary access is via Highway 36 from Bobcaygeon, in the west, or through Burleigh Falls in the east; Highway 28, from Peterborough, joins Highway 36 at Burleigh Falls, and Highway 507 crosses the township in a north-south direction from Flynn's Turn to Missisagua Lake.

Mineral Exploration

Mineral exploration within Harvey Township has been principally concerned with the re-evaluation of known uraniferous-bearing pegmatite dikes and sills as well as a search for potentially new economic deposits of uranium. Uranium exploration within the township began in the early 1950s and had reached its peak by 1960. Since that date few programs have been undertaken, the latest and largest being initiated by Imperial Oil Limited in 1975-1976. Exploration for base metal deposits has been virtually nonexistent.

General Geology and Structure

The map-area (covered by aeromagnetic map 103G, GSC 1949) is located within the southern portion of the Harvey-Cardiff tectonic arch, a 80 km long northeasterly trending zone of gneiss domes and associated, peripheral uranium-bearing pegmatite dikes and sills (Bright 1975).
The Burleigh Gneiss Dome underlies the entire eastern portion of the map-area and is structurally overlain by isoclinally folded metasediments and metavolcanics. To the west the metasediments which grade into migmatitic rocks of the gneiss dome are intruded and overlain by mafic metavolcanics. The central portion of Harvey Township, from Pigeon Lake to Mississagua Lake, is underlain by a relatively thick succession of mafic to felsic metavolcanic flow and pyroclastic rocks with subordinate epilastic metasediments and coeval intrusive rocks. These, along with the metasediments and migmatites to the east, have been intruded by a series of weakly foliated granite and granodiorite dikes, sills, and plutons. Much of the map-area, particularly the southern portion is underlain by limestone of Ordovician age.

The Burleigh Gneiss Dome dominates the regional structure, its emplacement having refolded the previously folded metasediments and metavolcanics into a series of isoclinal, northeast-trending anticlines and synclines. The dominant foliation within the basement gneiss complex and the mantling rocks is similar and conforms to the general shape of the gneiss dome.

**Basement Gneiss Complex (Burleigh Gneiss Dome)**

The Burleigh Gneiss Dome contains the oldest rocks in the map area and these can be subdivided into two distinct units: an outer zone (1 by 5 km in width) composed of banded and migmatitic gneiss (recrystallized metasediments), and an inner core zone (2 by 7 km in width), which extends to the township's eastern border, composed of veined, layered, and nebulitic migmatite. Migmatites structurally underlie the banded gneiss unit in which the leucosome consists of stringers, veins, lenses, and diffuse swirls of fine to medium grained potassic feldspar, quartz, biotite, and magnetite. The leucosome is enclosed by a medium grained, granodioritic matrix of plagioclase feldspar, biotite, and quartz with minor hornblende and potassic feldspar. Compositonally complex, the banded to migmatitic gneiss unit encircles the basement complex with contacts either covered by Paleozoic limestone or marked by a wide zone of faulting, folding, and anatexis. Grading west and north into bedded metasedimentary rocks, the banded gneiss unit appears to represent thin to thickly banded, recrystallized wacke, sandstone and shale. Towards the top of the unit the percentages of quartz and potassic feldspar increase whereas those of biotite and plagioclase decrease; here rocks are less deformed and relict bedding, and graded and cross bedding are often observed.

Intrusive into both the migmatite complex and the banded gneiss unit are dikes, sills, and irregular shaped plutonic bodies of granite and granodiorite. These intrusions decrease in abundance towards the contact with metasediments and are, themselves, divisible into two distinct types. The oldest is a fine to medium grained, weakly foliated, fresh appearing granite and /or granodiorite composed of potassic feldspar, quartz, plagioclase, and biotite with accessory magnetite, apatite, and muscovite. The colour index of these rocks varies from nil to 10 percent. This unit also forms an elongate north-northeast trending pluton which underlies some 25 km² in the west central portion of the township.

The second and youngest intrusive unit forms veins, dikes, and sills composed of coarse grained to pegmatic granite, granodiorite, and quartz diorite. These rocks are intrusive into all other Precambrian rocks found within Harvey Township and contain almost all of the known uranium mineralization. Both fine grained and pegmatic granitic rocks can compose up to 65 percent of exposed outcrops of banded gneiss and migmatite.

**Metasediments**

Folded and well foliated quartz-feldspar-biotite-hornblende gneiss and schist, which exhibit relict and graded bedding, slump and flame structures, both flank and grade into the banded gneiss unit. These rocks are believed to represent less deformed and recrystallized equivalents of the banded gneiss and thus represent the upper portion of a once thick sedimentary succession; tops from graded and cross bedding support this conclusion. These rocks are often magnetite-rich and are thought to be recrystallized arkose, sandstone, and wacke.

**Metavolcanics**

A relatively thick succession (3.5 km) of mafic to felsic metavolcanics underlies the central portion of Harvey Township. Exposed over a 100 km² area these rocks form a north-northeast trending syncline which plunges gently to the southwest. Close to Mississauga Lake, mafic metavolcanic flows and/or dikes are interlayered with bedded metasedimentary rocks. The metavolcanics increase in abundance to the west and with tops facing west these mafic rocks appear to represent the base of the volcanic succession. Here the metavolcanics are feldspar-poor basalts, basaltic tuff, banded amphibolites, hornblendites, and gneissic gabbros. Their composition is variable but typically consists of hornblende, actinolite, epidote, magnetite, and carbonate with minor quartz, feldspar, talc, and biotite. Small amounts of magnetite-bearing ironstone are also present.

This succession repeats itself south of Pigeon Lake and both east and west of Nogies Creek. It grades upwards into feldspar phric basalt flows, amygdaloidal flows, flow breccia, tuff, and bedded basaltic clast sedimentary rocks which are interlayered, in their upper portion, with rhyolite and dacite. The felsic volcanic rocks increase in abundance towards the core of the syncline where they are composed of banded flows, small intrusions, and medium to coarse grained fragmental rocks. Interlayered with the felsic metavolcanics are a series of quartz-rich, sulphide-bearing schists and gneisses which have been interpreted as a continuous sequence of chemical precipitates, volcanic muds, and ash tufts. Felsic
metavolcanics and associated metasediments are estimated to compose some 25 percent of the volcanic succession.

A fine to medium grained quartz monzonite-quartz diorite intrusion occupies the core of the syncline. This intrusion is well foliated, elongate in a north-northeastern direction, and is some 1.5 by 3 km in size. It is intrusive into the upper portion of the volcanic succession but is itself, intruded by metarhyolite dikes and occurs as fragments in a volcanic breccia immediately north of Highway 36. Minor quantities of molybdenite, chalcopyrite, bornite, and pyrite are associated with the intrusion either as concentrations in small breccia zones or as widely scattered disseminations.

With the exception of the late granite and granodiorite intrusions all of the Precambrian rocks of Harvey Township were subjected to Late Precambrian regional metamorphism under conditions ranging from upper greenschist to upper amphibolite facies.

**Economic Geology**

Mineral exploration within Harvey Township was primarily restricted to the years 1950 to 1960 inclusive, and was concentrated on uranium mineralization associated with pegmatite dikes and sills (Satterly 1956). In view of the presence of felsic and associated mafic to felsic metavolcanics, and evidence of widespread pyroclastic volcanism, Harvey Township would appear to represent a potential target for base metal exploration.

**Sulphide Mineralization in Metavolcanic and Related Rocks**

Rusty zones, disseminations, stringers, and irregular streaks composed of pyrite with minor chalcopyrite, sphalente, and pyrrhotite are present in felsic metavolcanic flow and fragmental rocks, and in quartz-rich schists and gneisses of sedimentary-volcanic origin: 1) west of the Squaw River between Highway 36 and Pigeon Lake; 2) South of Pigeon Lake on lots 13, 14, and 15, concessions XI, XII, and the eastern part of XIII; and 3) north of Highway 36 between the Squaw River and Rockcroft.

Disseminations and narrow stringers of pyrite and chalcopyrite with minor molybdenite and bornite occur in zones of crackle breccia, along contact zones with the quartz monzonite-quartz diorite which is centered on the Squaw River both north and south of Highway 36.

**Uranium Deposits**

Five uranium prospects are known within Harvey Township; all are relatively small, of low grade, and no active exploration is taking place on them. Satterly (1956) described four of the prospects; the fifth is situated north of Highway 36 immediately east of the Squaw River and was explored by Imperial Oil Limited in 1975 to 1976 (Assessment Files Research Office, Ontario Geological Survey, Toronto).

Weakly radioactive, potassium feldspar-rich pegmatite dikes and sills are common throughout the metasediments and metavolcanics west of the Burleigh Gneiss Dome. These intrusive rocks are generally bimodal with large euhedral subhedral crystals of microcline (2-4.5 cm) set in a finer matrix (1-2 cm) of smoky clear quartz, microcline, magnetite, and plagioclase. Dikes and or sills with abundant biotite and plagioclase, and those which lack magnetite usually exhibit relatively lower radioactivity. Pegmatitic rocks of the Burleigh Gneiss Dome are generally less radioactive than their counterparts within metasedimentary and metavolcanic units.

**References**


GSC 1949: Burleigh Falls; Geol. Surv. Canada, Aeromagnetic Map 103G, Scale 1 inch to 1 mile. Survey 1949.


Engineering and Terrain Geology Section
The name of the section was changed from Phanerozoic Geology to Engineering and Terrain Geology on January 1st, 1978. The change is expected to improve awareness and communications not only with the public but also within the Ministry. The 1978 field season has seen a significant increase in activities in northern Ontario and in sub-surface investigations in both northern and southern Ontario. Two new field projects were commenced in the fall of 1978 after the regular field season. Both are mentioned below but will be reported in more detail in the Summary of Field Work, 1979.

Surface and sub-surface investigations were continued in the James Bay Lowland, northern Ontario along the southern margin of the Moose River Basin. Several exposures of lignite were found in Adam Creek, a watercourse now used by Ontario Hydro as a diversion channel for overflow water from the reservoir impounded by the Little Long Rapids Dam. Eight holes were drilled at sites from within the vicinity of Adam Creek to Coal Creek. Holes ranged in depth from 63 to 183 m and revealed Pleistocene deposits up to 113 m thick. All holes but one ended in or penetrated Cretaceous sediments and two holes penetrated Devonian sediments to 16 m and 30 m respectively. Thick deposits of Cretaceous quartz sand, kaolin and some seams of lignite were encountered in several of the drilled holes. The whole project was operated with helicopter support from a base camp near the Kipling Dam and has contributed substantial information to our knowledge of the stratigraphy of this part of Ontario.

In October 1978, a drilling project to investigate the Silurian stratigraphy and dolostone resources of Manitoulin Island was initiated as the first phase of a four year program. The Quaternary mapping of southwestern Ontario continued with three parties in the field. W.R. Cowan completed the mapping of the Kincardine area and notes the occurrence of two tills often separated by glacio-lacustrine sediments and with the upper till (St. Joseph Till) overlain by postglacial lacustrine sands. These sands associated with shoreline features provide most of the sparse sand and gravel resources of the area.

B.H. Feenstra continued the mapping of the Markdale area which includes the Beaver Valley, a large re-entrant in the Niagara Escarpment. Several bedrock formations are exposed and immature karst topography was noted. A coarse till overlies the upland area and fine grained tills drape the shale slopes of the escarpment. Multi-till sections were found in several localities. Extensive deposits of kame and outwash sand and gravel occur in the upland areas.

E.V. Sado completed the mapping of the Lucan area which includes part of the City of London and the gravel deposits to the north of the city. Devonian limestones form the bedrock underlying the area but have only limited natural exposure. The area is crossed by five moraines most of which have a northwesterly trend. Four tills have been been recognized and correlated with occurrences in adjoining areas. Sand and gravel operations are numerous, limestone is quarried for cement production at St. Marys and clay tiles are produced at Elginfield from local glaciolacustrine clays.

In the Algonquin region of the Province, Quaternary mapping continued in the Renfrew County area and new projects were commenced in the Muskoka and Bancroft areas. In Renfrew County, P.J. Barnett continued the work he commenced last year and in 1978 spent most of his time in the Golden Lake and Brudenell areas. In these areas, the bedrock is formed by Precambrian rocks of the Grenville Province with occasional outliers of Ordovician sedimentary rocks. Drift deposits are thick in the Bonnechere and Ottawa River Valleys but very thin over other areas such as the Madawaska Highlands. Outwash deposits are extensive in the Bonnechere Valley but glaciomarine silts and clay are extensive in the Ottawa Valley. Sand and gravel deposits within the map-areas appear adequate for local needs.

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September 1978, Barnett commenced the Quaternary mapping of the Bancroft area and will continue in that area in 1979.

The three map-areas straddling Highway 11 north from Orillia were mapped by D.R. Sharpe. The three areas, Gravenhurst, Bracebridge and Huntsville, also include the very popular vacation areas of the Muskoka district. Much of the surface of these areas is underlain by thin drift-covered or bare Precambrian rock of the Grenville Province. Till deposits of the area are usually coarse textured but of variable density. Glaciofluvial deposits are not widespread but glaciolacustrine sediments are more common and varved silts and clays are commonly found in the valley of the Muskoka River and its tributaries. Sand and gravel operations are located in the outwash deposits along the Highway 11 corridor but supplies may not be adequate for long term requirements. Brick and tile production (in Huntsville and Bracebridge) ceased in the late 1960s.

Two areas on which reports have previously been issued are currently being re-investigated. P.F. Karrow is revising his original report on the Pleistocene geology of the Hamilton-Galt area (Karrow 1963). This was the first report issued for an area in southwestern Ontario and subsequent work in that region has introduced many new concepts which will be incorporated into the revised report to be issued under the new name of Hamilton-Cambridge.

No report has previously been issued for the area covered by the Markham NTS sheet although several reports have been issued covering parts of the Markham area. These include reports by Coleman (1932) long since out of print, Watt (1957), Karrow (1967, 1970) and Hewitt (1972). The present work by J.A. Westgate will bring together the relevant contributions by each previous worker into one comprehensive report making use of recent concepts of glacial history and new field work in the area.

In northern Ontario, engineering geology terrain studies (NOEGTS) have proceeded into Phase 2 of a three-phase project. The whole project will cover 370 000 km² and although primarily an air-photo interpretation study, considerable ground-truth investigations are involved. The resulting maps will be published at a scale of 1:100 000 and will be accompanied by reports for each area and a user's manual.

Another project, also covering a large area of northern Ontario and also in its second year of a three-year study is being undertaken by the Ontario Centre of Remote Sensing (OCRS). A.J. Cooper of this section was attached to the OCRS field party in 1978 to assist in the physiographic studies of the Hudson Bay Lowland.

In northeastern Ontario, mapping of the Quaternary deposits continued with field parties working in the Englehart and Larder Lake areas. The Englehart area was studied by J.D. Morton and R.F.C. King and was an extension of the work commenced in the New Liskeard area in 1977. Additional samples of organic materials were taken in the New Liskeard area in 1978 to assist in the elucidation of the geological history of the area.

The clay plains of the New Liskeard area extend northwards into the Englehart area and are flanked by a valley of the Blanche River. The northern and eastern parts of the area are underlain by hilly and bare rock outcrops of the Precambrian Canadian Shield. Drift is generally thick in the areas underlain by the clay plains and the Blanche River valley, although exposures of till (usually dense and coarse grained) are not numerous and there is only one small part of an end moraine in the whole area. Eskers occur throughout the area. The sands, silts and varved clays which underlie the lacustrine plains have been deposited in a series of late-glacial and post-glacial lakes. Shoreline and off-shore geomorphic features of these lakes are numerous and these, together with samples of organic deposits taken for dating, will assist in the unravelling of a complex history of deglaciation. The eskers of the area are the major sources of sand and gravel supplies. Some large peat bogs may be commercially viable for the production of horticultural peat moss. The low strength, varved clays of the Blanche River valley lead to difficulties in locating rail and road routes because of their tendency to create unstable slopes.

The Larder Lake area, mapped by C.L. Baker, is dominated by Precambrian bedrock outcrops and particularly by the NNE-SSW ridge of Huronian sedimentary rocks which includes Mount Cheminis. Quaternary deposits are varied and include a coarse grained till in thicknesses up to 5 m, four major eskers, one of which, the Munro Esker, rises 45 m above the surrounding land surface and fine grained glaciolacustrine materials with associated coarser grained shoreline deposits. Sand and gravel sources mostly in eskers, are believed adequate for local requirements for some years to come. Peat bogs are numerous and some may have the potential for future commercial operations.
In northwestern Ontario, some local communities are in urgent need of information on aggregate supplies and steps were taken during the 1978 field season to provide that information in advance of more extensive reports on the Quaternary geology of the area. In the Red Lake, Ear Falls and Sioux Lookout areas, V.K. Prest examined aggregate deposits along all highways, secondary roads and logging roads which could be traversed. E.V. Sado undertook a similar investigation in the Nakina and Onaman Lake areas where information on aggregate resources was required for the construction of forest access roads. Prest reports that gravelly tills and sorted gravel provide suitable aggregate for road construction and are available close-at-hand in most areas in the Red Lake-Ear Falls area. In the Sioux Lookout area many potential sand and gravel deposits close to town are generally unavailable but some areas have been identified as potentially good for prospecting. Sado reports that loose stony till in the local ground moraine and outwash materials associated with the Nakina Moraine both provide good material for road construction, but the best deposits of crushable material are to be found in the eskers.

In an extension of studies initiated in 1976, R.M. Quigley has reported the installation of eight piezometers in two deep boreholes in the Hawkesbury area of southern Ontario to establish the existing ground water conditions and relate them to the physio-chemical profiles previously established (Haynes and Quigley 1976). Details of this project will be made available in 1979.

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No. 25  Surface and Subsurface Geology of the Smoky Falls Area, James Bay Lowland

H.M. Verma¹ and P.G. Telford¹

Introduction

In continuation of previous studies (Telford et al., 1975; Rogers et al. 1975; Verma et al. 1977; and Verma et al., 1978), surface and subsurface investigations were carried out along the southern margin of the Moose River Basin, James Bay Lowland.

Although the 1975 and 1977 drilling, geophysical, and outcrop reconnaissance programs has resulted in a better understanding of the Paleozoic and Mesozoic stratigraphy in the eastern and central sections of the Moose River Basin, considerable work is needed in the southern part of the basin in order to build a three-dimensional model of the geology of the Moose River Basin. The purpose of the 1978 program was to obtain new subsurface information about the geological framework of the southern part of the basin.

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Location

The study area falls on NTS 1:250 000 sheets 42J (Smoky Falls) and 42I (Moose River), between Latitudes 50°00' and 50°20'N and Longitudes 81°45' and 83°05'W. The subsurface investigations consisted of drilling eight holes with a total depth of 1176.5 m on a general east-west line (location map). The surface studies consisted of outcrop reconnaissance and sampling along Adam Creek, a tributary of the Mattagami River north of Smoky Falls. Some sampling was also done along the east bank of the Mattagami River, 1 to 2 km north of Kipling dam.

Operations

Drilling was carried out by Bradley Brothers Limited, of Timmins, using a Longyear 38 drill rig. The boreholes were sampled using a combination of three sampling techniques viz. split spoon sampler for shallow overburden; NQ triple tube core barrel for intermediate horizons; and chip samples by reverse circulation for deep horizons using Drilco 69.9 mm, OD reverse circulation rods. Heli
Subsurface Geology

The following is a summary of the drill logs of the eight holes.

**Drill Hole 78-01** (Kipling Township, west side of Adam Creek) This hole was drilled to a depth of 163 m. Pleistocene sediments were encountered from 0 to 39 m. These included the Adam and Kipling Tills overlain by clays of the Missinaibi Formation. From 39 m to the bottom of the hole, the sediments included clays and sands of the Cretaceous Mattagami Formation. The clays were interbedded with several lignite seams. Three lignite seams each 0.75 m thick were cored between 74 m and 85 m. At least eight seams ranging in thickness from 2.5 cm to 15 cm were also included in the above interval. Another lignite bearing interval occurred between 116 m and 125 m. The thickness of seams in this interval was undetermined since only chip samples were recovered from this zone. Fragmentary and detrital lignite occurred throughout the Cretaceous section.

**Drill Hole 78-02** (Wright Township, south side of Friday Creek) This hole, drilled to 189 m, was the deepest hole of the 1978 series. A very thick sequence (113 m) of Pleistocene stony and sandy tills overlies 76 m of Cretaceous quartz sands and clays with minor amounts of lignite.

**Drill Hole 78-03** (Garden Township, east half) This hole was drilled to 182 m. The Pleistocene cover in this hole was much thinner than the preceding hole, consisting of 32 m sandy tills overlying 150 m of Cretaceous interbedded varicoloured, plastic clays and fine to medium grained quartz sands with occasional kaolin interbeds.

**Drill Hole 78-04** (Garden Township, west half) This hole was drilled to 136 m and was abandoned prematurely because of technical problems caused by coarse sands in the Cretaceous sequence. From 0 to 96 m Pleistocene tills, clays and sands were encountered. The Cretaceous sediments, from 96 m to 136 m consisted largely of quartz sands with minor amounts of kaolinitic clays.

**Drill Hole 78-05** (McBrien Township, north of Missinaibi River, opposite mouth of Coal River) This hole was drilled to 178 m. From 0 to 72 m Pleistocene tills, gravel and varved clays were cored. From 72 m to 148 m, sands, silty clays and lignite of the Cretaceous Mattagami Formation were encountered. A 4 m zone of interbedded lignite and carbonaceous clays occurred at 107 m. From 148 m to the bottom of the hole, Devonian limestones, dolostones, and greenish clays were encountered.

**Drill Hole 78-06** (Sanford Township, east side of Waboose River) This hole was drilled to 147 m. A 42 m thick sequence of mainly Pleistocene tills overlies 105 m of Cretaceous fireclays, silica sands, and lignite. A 1.4 m lignite bed was cored at 70 m. Three additional lignite bearing zones were encountered: a 6 m zone at 94 m; a 1.5 m zone at 106 m, and a 1.2 m zone at 108 m. Thicknesses of lignite seams in the above three zones are approximate because only chips were recovered.

The data from this hole enables revision of the geological map of this part of the Moose River Basin. Sanford and Norris (1975) have shown an elongate inlier of Devonian sediments extending northeasterly between Opasatika River and Mattagami River. This inlier appears to have been based on the drill log from the Campbell Lake No.1 drill hole about 8 km northeast of hole 78-06 where reportedly 213 m of “overburden” overlies the Middle Devonian Moose River Formation. A check of the drill log of the Campbell Lake hole showed that only 6 m of the core from the “overburden” was recovered. Samples from the rest of the so-called overburden are reportedly missing.

The occurrence of Cretaceous in hole 78-06 and the extremely poor record of the Campbell Lake Hole lead to the conclusion that the above mentioned Devonian inlier within the outcrop area of Cretaceous sediments does not exist.

**Drill Hole 78-07** (Hecla Township between Long Creek and Pike River) This hole was drilled to 118 m. At the top were 102 m of Pleistocene tills, clays, sand and gravel underlain by 16 m of interbedded silty green clay and hard brown dolostone, possibly of the Devonian Long Rapids Formation. The absence of Cretaceous in this hole implies that either the hole is located on a localized Devonian “high” or that it is outside the outcrop area of the Cretaceous.

**Drill Hole 78-08** (East side of Adam Creek, boundary line between Kipling and Emerson Townships) This was a shallow hole (63 m) put down to determine the thickness of overburden east of Adam Creek. Twenty-three metres of Pleistocene tills overlie 40 m of Cretaceous sands and interbeds of carbonaceous clays and lignite. A 1.2 m zone of woody lignite with minor amounts of carbonaceous clays was encountered at 60 m. Fragmentary lignite occurred throughout the Cretaceous section. This hole was terminated without reaching the bottom of the Cretaceous sediments.
Figure 1—Location of key stratigraphic sections, Adam Creek.
CRETAICEOUS LIGNITE

Surface Geology of Adam Creek

Adam Creek is a diversion channel for the four hydro dams of Mattagami River, all located within 5 km of Smoky Falls. Since 1966, when this diversion channel was created, erosion by excess water from the Little Long Rapids Dam spillway has produced extensive exposures of Pleistocene, Cretaceous and Devonian strata along the banks of the creek. This year’s extremely low water levels afforded an excellent opportunity to examine and sample the outcrops along the creek. Therefore, supplementary to the drilling program, a geological survey of Adam Creek was carried out. Several sections along the creek were examined and sampled (Figure 1). The more interesting sections occur within a distance of about 10 km from the mouth of the creek.

A significant result of the field survey was the discovery of an outcrop of lignite (about 1.2 m thick) in the stream bed and on the east bank about 10 km from the mouth. Thinner lignite beds (up to 0.5 m) and several in situ lignitic tree trunks were also found in the Cretaceous sections downstream from the main outcrop.

Conclusion

The 1978 drilling and fieldwork has provided additional useful information about the subsurface geology of the southern part of the Moose River Basin. This information, together with the results of earlier investigations will help reconstruct a three dimensional picture of the subsurface stratigraphy of the Moose River Basin.

Outcrop and subsurface samples of the Cretaceous and the Pleistocene sediments will be analysed for pollen to determine their exact age. Samples of the Devonian shales and limestones will be analysed for conodonts to establish their precise age. A detailed report on the geological results of the drilling project is under preparation by Gartner Lee Associates Limited.

References


1 Preliminary lithological logs from the 1978 drilling program have been released as Ontario Geological Survey Open File Report 5255.
No. 26 Quaternary Geology of the Kincardine (41A/4) Area
Bruce and Huron Counties

W.R. Cowan

Introduction

The Kincardine area is bounded by Longitude 81°30'W on the east and Lake Huron on the west and by Latitudes 44°00' and 44°15'N. Reconnaissance stratigraphy was carried out in 1975 and mapping was initiated in 1977; superficial mapping was completed in 1978 and some test drilling was carried out.

The area is flat with the only topographic breaks being incised river and stream valleys and a few abandoned shore features of the Glacial Great Lakes. Carbonate rocks of the Detroit River Group underlie the area; these outcrop at several localities near Kincardine and have been quarried for lime and road aggregates in the past.

Quaternary Geology

The Quaternary sequence (from oldest to youngest) consists of an older, very dense, stony to bouldery sandy silt to silt till; a sequence of glaciolacustrine silts, clays, and sands; an upper clayey silt to silty clay till; and late glacial and postglacial lacustrine and alluvial sediments.

The lower till occurs throughout the area, but it is best exposed in deep river sections from Kincardine northward; it is well exposed in the North Penetangore River banks and bed at Kincardine and easterly for several kilometres. This till may exceed 15 m in thickness and generally overlies bedrock, however proglacial fluviatile or lacustrine sediments may intervene locally. Three till fabrics imply that this till was deposited by ice flowing from north to south but varying from northwesterly to northeasterly.

On the average the lower till contains 13 percent clay (range 8 to 20 percent for 7 samples) and 37 percent sand (range 25 to 54 percent) in the minus 2 mm grade; bulk samples contain 10 to 35 percent material greater than 450 μm.
than 2 mm in size. Standard penetration tests show that N values exceed 100 blows per foot except in the upper 3 to 5 m where the till is less dense due to post depositional alteration. The till has low to no plasticity with liquid limits ranging up to 14 and plasticity indices up to 3 or slightly more.

The lower stony till is believed to have been deposited during the Port Bruce Stadial (Dreimanis and Karrow 1972) of the Late Wisconsinan glaciation, however it may be older.

Intervening between the lower stony till and the upper till is a sequence of glaciolacustrine sediments consisting of fine sands, silt, and varved clay, silt and sand. These may be absent where the two tills are in contact; however, more than 5 m of lacustrine sediments have been observed beneath the upper till in stream banks. These sediments represent glaciolacustrine sedimentation during the Mackinaw Interstadial about 13 500 years ago.

Overlying these sediments is a clayey silt to silty clay till which comprises the surface material over most of the Kincardine area. This till forms the Wyoming Moraine on the very eastern part of the map area and flat ground moraine west of this. It represents an advance by the Huron lobe glacier during the Port Huron Stadial (about 13 000 years ago) and is continuous with the St. Joseph Till mapped to the south.

The St. Joseph Till within the map area ranges from a few metres in thickness to more than 20 to 25 m. Though it is primarily a basal till, sections of interbedded waterlain till and lacustrine sediment have been observed and in the north part of the map area sheared or deformed lacustrine sediments comprise much of the till.

St. Joseph Till, within the area, averages 32 percent clay (range 26 to 45 percent for 15 samples) and 13 percent sand (range 6 to 18 percent) in the minus 2 mm fraction; plus 2 mm material occurs to one or two percent in the bulk samples. The till has low plasticity; liquid limits range from 23 to 26, plastic limits 15 to 17, and plasticity indices are 7 to 10: greater ranges in liquid limits and plasticity index have been reported elsewhere. Standard penetration tests give "N" values between 15 to 40 blows per foot for much of the material but values as high as 80 have been obtained at depth.

Glacial retreat from the Wyoming Moraine toward Lake Huron was accompanied by proglacial lakes. These are represented by shoreline features and deposits; many of the latter consist of discontinuous thin sands. The uppermost of these represents Glacial Lake Warren while the next lower ones may be equated with Lakes Grassmere and Lundy. The most prominent shore feature in the area is that of Lake Algonquin which consists of a strong erosional bluff north of Kincardine and a barrier bar and lagoon system at Kincardine and for several kilometres to the south. Lake Algonquin is generally believed to have “early” and “late” phases; the latter has been well documented in the Lake Huron area by P.F. Karrow (Karrow et al. 1975; Karrow 1978; and Karrow, personal communication, 1978) and radiocarbon dated at about 11 300-10 500 radiocarbon years B.P. Post-Algonquin shore features represent Lake Nipissing and perhaps Lake Algoma. There is very little deepwater or off-shore sediment mantling the St. Joseph Till between the Lake Warren shore and Lake Huron.

Postglacial alluvium is represented by abandoned terraces graded to Lake Algonquin and studied by P.F. Karrow (1978; Karrow et al. 1975) and post-Algonquin floodplain deposits. The latter occur as broad floodplains having their surfaces 1.5 to 2 m above present day low water stream surfaces and as lesser channel bar and flood deposits within present day channel zones. Wood from three of the broad terraces has been radiocarbon dated as shown below in Table 1. Since all samples are from stratigraphically similar horizons it seems that these broad floodplains represent post-Algonquin deposition and reworking to give a wide range of dates.

Sand and Gravel Resources

Sand and gravel resources within the area are generally sparse, particularly with regard to coarse aggregate. The oldest deposits are located 4 km southwest of Ripley where two pits have been developed in materials related to the lower stony till. These are ice-contact deposits which may represent a recessional position for this ice sheet. It is possible that these reserves could be extended by exploratory drilling as the younger St. Joseph Till appears to overlie these materials in places. The uppermost part of this deposit has been reworked into beach gravel.

Gravels in a regraded pit 2 km northwest of Armow appear to be outwash or ice-contact gravel associated with a fluctuation of the St. Joseph ice. These too have been partially reworked and the total extent of the deposit,

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TABLE 1 RADIOCARBON DATES FROM WOOD IN POSTGLACIAL DEPOSITS IN THE KINCARDINE AREA.

<table>
<thead>
<tr>
<th>Stream</th>
<th>Location</th>
<th>Material</th>
<th>Depth below Surface (cm)</th>
<th>Radiocarbon date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Penetangore River</td>
<td>Kincardine Tp., conc. I11N, lot 20</td>
<td>wood</td>
<td>120</td>
<td>8000±120 (BGS-534)</td>
</tr>
<tr>
<td>South Pine River</td>
<td>Huron Tp., conc V, lot 38</td>
<td>wood</td>
<td>150</td>
<td>7480±120 (BGS-535)</td>
</tr>
<tr>
<td>Boyd Creek</td>
<td>Ashfield Tp., conc. XIV, lot 16</td>
<td>wood</td>
<td>130</td>
<td>1640±80 (BGS-536-I)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1790±80 (BGS-536-II)</td>
</tr>
</tbody>
</table>
which may be partially buried, is uncertain.

Lake Warren beach deposits have been worked from north of Armow to southeast of Ripley. These are generally shallow (1-3 m) and contain little coarse aggregate. Lower beach deposits have been worked north of Kincardine and southeast of Lochalsh. These too are shallow and sandy. Pre-Algonquin beach deposits are generally fine and shallow; they do however represent an important but restricted source of local aggregates.

The largest sand and gravel deposit within the area is an Algonquin bar complex which trends southwesterly through Kincardine for almost 4 km. Several pits have operated or are presently operating within the complex to produce a wide range of products however, crushable material is generally lacking. Much of the deposit is being built over and steps need to be taken to outline and conserve the remaining resources.

References


Introduction
The Markdale area (NTS 41 A/7) is located in Grey County south of Georgian Bay. Mapping at a scale of 1:50 000 of the west half of the area was completed in 1975 (Feenstra 1975), while mapping of the east half was resumed during the summer of 1978.

Paleozoic Geology
The Paleozoic bedrock formations underlying the area have been previously described by Liberty (1966). In the east part of the map-area the Beaver Valley, a large re-entrant in the Niagara Escarpment north of Flesherton, is underlain by shales of the Georgian Bay and Queenston Formations which are exposed along the numerous gullies dissecting the valley slopes. The upper parts of the shale bedrock are weathered to clay in many places and the harder interbeds of siltstone are disrupted.

The shale sequence is capped by the more resistant dolostones of the Manitoulin and Fossil Hill-Amabel Formations forming a distinct scarp and terrace landscape at the top of the Beaver Valley and further west along the Niagara Escarpment to Walters Falls and vicinity at the eastern margin of the Bighead Valley. Terrace formation along the lower slopes of the Beaver Valley is probably related to resistant limestone ledges of the Georgian Bay Formation.

The upland portion of the area is underlain by dolostones of the Amabel and Guelph Formations. The Amabel dolostone is well exposed in the form of reef masses (knolls, ridges) along the Beaver Valley and elsewhere at the top of the Niagara Escarpment between Epping and Walters Falls. The Guelph dolostone is well exposed along the Rocky Saugeen River near Markdale and Traverston.
Solution of the dolostone bedrock has resulted in immature karst topography.

**Quaternary Deposits**

The bedrock of the area is overlain by Quaternary glacial, alluvial, and bog deposits of Late Wisconsinan to Recent age. The glacial drift consists mainly of till, kame, and outwash deposits, and minor deposits of eskeringe, and glaciolacustrine origin. The continental ice sheet moved from the Georgian Bay area generally in southern directions across the Markdale East area as indicated by the alignment of striae on bedrock surfaces, of streamlined ridges (drumlins, crag-and-tail), and of the Beaver Valley itself. The Singhampton, Gibraltar, and Banks Moraines (Feenstra 1975), other kame complexes, and small morainic ridges (Walters Fall-Faarmount, Tara Strands correlatives) feature a sublobate pattern of the retreating ice margin in the area during Port Bruce-Port Huron Stadial times. The Beaver Valley sublobe crossed the west rim of the valley in southwestern directions.

Till covering the upland portion of the area, underlain by dolostone bedrock, is generally coarse, gravelly and has a sand-silt matrix. Till covering the Beaver Valley slopes, underlain mainly by shale bedrock, varies in texture from gravelly clayey-sandy silt to fine grained clay and silt. The textural variation of till in the valley is also related to incorporation of glaciolacustrine clay and silt locally. A few exposures in the Beaver Valley and at the distal side of the Singhampton Moraine (near Flesherton at the head of the valley) exhibit finer over coarser textured till (Port Huron/Port Bruce Stadial?).

Kame and outwash sand and gravel deposits cover large tracts of the central and southern portions of the upland area. A small esker-delta complex occurs south of Walters Falls.

Glaciolacustrine clay and silt deposits were mapped near Wodehouse on the west side of the Beaver Valley and also across on the east side of the valley.

The main alluvial deposits include those underlying the Beaver River floodplain and fans at the mouths of gullies dissecting the Beaver Valley slopes. Numerous bog deposits were mapped on the upland.

**References**

Feenstra, B.H.

Liberty, B.A.
Introduction

Mapping of surface and subsurface glacial units in the Lucan area was completed to permit correlation with similar deposits outlined in adjoining map areas. This project continues the work previously published by E.V. Sado and U.J. Vagners (1975). The Lucan area is bounded by Latitudes 43°00'N and 43°15'N and by Longitudes 81°00'W to 81°30'W. The City of London occupies the south-central portion. Other population centers of the area include Thamesford, Thorndale, Lucan and Ilderton.

General Geology

Limestone of Middle Devonian age underlies the area (Sandford 1969), and is exposed along part of the North Thames River at St. Mary's because of a local bedrock high. Glacial deposits 30 m to 45 m thick cover the rock elsewhere and thicken generally to the southwest.

Five prominent end moraines, the Dorchester, Arva, Mitchell, Lucan and Seaforth cross the area. All save the first have a northwesterly trend. These plus several deeply incised river valleys provide the only topographic variance in an otherwise flat landscape. Relief differentials exceeding 15 m are uncommon.

Quaternary Geology

The surface till was subdivided into four separate lithostratigraphic units. The oldest (18 000-20 000 years B.P.) deposit, the Catfish Creek Till (de Vries and Dreimanis 1960), a compact, stony, sandy silt till is exposed within portions of the Dorchester Moraine. It lies directly over the bedrock surface.

Tavistock Till (Karrow 1974; 1977) is the dominant surface deposit. It was formed by ice advancing from the northwest out of the Lake Huron Basin. This gritty, clayey to sandy silt till lies south and east of the Mitchell and Lucan Moraines and may be traced into the Kitchener-Waterloo area to the northeast. It overlies the Catfish Creek Till but is commonly separated from it by a thick lacustrine rythmite sequence. These fine grained sediments have tentatively been correlated with the Erie Interstadial (Dreimanis and Karrow 1972).

The Mitchell, Lucan and most of the Seaforth Moraines and associated till plains west of them are composed of a younger till deposited from the northwest, the Rannoch Till (Karrow 1977). This is a clayey silt till heavily charged with local limestone pebbles; it has a blockier structure and contains fewer grits than the similarly tex-
tured Tavistock Till.

The youngest till, the “southern till” (Cooper 1978), is a clay till restricted to the western map margin. It occupies the southern segment of the Seaforth Moraine and a portion of the till plain to the north and west.

Stratified sediments deposited in contact with glacial ice (ice-contact stratified drift) are widespread along the moraine margins east of the North Thames River. The Dorchester Moraine and deposits at Cobble Hills, Lakeside, Granthurst, Cherry Grove and Evelyn are mostly sandy in character but contain sizeable gravelly pockets. Gravelly sand deposits exist locally within the Seaforth, Lucan and Mitchell Moraines. Varying amounts of clay, silt, boulders and till are common in these deposits.

Well stratified, clean outwash bodies predominate within the major river channels and portions of the Dorchester Moraine. Less well sorted outwash deposits also occur along the western margins of most end moraines. A massive glaciolacustrine outwash-delta was developed at the confluence of these meltwater channels between Thorndale and the City of London. Three successively lower beach terraces attributed to glacial Lake Maumee are well defined here.

Lacustrine silts and clays related to local pondings are found throughout the area. Since deglaciation, alluvium has been deposited along drainage courses and organic deposits have developed in local kettle depressions; major peat areas occur within the Dorchester Moraine near McWilliams.

## Economic Geology

Limestone bedrock of the Dundee and Lucas Formations is being extracted by St. Mary’s Cement Company south of the town of St. Mary’s (Hewitt 1964). Clay drainage tile is manufactured from local glaciolacustrine clays by Rydall Brick and Tile Limited at Elginfield (Guillet 1967). Numerous sand and gravel operations exist in the area. The major operations described by D.F. Hewitt and P.F. Karrow (1963), are concentrated in the outwash-deltaic complex in the Thorndale-London area.

## References

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Dreimanis, A. and Karrow, P.F.
1972: Glacial History of the Great Lakes-St. Lawrence Region, the Classification of the Wisconsin(an) Stage and its Correlatives; XXIV Int. Geol. Cong., Sec. 12, p.5-15.

deVries, H. and Dreimanis, A.

Guillet, G.R.

Hewitt, D.F.

Hewitt, D.F. and Karrow, P.F.

Karrow, P.F.


Sado, E.V. and Vagners, U.J.

Sanford, B.V.
Location

The area is bounded by Latitudes 43°15'N and 43°30'N, and by Longitude 80°30' on the west and Lake Ontario on the east.

Objective

This project consists of the revision of Geological Report 16, Pleistocene geology of the Hamilton-Galt area, published in 1963 (Karrow 1963) and out of print for several years.

Work Plan and Progress

Map changes underway involve a few small boundary changes, particularly in the urban areas of Kitchener, Cambridge, and Hamilton to incorporate more recent information, and along the margins of the area to resolve inconsistencies with maps prepared later for adjoining areas. Sand deposits, shown as one unit on the 1963 map, will now be subdivided to distinguish ice-contact deposits in parallel fashion to the way gravels were previously subdivided. This will also be consistent with mapping to the west in the Stratford-Conestogo area (Karrow 1971). The area of shallow lake deposits and modified till surface associated with Lake Peel will be delineated on the Hamilton map. As with newer surrounding maps, sites where analyzed till samples were collected will also be shown on the revised maps.

The classification of tills on the map will be altered to separate Port Stanley Till from Wentworth Till according to more recent interpretations (Karrow 1974).

Revision of the report involves substantial rewriting to incorporate the results of numerous studies published since GR16 appeared. Particularly important changes include reclassification of the tills of the area and some reinterpretation of the history according to more recent information. Individual till sample analyses will be included in an appendix, standard practice in more recent reports. Apparent errors in the original carbonate analyses are being eliminated by redoing the analyses.

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1 Professor, Department of Earth Sciences, University of Waterloo, Waterloo, Ontario.
2 The Galt NTS area has been renamed Cambridge.
Bedrock topography mapping has been revised for the Cambridge area. Because bedrock topography maps rapidly go out of date as new wells are drilled, a revised Cambridge map will be issued only in the preliminary series separately from the report. This map, already submitted for publication, will be available soon. Bedrock topography maps like those included in Geological Report 16 in 1963 will be deleted from the revised report.

References

Karrow, P.F.
Introduction

The Markham area is bounded by Latitudes 43°45' and 44°00'N and Longitudes 79°00' to 79°30'W and comprises NTS sheet 30M/14. Mapping commenced in 1978 and is planned to be completed in 1979. Only one natural exposure of the Paleozoic bedrock was observed in the area. Brown, graptolitic shale that probably belongs to the Whitby Formation (Liberty 1969) outcrops along Duffins Creek, approximately 1.6 km north of Pickering. It remains to be determined whether this is an in situ occurrence or merely a very large erratic in the glacial drift. Ordovician shale underlies Quaternary deposits throughout the map-area, although in the southwestern quadrant the Georgian Bay Formation contains interbeds of siltstone, limestone, and dolostone.

Previous mapping in this area has been carried out by Watt (1957), Karrow (1967, 1970) and Hewitt (1972).

Quaternary Geology

The map-area may be subdivided into several distinctive regions on the basis of its landforms and sediments.

1) The southeastern region adjacent to Lake Ontario contains a great variety of surficial sediments. Thin lacustrine sands, and clays discontinuously cover till or older stratified sediments. Numerous drumlins project above the lacustrine plain but have not been strongly modified for till is exposed along their crests and a streamlined form is still evident. A well-defined bluff demarcates the northern limit of this area.

2) A belt of ground moraine, 4 to 8 km wide, lies immediately to the north and west of area (1); it extends from the southwestern corner of the map-area to the northeastern corner. The central portion is fluted in a NNW direction, an alignment that is parallel to the elongation of those drumlins to the southeast.

3) A lacustrine plain dominates the north-central region. It covers about 160 km² and the towns of Markham and Stouffville are situated at its southern and northern limits respectively. Fine-grained lacustrine sediments are thin over most of the basin, which is framed on its southern and eastern margins by a buried end moraine that still has topographic expression. The Oak Ridges Moraine provides closure to the north and west.
4) The northern fringe of the Markham region is occupied by the interlobate Oak Ridges Moraine. Till, deposited by a Lake Ontario glacier lobe, covers much of this hummocky kame moraine whose stratified deposits are exposed at the surface about 3 km to the north of the study area.

5) Lacustrine sediments cover part of the Oak Ridges Moraine in the Aurora district at the northwestern corner of the area; the lake formed between a Lake Simcoe ice lobe and the Oak Ridges Moraine.

The stratigraphic succession recognized so far in the Markham area is summarized below, from oldest to youngest.

a) Stratified sediments; sand, silts, and clays; detrital peats are present.

b) Till; dark-brown, silty matrix with few stones; dense; joint sets common; deposited by a Lake Ontario lobe.

c) Stratified sediments; gravels, sands, silts and clays; fluviatile and glaciolacustrine; in places the fluviatile sands are rich in detrital peat and logs; C-14 dates pending; lowermost unit observed consists of glaciolacustrine silts and clays that are laminated, highly consolidated, and badly fractured.

d) Till; grey, stony; sandy matrix dominant but in places a silty facies is present; commonly underlain by stony glaciolacustrine diamictons; ice-movement to 300°-310° on basis of few drumlins that still show through a thin sedimentary cover and till fabric analyses; deposited by a Lake Ontario lobe; joint sets common; some end moraines in this material still have topographic expression.

e) Stratified sediments; gravels, sands, silts, and clays; fluviatile and glaciolacustrine; no organics recovered.

f) Till; brown, sandy to silty matrix; ice-movement to 330°-340° on basis of drumlins and till fabric analyses; fissile structure is ubiquitous; deposited by a Lake Ontario lobe; northern limit of this till sheet is about 3 km to the north of the map-area in the Oak Ridges Moraine.

g) Stratified sediments; gravels, sands, silts, and clays; fluviatile glaciolacustrine; fossiliferous palaeosol preserved in part of sequence; C-14 date pending.

The oldest till probably correlates with the Sunnybrook Till and the underlying stratified sediments to the Scarborough Formation, as defined by Karrow (1967). The C-14 age of organic material from the younger horizons should facilitate their correlation to Karrow’s sequence.

Several other features are worthy of note. Boulder pavements are commonly present at the top of a till unit where it is overlain by lacustrine sediments and at the contact between two distinctive till beds. Joints sets are conspicuous in all the tills as well as the older stratified sediments. Whereas some joints are clean and tight and therefore probably quite young, others have thick oxidized rinds and show mineralization along their surfaces that bespeak some antiquity. Ice-wedge structures occur in the grey till and have also been observed in stratified sediments below the Sunnybrook Till at Woodbridge, just to the west of the map-area. The history of the Oak Ridges Moraine is complex. Subsequent to emplacement of this interlobate kame moraine, an ice lobe advanced on to it from the south, depositing the brown till, and later sedimentation in proglacial lakes produced further modifications. Lastly, there are huge resources of granular materials in the Markham area. Sands and gravels not only form the bulk of the Oak Ridges Moraine but occur in the form of deltas in the glaciolacustrine basins and as terraces within the spillways. Gravels and sands are commonly associated with the old strandlines and it is here that the occasional bouldery lag deposit is found. Elsewhere, erosion has brought old granular materials to the surface.

References

Hewitt, D.F.
1972. Industrial Mineral Resources of the Markham-Newmarket Area, Ontario Dept. Mines; Map 2124, 1 inch to 1 mile.

Karrow, P.F.

Karrow, P.F.

Liberty, B.A.

Watt, A.K.
Introduction

Field mapping of the Golden Lake (31F/11) and Brudenell (31F/6) areas, approximately 2000 km², was carried out during the summer of 1978. Emphasis was placed on areas of thick drift accumulation, such as the Bonnechere and Ottawa River valleys, whereas areas of very thin drift and extensive rock outcrop were covered quickly.

The areas mapped are located between Latitudes 45°15'N and 45°45'N and Longitudes 77°00'W and 77°30'W. The villages of Eganville, Golden Lake, Killaloe Station, Brudenell, Quadeville and Rankin are within the area mapped.

Physiography

The Golden Lake and Brudenell map-areas lie within the Ottawa Bonnechere Graben and the Madawaska Highlands. The bedrock in the area is, for the most part, Pre-
cambrian rocks of the Grenville Province, with the exception of a few Paleozoic outliers of Ordovician age.

The Muskrat Lake, Lake Doré, Deacon, St. Patrick, Hopefield and numerous other unnamed faults traverse the area and are the major control of the present, as well as the past drainage in the area.

The main areas of drift accumulation, along the Ottawa and Bonnechere Rivers, are on the floor of the graben, whereas areas of very thin drift and extensive bedrock outcrops are found mainly in the Madawaska Highlands.

The northeast corner of the area has been subdivided into the Petawawa Sand Plain, Ottawa Valley Clay Plain and Muskrat Lake Ridge physiographic regions by Chapman and Putnam (1966).

Quaternary Geology

Striations, drumlins, flutings and crag-and-tail features indicate an initial north to south flow of glacial ice across the map-areas. During the latter stages, however, ice flow was controlled by the topography. Glacial ice retreat occurred in a general south to north direction, except along the Ottawa River Valley where the ice front receded towards the northwest.
The area mapped will be divided into three parts for discussion purposes: areas of i) dominant bedrock, ii) the Bonnechere River Valley and iii) the Ottawa River Valley.

**Bedrock Areas**

Two large areas dominated by bedrock outcrops occur within the map-area. One occurs south of the St. Patrick Fault (Clontarf-Cormac-Rochefort) and the other is located in the northwest corner of the map-area bounded by the Deacon and Lake Doré Faults. These areas are bedrock highlands (part of the Madawaska Highlands) characterized by a usually thin drift cover which is dominantly a weathered basal till (loose, stony and very sandy). Areas originally cleared for farmland usually have a thicker cover of till and in many instances are drumlins or drumlinoid ridges.

Along most of the valleys, varying thickness of outwash sand, gravelly sand, and gravel can be found. These valleys were once filled by a network of rivers which flowed southward from the retreating ice margin. Along these valleys the water table often is high, because of bedrock sills, and this results in the formation of numerous swamps. The larger outwash systems are along Jacks and Gariepy Creeks, Pilgrim and Eneas Creeks, Highland Creek, Donald Creek and the Madawaska River.

Within these highland areas, end moraines are very fragmentary and difficult to trace.

**Bonnechere River Valley**

Within the Bonnechere River Valley, the cover of glacial drift is more continuous and of a greater thickness. There are however, several areas of thin till over rock. The valley contains several drumlins, eskers and east-west oriented end moraines. The till varies from a gritty sand to silty sand till in the west to silty sand to sandy silt till in the east where several Paleozoic limestone outliers are present.

Outwash sediments (sand, gravel) cover a large proportion of the valley, with a flow direction from west to east. As the glacial ice retreated from the St. Patrick Fault, the braided streams flowed eastward between the escarpment and the ice to the Champlain Sea. This resulted in several levels of outwash plains (such as Cormac area) and large channels cut through some of the thicker till areas (south of Eganville).

Although the Champlain Sea did not enter the part of the Bonnechere Valley within the map-area, several glaciolacustrine lakes did exist in the basins of Golden Lake, Lake Doré and Silver Creek.

**Ottawa River Valley**

A large part of the map-area within the Ottawa Valley is covered by glaciomarine silty clay and clay. The shoreline of the Champlain Sea is not well defined because much of it had a rugged bedrock shoreline. The distribution of nearshore sands best approximates its position, between 160-168 m above sea level. Several well developed shorelines occur in French Hill at an elevation of about 160 m above sea level.

Several small end moraines can be traced across the Ottawa Valley, but curve northward along the valley’s edge, (e.g. at Micksburg to Rankin). The glacial ice must have remained longer in the valley than in adjacent highlands.

Several eskers are found both below and above the Champlain Sea Level (Lower Stafford area, Green Lake area).

**Economic Geology**

Sand and gravel deposits within the areas mapped are probably more than sufficient for local needs. Several sand and gravel pits in Alice and Wilberforce Townships were operated during the summer because of the local demands of re-routing Highway 41 between Letts Corners and Millers Bay, paving of this highway from Rankin to Letts Corners, and paving parts of Highway 62 from Golden Lake to Eganville. The installation of a sewer system in Killaloe Station resulted in several pits in Haggarty Township being operated regularly throughout the summer. Several pits in Eganville, were active on demand.

**Reference**

No. 32  Quaternary Geology of the Gravenhurst, Bracebridge and Huntsville Areas, District Municipality of Muskoka

D.R. Sharpe¹

Introduction

Geologic mapping of Quaternary deposits was carried out in the Gravenhurst, Bracebridge and Huntsville (NTS 31 D:14, 31 E:3, 31 E:6) 1:50 000 sheets, in the District Municipality of Muskoka. Mapping was essentially completed in the Gravenhurst and Bracebridge areas while the Huntsville area is almost completed.

General Geology

Rock outcrop and drift-mantled rock complexes comprise about 90 percent of the investigated area. The result is a very scattered and patchy Quaternary record.

The bedrock consists of highly folded, faulted metamorphic rocks of the Precambrian Grenville Province. These consist of banded to veined migmatitic plutonic and sedimentary gneisses consisting of quartz-feldspar-biotite assemblages with garnet as a common accessory mineral. However, the bedrock within the area is poorly known as only one semi-detailed published map exists for any portion of the area; even this (Hewitt 1967) is a compilation of earlier work. A recent compilation (Freeman 1978) shows much of the area as metasedimentary rocks.

Structural features such as tight folding, faulting, and strong foliation control the physiography and drainage of the area.

A few outliers of Gull River Formation limestone (Middle Ordovician) are present in the southern edge of the Gravenhurst area. This rests unconformably on the Precambrian rock.

Quaternary Geology

Evidence for a glacial advance, moving from north to south, or southwest was found in the area. The consistency of the glacial striae data and the absence of any multiple till cuts suggest this conclusion. In fact, there are only scattered locations with stiff basal till, although a loose ablation till mantles many thin-drift covered bedrock areas. Thicker till deposits, which are only common near

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Lake of Bays, consist of loose to compact stoney sand to silty sand till of Grenville Province lithologies.

Glaciofluvial deposits are also scarce, these being noticeable in the areas northwest of Bracebridge, underlying the Muskoka Airfield, southeast of Huntsville and south of Port Sydney. These deposits are mainly outwash in origin, having been formed by rapidly retreating ice supplying meltwater to the drainage area now occupied by the south and north branches of the Muskoka River. Several of these outwash systems have deltaic sediments at their distal ends, probably representing drainage into a northward expanding Lake Algonquin. Because of the continued expansion of glacial Lake Algonquin, lack of sediment to rework and a protected shoreline, no well-developed shoreline features have been formed.

A preliminary uplift curve (Figure 1) drawn for the Lake Simcoe area and this map-area, shows a marked discontinuity between the two areas. This could mean that: 1) the delta features in the map-area formed in lower level lakes than Algonquin; or 2) the discontinuity is related to Main Algonquin or events after the Kirkfield low-water stage whose outlet is located between the two areas in question.

A considerable amount of glaciolacustrine sand, silt and clay was deposited in the area during ice retreat. This material tends to be located around bedrock highs, as a draping of sediment deposited by density currents. In low areas, varved silt and clay deposits are common, especially along the branches of the Muskoka River. Antevs (1925) studied nine localities of varved sediment in the Bracebridge-Huntsville area and suggests a chronology of about 800 years including a record of 784 years at one site. The present surveyors measured seven sites including a 690 year record at one site. The sections revealed a complex variation in varve pattern, structure and material which will be studied in detail to document late glacial history of this area.

Despite this substantial lake history, lacustrine sediments do not blanket large areas. This is due to the noticeable paucity of glacially derived sediments in Precambrian terrain compared with that deposited in Paleozoic terrain of softer lithologies.

**Economic Geology**

Present activities in the area are confined to sand and gravel interests. Several full-time pit operations are currently active in the Bracebridge-Huntsville area. Several part-time operations are currently active as expansion of Highway 11 north to Highway 60 continues. All these operations are in the outwash units located close to the Highway 11 corridor. The material has good sizing for crushed aggregate; the stone is sound although 10 to 15 percent of the foliated rocks may be friable. Local aggregate supplies from surficial deposits are adequate for the short term (5 years) but in the longer term, crushed bedrock is a possibility as well as importing from other areas.

Two clay pits (a tile plant near Bracebridge; and a brick plant near Huntsville) were in operation in the late 1960s (Guillet 1967); these have since closed down.

Diatomite (opaline silica from algae skeletons) is common in the lake bottoms of lakes in Muskoka but has not been recovered for production for many years (Hewitt 1967).

**References**

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Chapman, L.J.
Deane, R.E. 1950: The Pleistocene of the Lake Simcoe District, Ontario; Geological Survey Canada, Memoir 256.


No. 33  Quaternary Geology of the Englehart Area  
District of Timiskaming  
J.D. Morton¹ and R.C.F. King²

Introduction

The Englehart map-area (NTS 31M/13) is located between Latitudes 47°45' and 48°00'N and Longitudes 79°31' and 80°00'W, and lies towards the upper margin of the broad valley at the head of Lake Timiskaming. Interpretive mapping, ground search and the vertical aerial photographic analysis were extended into the surrounding areas as necessary to resolve certain extensive geological features, and to establish key events and sequences. Liaison was maintained with the ministry’s Resident Geologist in Kirkland Lake, H.L. Lovell, the party chief and field staff of the Ontario Geological Survey who were mapping the contiguous Larder Lake sheet and the party chief and field staff of the Geological Survey of Canada who were mapping the adjacent regions of Quebec.

¹ Project Consultant, Principal, Morton, Dodds and Partners Limited, Rexdale, Ontario.  
² Co-party leader seconded to Ontario Geological Survey; Geologist, Morton, Dodds and Partners Limited, Rexdale, Ontario.

Physiography

The physiography of the Englehart map-area is strongly controlled by the structure of the underlying Precambrian Canadian Shield, comprising the NWW-trending faults of the Timiskaming fault system and the N to NNE trending faults of the Larder Lake block. The boundary between the two systems is followed approximately by the course of the Blanche River. Four distinct regions can be defined:  
a) the terraced clay tableland with scattered, low rounded Precambrian outcrops to the west and northwest of Englehart;  
b) the broad plain and intermediate terraces of the valley of the Blanche River and its tributaries, with only rare rock outcrops;  
c) the northern tip of a limestone cuesta or upland formed of Lower Paleozoic strata located south of Englehart;  
d) the hilly, rocky uplands to the north and east of the Blanche River Valley.

A fifth, smaller region confined entirely within unit d, comprises the ovoid-shaped Skeleton Creek basin. The latter unit is almost completely surrounded by high arculate rock ridges.

Thick Quaternary sediments occupy the lowlands and several of the intermediate terraces, while the uplands and tablelands tend to be more sporadically veneered with till, outwash, morainic, or lacustrine sediments. Many of the sediments in the central and eastern parts of the map-area are lacustro-deltaic in character and comprise layered silts and sands, while finer lacustrine varved clays appear more typical of the southwest, west and northwesterly tableland. Several major delta structures have been identified. Many of the rock hills have been washed clean by wave action during high water stages of late-glacial Lakes Barlow and Barlow-Ojibway, and the plane of highest water level has been established.
Quaternary Geology

Extensive wave washing and subsequent frost spalling and solution weathering of much of the rock exposed in the higher terraces and uplands, has resulted in glacial striations being uncommon. Several have been clearly identified however, with the majority clustered on rock surfaces recently exposed along highways, regional or forest development roads or in stream beds. In general, the latter cases illustrate the strong influence of rock morphology, and the striations tend to parallel or subparallel the underlying bedrock structure.

Several striations or cross-striations occurring at levels well above the pre-Quaternary valley floors are judged to be the more likely indicators of direction of flow of the main body of the ice sheet, and these tend towards an axis of orientation ranging from SSE to only slightly west of south.

Till outcrops are present at scattered locations across the map-area, in the form of both lodgement and ablation material. Lodgement till has been identified in declivities along the prominent escarpment located immediately north and northeast of Englehart, associated in at least one case with push moraine features and disturbed and contorted varved sediments. Similar dense till material occurs sporadically among the rock exposures of the Misema River and Boston Creek defiles, and around the limestone exposures at Highway 11 at the south edge of the map-area, in Armstrong Township. An irregular body of lodgement till is also presently associated with the rocky-hummocky terrain of Pense Township to the south and east of Pontierroy Creek. Areas of sandy ablation till are confined to the highest points of rock above the maximum postglacial water plane, mostly in the structurally controlled ridges bordering the Skeleton Creek Valley in Rattray Township. Nominal outcrops of till occur elsewhere on top of isolated hills, such as in Beauchamp Township at the southwest corner of the map sheet.

All the hills appear similar in character, though the ablation unit is distinctly coarser and sandier as well as being less dense.

Mammalian features are noticeably lacking in the area except for the presence of the northern margin of the Hill Lake Moraine along the southwest edge of the map-area, in Beauchamp Township.

Several continuous, discontinuous or intermittent (buried) eskers are prominent within the area, comprising:

i) an intermittent north-south esker extending from the Beauchamp-Armstrong Townline Esker, previously identified in the New Liskeard map-area, through eastern Chamberlain Township towards Pacaud Township;

ii) the buried Heaslip Esker exposed for 0.5 km in two borrow pits adjacent to Highway 569, this may be linked to the sands underlying the lacustrine sediments along the Larder River to the north and thence to the Munro Esker;

iii) the south end of the prominent Munro Esker (which extends northwards for more than 300 km) from the west end of Wendigo Lake along the east margin of Marter and Catherine Townships;

iv) intermittent eskers in Skaed Township, which extend northwards from the north of St. Anthony Lake into the Larder Lake area;

v) the boundary esker which extends in discontinuous fashion from south of Sheppard Lake via the isthmus between Skeleton Lake and Clear Lake, thence northeastwards along the narrow, rocky Larder River valley.

vi) a short exposure of buried esker exposed by Pontierroy Creek in south-central Pense Township.

Glaciofluvial deposits other than the eskers appear to be confined to several small kames located within the eastern part of the map sheet; a small kame wedge situated at the south end of a rock ridge has been identified in the southwest of Mulligan Township and two other small kame terraces in central Rattray Township.

Lacustrine deposits of sands, silts, and varved clays are extensive throughout the area, laid down in various stages of a series of late-glacial and postglacial lakes which have been variously designated "Lake Barlow", "Lake Barlow-Ojibway", "Early Timiskaming". Several major deltas exist, formed at various stages of lake level, and a progressive eastward shift of the source inflow is indicated. Many abandoned delta distributary channels, abandoned shorelines and strand flats exist, along with such other relict geomorphic features as beach bars, storm beaches, tombolos, spits, wave washed rock exposures (headlands) and boulder pavement. Laminated still-water lake deposits of clay and silt exist beneath the late stage deltaic and beach sediments, and are exposed extensively on the higher terraces to the south and west of Englehart.

The maximum level of submergence has been established at several points, rising from approximately elevation 335 m at the north end of the Hill Lake Moraine (SW corner of map sheet) to elevation 358 m along the high ridges of Rattray Township in the northeast corner of the map-area. Several persistent erosional and dispositional beachlines with associated well developed strand flats (terraces) have been identified below the maximum level of inundation, down to the 200 m elevation delta flats of early Lake Timiskaming upon which the Town of Englehart and the community of Tomstown are built.

Several stratigraphic sections have been detailed, including varve counts on high exposures along the Larder River in Marter Township, in new road cuts adjacent to Sunday Creek in Dack Township, and in the walls of the Heaslip gravel pits in Eventurel Township. Delta sequences have been detailed on the Misema River in Marter Township, Alligator Creek in Chamberlain Township, and Englehart River in Eventurel Township.

Geological Dating

The close inter-relationship between postglacial deposition and the retreating lake stages has produced a complexity of pattern and sequence which is difficult to interpret. Several sites with organic remains have been located, however, and radiocarbon dating of samples has been implemented. At least one small kettle lake deposit...
lying close to or above the highest level of inundation has been sampled for additional palynological analysis, and it is hoped to establish a comprehensive chronology of events from this research.

**Economic Geology**

Sand and gravel for construction fill, road pavement, rail ballast, concrete mix and brick sand are the only economic commodities which have previously been, or are presently being, extracted from the Quaternary sediments of the map-area. Major producers in the past were located along the intermittent esker extending from Armstrong to Pacaud Townships, wherever esker nodes outcrop through the lacustrine sediments. Several other pits (now depleted or approaching depletion) have exploited short sections of buried eskers in Dack and Eventurel Townships, or channel bars within a distributary channel system which extends southward from Wendigo Lake.

Several working pits and excellent reserves of sand and gravel exist in the Munro Esker adjacent to and accessible from Highway 624. Deltaic sands are being worked for road fill in Marter Township, and beach sands in Ingram Township. A very coarse esker deposit at Skeleton and Sheppard Lakes has been used for development road construction, as also have small kame terraces in Mulligan Township and in Pense Township. Outwash gravel overlying varved clay on the eastside of Sheppard Lake has also been utilized for development road construction. Significant reserves (that is, in excess of 1 million t) of sand and gravel capable of providing good quality aggregate and granular fill exist only in the Munro, Skead and Larder Lake (Misema) Eskers. The very coarse materials of the Skeleton Lake-Clear Lake-Sheppard Lake extension of the Boundary Esker could also be exploited but would require crushing. Smaller reserves of finer gravel with sand exist beneath increasingly heavy cover at the Heaslip buried esker and the Armstrong Townline-Pacaud Esker.

The clays of the area are generally silty and have not been well tested for brick making or other ceramic usages (Guillet 1977).

Several peat bogs and muskegs exist within the map-area located on former delta, terrace, beach lagoon and abandoned channel deposits, also in kettle depressions of the Munro Esker and Hill Lake Moraine. Only the organic channel fills extending from the vicinity of Tomstown to the south margin of the map-area in Hilliard Township, and the lagoonal swamp at the corner of Highway 569 in Ingram Township appear to be economically exploitable for moss litter or peat moss. An extensive bog at the head-waters of South Skeleton Creek, in north-central Pense Township also appears to be sufficiently deep to be exploitable but would be difficult to drain.

**Agricultural and Engineering Geology**

The section of map-area lying south and west of the diagonal line connecting the northwest and southeast corners of the map-area has been undergoing agricultural development since initial settlement began in the early 1900s. Heavier clay soils are restricted to the lacustrine terraces lying south and west of Heaslip-Englehart in the southwest corner of the map-area, and in the vicinity of Kruger-dorf to the north of the Misema River and Aidie Creek deltas. Elsewhere the soils are lighter and sandier and are subject to late summer drought.

The sand soils of Marter, Ingram and northwestern Pense Townships are being allowed to revert to woodland, along with the formerly cleared areas adjacent to the Munro Esker.

An extensive area of silty clay deposit, perhaps capable of agricultural development, exists in the Skeleton Creek basin, in Mulligan and the eastern part of Bayly Townships.

The existence of weak lacustrine varved clays at depth beneath the delta sediments of the Blanche Valley has created unstable valley walls, and severe engineering problems have been experienced in locating and constructing the road and rail communication systems. Frost heave problems are also severe on most township and regional roads due to the predominantly silty character of the subsoil and the prevailing high groundwater table. Frequent, round Precambrian rock outcrops projecting through the Quaternary sediments have added to alignment and construction difficulties, and the concession and townline road system so well developed in the adjacent New Liskeard map-area is noticeably less complete and more tortuous.

The presence of buried peat deposits within parts of the Town of Englehart has created foundation and development problems which have not previously been appreciated.

**Reference**

Guillet, G.R.
Quaternary Geology

The map-area and fringes is pivotal to interpretation of the interaction of Hudson Bay and Laurentian ice sheets during Late Wisconsinan ice retreat, and to resolution of the stages of development and decline of Glacial Lake Barlow.

Mapping and interpretive ground search of several key features and sequences within the map-area which remained unresolved from the previous year's work were carried out and where necessary were extended into the adjacent areas. Consultation was provided to the Ontario Geological Survey field crews actively mapping the Englehart and Larder Lake map-areas, and frequent discussions and exchange of information were instituted with the Geological Survey of Canada Pleistocene geology mapping party operating in contiguous parts of the Province of Quebec. A one-day seminar, followed by a one-day work-shop session involving technical staff from other sections of local Ministry of Natural Resources offices was held in Kirkland Lake in late June, to provide additional input, information and records. The seminar was held in the Ministry of Natural Resources office in Kirkland Lake and was chaired by H.L. Lovell, Resident Geologist.

A single occurrence of fibrous organic material layered within a lacustrine beach feature identified in the preceding year's field work near Whitfield and dated at $7840 \pm 120$ years BP (BGS-511) was re-examined and is now considered to be of pre-beach origin.

A second occurrence of fibrous organic material has been identified in coarse sand-silt rythmite located immediately north of the ice marginal position of the Hill Lake Moraine, at the northwest boundary of the map-area. No other datable finds were located. In the absence of such other datable occurrences within the postglacial inorganic sediment sequence, several surficial peat bogs were sampled in order to obtain “minimum dates” for definable beach features or lake drainage stages. Selection of such sites was made in co-operation with the field parties in the bordering Englehart and Larder Lake map-areas, with the Geological Survey of Canada field party in Quebec and with the Department of Geological Sciences at Brock University so as to avoid overlap and to minimize the number of samples taken for radiocarbon dating. Assistance was given to and accepted from the Brock University field crew who visited the area in August, to continuously sample several kettle bogs chosen for their accessibility and relationship to the highest level of postglacial inundation. It is expected that several other bogs will be similarly sampled next year by the Department of Geological Sciences, Brock University and by the Geological Survey of Canada field party in Quebec, so that firm chronology for the region can be established.
Introduction

The Larder Lake NTS map sheet (32/D4) is bounded by Latitudes 48°00'N and 48°15'N and Longitudes 79°30'W and 80°00'W. Mapping was undertaken using air photographs at a scale of 1:15 840 for publication at a scale of 1:50 000. Surficial geological information gathered from roadside exposures was supplemented by traverses along abandoned drilling and lumbering roads. Field mapping was completed during the summer of 1978.

Emphasis of the mapping was on outlining the major areas of till exposure and determining its characteristics as an aid to a planned program of overburden drilling in the area. Additional goals of mapping included the assessment and delineation of existing and potential aggregate resources as well as determining any engineering or geological hazards.

Bedrock Geology

The townships making up the Larder Lake map-area have been, or are in the process of being mapped by the Precambrian Geology Section of the Ontario Geological Survey. Most of the area is underlain by Early Precambrian felsic to mafic metavolcanics which in many places are intruded by gabbro and diorite, notably in a zone between Gem and Crosby Lakes. Early Precambrian metasediments and alkalic metavolcanics occupy a narrow east-trending strip north of Highway 66.

Felsic intrusive rocks are extensive throughout the map-area. The most notable of these are located in Boston, Lebel, Gauthier and McElroy Townships. Gold-bearing carbonate rocks occur on the Larder Lake Break Fault, this being contained within the band of metasediments outlined above. Cobalt Group sedimentary rocks, (Huronian) outcropping to the south and east of Larder Lake, consist of conglomerate, wacke and arkose. Tillite has also been recognized within these rocks. The youngest rocks of the area are diabase dikes which generally trend northeast. These dikes are dispersed throughout the area and cut all rock types.

Two mining operations, the Kerr Addison gold mine at Virginiatown and the Adams iron mine north of Boston Creek are located in the map-area.

Physiography

The map-area may be divided into three physiographic units. The most prominent of these is the NNE-SSW trending ridges of Huronian (Cobalt Group) sedimentary rocks which rise up to 225 m above the surrounding land surface. Mount Cheminis, a local tourist attraction, is a de-
Glaciofluvial material, correlation between sites remain un-
tached remnant to the north of the largest of these ridges.

The most extensive physiographic unit within the map-area is composed of rock outcrops with thin, discontinuous drift cover. The majority of the overlying material is lacustrine in origin although patches of till are encountered. This physiographic unit occurs in the following areas within the Larder Lake map sheet: i) northwest of Victoria Lake and east of Nettie Lake; ii) the southwest corner of the study area bounded on the north by Highway 66 and on the east by a line running southward from Jordan Lake to the Big Bend on the Misema River and iii) east of a north-south line through Howard Lake, Dobie Lake, Grassy Lake, and Spring Lake. Relief within these areas is up to 100 m but is commonly in the range of 30 to 60 m.

A third physiographic unit, formed of relatively flat lying ground to either side of the Munro Esker, separates the areas described above. The Munro rises as much as 45 m above the flanking lacustrine sediments.

**Quaternary Geology**

The oldest Quaternary deposit within the Larder Lake map-area is a silty sand to sandy silt till of Late Wisconsinan age. The finer facies occurs in the eastern section of the area where the till overlies the softer rocks of the Cobalt Group. Here, in valleys perpendicular to the regional ice flow, thicknesses of up to 5 m were observed, this being substantially thicker than the usual 0.5 m to 1 m sections intermittently distributed throughout the remainder of the area. Movement of the ice depositing the till centred on S11°E as determined from striae measurements on bedrock.

Glaciofluvial deposits are common with the bulk of the material occurring in four major eskers. The most notable of these is the Munro Esker trending southward east of Victoria and Mousseau Lakes then southeast after crossing the Misema River at the Big Bend. Kames, kame terraces and crevasse fillings are scattered over the area with a heavier concentration along and on the rock ridges in the eastern half of the map-area.

Glacial Lake Barlow-Ojibway, present in front of the ice during the ice retreat washed rock outcrops below 381 m. Fine grained lacustrine deposits, clay and silt, are common throughout the area though generally below elevations 320 m. Varved clay is dominant in the southern part of the mapped area with exposures present in sections around Larder Lake.

Lacustrine deposits of shallow water origin, sand to silty sand, are confined to pockets developed by wave action eroding till and occur in the 320 to 381 m elevation range. More extensive deposits surround glaciofluvial material and are often an off-lapping facies developed by receding water levels. Eolian sand dunes are present on such an apron east of the Munro Esker in Arnold and Gauthier Townships and south of an esker delta complex west of Mousseau Lake.

A limited number of locations displayed deposits associated with a nearshore or beach environment. However, due to the nature of the topography and the occurrence of these features only on easily modified glaciofluvial material, correlation between sites remain un-
certain. Initial indications are that two poorly developed beaches occur at approximately 290 m and 320 m, representing recessional stages of Lake Barlow-Ojibway.

Falling water levels also caused the development of spillways in the rock highlands and along present day drainage routes. Gravel deposits originating in such a manner are found south of Mud Lake and along the western edge of Ward Lake.

Upon emergence of the land, accumulation of organic matter, in the form of peat and muck, began in swamps and along stream courses.

**Economic Geology**

Sand and gravel resources within the map-area are of sufficient grade and volume to meet local demand for some time to come. Esker systems provide most of the material presently being produced although smaller operations do exist in kames and kame terraces. The largest pits are in the Munro and Boundary eskers where large amounts of sand have been extracted for mine backfill. No pits in the map-area are currently being worked on a continuous basis.

Glaciofluvial deposits range widely in size and sorting. Within eskers sand is more prevalent but large reserves of gravel are located within their central cores. Kame materials are generally of limited volume and to date have been used only as a local source for fill and road construction.

Secondary products of the Adams iron mine include crushed rock and sand. The former originating from waste rock and the latter from tailings or "slimes".

To date there has been no development in any of the numerous peat bogs about the map-area although the possibility of a commercial venture may exist.

**Engineering and Environmental Geology**

Engineering and construction problems in the area are rarely serious because bedrock is usually near or at surface, or areas of thicker drift are underlain by well drained sand and gravel. Difficulties may arise from having to blast rock to obtain level grades or from the presence of bog deposits in low lying districts.

Although no failures were observed in varved lacustrine sediments, these deposits are subject to landslides along streams a short distance to the south (R.C.F. King, Geologist, Morton, Dodds and Partners Limited, personal communication, 1978). The limited occurrence of high scars of lacustrine material may account, in part, for the lack of landslips in the Larder Lake map-area.

Potential problems exist in the removal of trees from areas of sand dunes. Care must be taken to leave sufficient wind breaks or surface vegetation to prevent re-mobilization of the dunes.
Introduction

A reconnaissance inventory of glacial materials along a 50 by 150 km belt in the North Central administrative region of the ministry was performed at the request of the Geraldton district office, Ministry of Natural Resources. The area, bounded by Latitudes 50°00'N and 50°30'N, and Longitudes 86°00' and 88°00'W includes the Nakina 42L/SE and Onaman Lake 42L/SW NTS map sheets (scale 1:126 720). Suitable road base materials were sought for the construction of additional forest access routes.

Field work was restricted to roadside studies along accessible roads. Air photographs (scale 1:63 360) were used to outline recognizable geomorphic features. An air tour of the area was useful in correlating the above information.

General Geology

Early Precambrian rocks, mainly granite and banded gneiss are intermittently exposed at the surface. "Greenstone" lithologies centered about Kowkash Township occupy the westerly portion. They consist of metamorphosed, complexly folded volcanic, sedimentary and intrusive rocks.

Glacial ice advancing from the northeast eroded the bedrock surface and deposited the mantle of rock debris overlying it. Evidence of earlier glaciations was not seen. Ground moraine consisting of a loose, stoney sand ablation till is the most widespread glacial deposit. It is highly charged with locally derived bedrock and has a thickness ranging from 0 to 3 m. It makes an excellent base course road material when properly compacted.

The Nakina Moraine (Zoltai 1965) is the most prominent physiographic feature trending NW to SE. Other less prominent morainic ridges are connected to it. Sand is the dominant material. Outwash bodies developed along morainic margins have sandy upper surfaces but contain...
AGGREGATE DEPOSITS

course gravels at depth. Several pits studied in the Cavell to Nakina area displayed this relationship.

Numerous eskers trend perpendicular to the moraines. They contain the best deposits of crushable stone in the area. An exceptional esker complex over 30 m high and 3 km wide is found north of Nakina (Cordingley Lake). This deposit is utilized as a natural highway route into the hinterland.

The moraines, outwash plains and eskers are excellent routes along which to align future resource roads. Glacial till where present in sufficient thicknesses also allows for inexpensive road construction and maintenance. Large areas covered by lacustrine silts and clays, thin drift and abundant rock outcrop should be avoided whenever possible. All of the above mentioned materials are heavily charged with carbonate rock (approximately 30 percent by volume) derived from the Hudson Bay Lowlands.

References

Zoltai, S.C.
Occurrences of road aggregate materials were examined within the following 1:50,000 scale map-areas in the Red Lake-Ear Falls and Sioux Lookout areas: Kirkness, 52N/-12; Nungesser, 52N/5; Red Lake, 52N/4; Medicine- Stone Lake, 52L/16; Madsen Lake, 52K/13; Pakwash Lake, 52K/14; Ear Falls, 52K/11; and Sioux Lookout 52J/4. Borrow pits along the highways, secondary roads and logging roads were examined to determine the nature and origin of the materials utilized. Air photo studies and some foot traverses were made to expand or substantiate the distribution of the favourable materials. The network of roads and trails in the Red Lake, Madsen Lake, Pakwash Lake and Ear Falls map-areas has provided the essential ground-truth data for the mapping of the surficial geology of these areas from air photos as planned by the Engineering and Terrain Geology Section. The road aggregate materials within the areas includes a great variety of deposits ranging from non-sorted, but gravelly, till through poorly sorted kame and end moraine gravels to well sorted esker and deltaic sands and gravels to glacial lake shoreline deposits. The gravelly tills obtained from end moraines, where not too bouldery, provide excellent road materials; these appear to pack readily and are not prone to development of rough, washboard surfaces nor are they unduly dusty. The sorted gravels are also of good quality and, when crushed, provide excellent road-surfacing material. In most areas suitable aggregate materials for all road construction purposes are to be found close at hand. Only in some major outcrop areas, as around and west of Red Lake, are adequate road materials limited or absent. Gravel deposits in this general region, that are commonly referred to as outwash and pitted outwash are actually subglacial/deltaic in origin. True outwash is very limited because the ice front stood in glacial Lake Agassiz during glacier recession.

Knowledge of the origin of gravel deposits in this region will facilitate their exploitation. In many places waste materials were seen to have been dumped over potentially good ground rather than over adjacent non-usable ground. Elsewhere sand-pit operators have not realized the potential for gravel at depth in certain types of deposits.

In the Sioux Lookout area, the southwest quarter of the map-area was examined in some detail to provide background information for town-planning purposes. Borrow pits and areas of potential sand and gravel close to town are either built over, privately owned, or held by the Canadian National Railway or the Ontario Ministries of Transportation and Communication, and Natural Resources. Certain areas not too far from town were outlined as potentially good prospecting ground for sand and gravel; these require exploration by test-pitting or trenching. Otherwise gravel supplies northeast of town are reported to be lacking over a distance of about 50 km. To the east and southeast there are no gravel deposits to beyond Alcona some 16 km distant. Major lakes and outcrops areas west of town restrict exploration in that direction.
No. 38 Northern Ontario Engineering Geology Terrain Study — Phase 2
J.F. Gartner

Introduction

The 1978-1979 program of engineering geology terrain mapping in northern Ontario is the second phase of a three phase program. This year’s study covers approximately 139,000 km² and comprises the following 1:250,000 NTS map sheets: full map sheets 42B, 42C, 42D, 42E, 42F, 42G, 52F and 52G, and part of map sheets 41N, 52B, 52C, 52D and 52E.

The work on this second phase is being carried out for the Engineering and Terrain Geology Section of the Ontario Geological Survey by Gartner Lee Associates Limited in conjunction with Geo-analysis Limited, Lee Geo-Indicators Limited and J.D. Mollard and Associates Limited.

Objectives

The prime objective of the study is to provide an inventory of basic engineering terrain information, at a scale of 1:100,000, which can be used as a resource base for regional planning in northern Ontario.

The work of the 1978-1979 phase of the study will provide:
1) planimetric maps, at a scale of 1:100,000, showing engineering terrain units,
2) comprehensive technical reports to accompany the engineering terrain maps,
3) examples of types of specific use maps that can be derived from the engineering terrain maps,
4) a composite map, at a scale of 1:1,000,000, illustrating the distribution of sand and gravel resources within the 1977-1978 and 1978-1979 areas.

Methods

Mapping will be completed primarily by airphoto interpretation, supplemented with a technical data search and reconnaissance level ground checking. The aerial photography, at approximately 1:50,000 scale, was flown mainly in 1976. Field checking is conducted by the interpreters themselves. General observations are made of surface phenomena, with the location and nature of man-made and natural cuts being logged. Published and unpublished records are searched for existing technical information, and the data integrated into the airphoto interpretations.

The mapping legend, which was derived for the first phase of the program (Gartner 1977) has been adopted for this second phase. It takes into consideration the texture of the material and its origin, the geological landform, morphological modifiers and the surface drainage characteristics. The format of the legend is as shown below.

material texture  LANDFORM  modifier—DRAINAGE

For additional details concerning derivation of the legend, refer to the description of last year’s program, (Gartner 1977).

Derivative Maps

The main objective of the study is to provide basic engineering terrain data on 1:100,000 scale planimetric maps. It is of equal importance, however, to illustrate how these maps can be utilized by the user community of planners, engineers, architects and public officials. With this in mind, the consultants are designing a “user manual”. The purpose of the manual will be to describe in non-technical terms how the maps can be utilized for a number of different potential uses. To provide a further emphasis as to the use of the basic data, nine derivative maps will be produced, one to accompany each report.

A compilation map at a 1:1,000,000 scale is being prepared to show the areal disposition of major sand and gravel resources. This map will cover the areas interpreted both in 1977 and 1978 and will provide a regional look at Quaternary aggregate resources between Latitudes 46°N to 50°N in northern Ontario.

Reference

Breakdown of Primary Quadrangle (NTS)

Cochrane

Kirkland Lake

Elliot's Sudbury

Marie Lake

Territorial District boundary

NTS boundary

100 200 KILOMETRES

LOCATION MAP
In 1978 the Ontario Centre for Remote Sensing (Ministry of Natural Resources, Lands and Waters Group) continued its physiographic mapping program in northern Ontario. The area covered 14 full or part 1:250 000 map sheets adjoining the area surveyed in 1977 (Cowan 1977). The Ontario Geological Survey supported this project by contributing a geologist for the field survey and air photo interpretation, and by analyzing soil samples. Field work was carried out with a Bell Longranger helicopter fitted with floats.

Field work consisted of collecting ground data (primarily botanical) to aid in airphoto interpretation. A limited number of stops were made to observe geological features. Between one and two days were spent in each map sheet, according to the complexity of the terrain.

It is intended that short reports will accompany each of the maps which are to be published at a scale of 1:250 000. Information on this project may be obtained from Dr. Simsek Pala, Ontario Centre for Remote Sensing, Ministry of Natural Resources, 880 Bay Street, (Third Floor), Toronto, M5S 1Z8.

Reference

Geophysics / Geochemistry Section
Uranium Reconnaissance Program

The results of two federal-provincial airborne gamma-ray spectrometer surveys covering parts of northwestern Ontario and southern Ontario were released in June and July, 1978 (No. 1 and No. 2 on Figure 1). The northwestern Ontario Survey covered an area of approximately 35,000 km² and consists of: NTS sheet 53C, North Spirit Lake; and parts of NTS sheets 53F, Ooasquia Lake; 53K, Stull Lake; and 53E, Island Lake. The southern Ontario survey covered an area of approximately 58,000 km² and includes: NTS sheets 41I, Sudbury; 31E, Huntsville; and parts of NTS sheets 41H, Tobermory; 31L, North Bay; and 31D, Lake Simcoe.

In addition, the results of one federal-provincial lake sediment geochemistry survey (No. 3 on Figure 1) covering the Thunder Bay — Schreiber Area were released in June 1978. The multi-element lake sediment survey covered an area of approximately 31,400 km² and included parts of NTS sheets 52A, Thunder Bay; 52H, Nipigon; 42D, Schreiber; and 42E, Longlac. This survey stimulated considerable exploration activity in the area which resulted in approximately 1800 claims being staked.

A combined geological-geophysical uranium follow-up investigation program was carried out in northwestern Ontario in June and July of this year. The geophysical portion of the project consisted of tracing radio-element trends using a helicopter equipped with a gamma-ray spectrometer. The purpose of the project was to obtain further reconnaissance information on the uranium potential in the West Patricia area of northwestern Ontario for a ministry land-use planning exercise. The data collected during the course of the project will be used for internal planning purposes.

Gravity Program

During the 1978 summer season, staff of the Geophysics/Geochemistry Section carried out a gravity interpretation study which was based on gravity data collected during 1975 and 1976 in the Birch-Uchi-Confederation Lakes area and the Red Lake area respectively. Over 5100 Bouguer values and 2571 rock densities are being used to interpret the 21,320 km² area which is centred on the two prominent metavolcanic-metasedimentary belts. Spectral analysis and two dimensional modelling have been completed at this time and an open file report is expected to be released by March 1979.

Geochronology Program

During the summer season Paul Nunes continued his study of the geochronology of the Uchi-Confederation Lakes area and the Kirkland Lake — Timmins Area.

The Uchi-Confederation Lakes project is now nearing completion. To date, five lithological dates have been produced from 19 analyses and a paper has been presented at the 4th International Conference of Geochronology, Cosmochronology and Isotope Geology at Aspen, Colorado this spring.

1 Chief, Geophysics/Geochemistry Section, Ontario Geological Survey, Toronto.
Figure 1—Federal-Provincial Uranium Reconnaissance Program.
The Kirkland Lake—Timmins area project is approaching completion. Several additional samples which were collected this summer are being readied for analysis. To date, four lithological dates have been produced from 20 analyses. More analyses are needed in this area because the age differences across the geological section are small and more accurate dates are required.

An additional geochronology program was organized at the beginning of the summer field season to study lithologies in the Sturgeon Lake—Vermilion Bay area. A geochronologist (Don Davies) was hired to carry out this project involving field sampling and analysis. Don spent a good portion of the season familiarizing himself with the geology of the area in addition to collecting a wide variety of samples. He will prepare and analyze the samples during the winter months.

**Airborne Survey Program**

The results of an airborne electromagnetic-magnetic survey of the Red Lake metavolcanic belt consisting of approximately 9500 line kilometres of data were released in September 1978. The results of two additional airborne surveys covering the Marshall Lake area and the southern and eastern portion of the Cretaceous Basin in the James Bay Lowlands will be released later this year.
Introduction

Gravity surveys represent one of the few feasible methods for determining the deeper geological and structural characteristics of the relatively flat and sometimes inaccessible Precambrian terrain of Ontario. A systematic gravity data collection and interpretation program was instigated in 1974 by the Ontario Division of Mines (Barlow et al. 1975; Dusanowskyj 1976). The aim of this program is to improve the gravity station coverage in Ontario and to aid in defining the deeper structural characteristics of the Canadian Shield. This will in turn give a better understanding on the evolution of the Canadian Shield, especially the metavolcanic belts and their associated mineral deposits. As a part of this continuing program, two economically important and structurally complex metavolcanic-metasedimentary belts, namely, the Red Lake and Birch-Uchi “greenstone” belts in northwestern Ontario, were selected for gravity surveys. The field work was undertaken during the summer months of 1975 and 1976 and as a result of this work, two Bouguer gravity maps (Barlow et al. 1976; Gupta and Wadge 1978) were published. For interpretation purposes, the two maps are now combined to produce a Bouguer gravity map at a scale of 1:250 000.

The study area, situated within the Superior Province of the Canadian Shield, includes parts of three geological subprovinces. These are the Uchi Subprovince in the middle, bounded on the north by the Berens River Subprovince and on the south by the English River Subprovince.

During the course of the gravity survey, over 2500 fresh rock samples were collected from outcrops at or near gravity stations for the purpose of density determina-
throughout the survey area. Most of the positive regional anomalies are associated with shallow sources.

A variety of regional residual separation methods were applied to the Bouger map. These include upward continuation filters, optimum filters designed from an analysis of the energy spectrum, and visual graphical smoothing. The filtered maps thus obtained have been compared with the mapped geology. A second derivative map has also been computed to enhance anomalies originating from shallow sources.

Quantitative two-dimensional model analysis of the residual gravity field has been carried out on 17 profiles covering most of the prominent anomalies. For certain strike-limited anomalies, a strike correction was applied to the two-dimensional models. A crustal gravity model has also been computed across the broad, long wavelength, regional gravity low of the survey area to investigate the configuration of the deep crustal boundaries, the Riel and Mohorovicic discontinuities. The regional interpretation derived from gravity data is compared with the seismic results of Hall and Hajnal (1969).

The object of this study has been (a) to study the relationship of the residual gravity field with the geology; (b) to obtain the geometry and depth of infolding of the various metavolcanic units and igneous rocks that have a gravity effect which suggests that they are either very thin or serpentinized, or both. Similarly, the boundary of the Killala-Medicine Stone Lakes, Linge Lake, Trout Lake, Odeil Lake, Allison-Siksanga Lakes, Gull Lake, and Shearstone-Kerswill Lakes, which are associated with areally large negative anomalies, strongly suggests that they are associated with bodies of batholithic proportions.

The steep gravity gradients, which correspond remarkably well with the "greenstone"-granite boundaries, do not necessarily imply steep geological dips but are believed to be caused in part by large density contrasts due to the higher grades of metamorphism of the extrusive rocks at the contacts.

Within the "greenstone" areas of the larger belts, the gravity highs are sometimes distinctly separated by the gravity lows which are associated with the plutonic bodies of various sizes, e.g. the Dome stock in the Red Lake belt and the Okanse pluton in the Birch-Uchi belt.

On the basis of large gravity features, the residual gravity map is divisible into six characteristic segments: the Red Lake belt in the west, the Dixie Lake belt in the south, the Coli Lake belt in the north, the Birch-Uchi belt in the east, the northern domain of the English River Subprovince along the southern edge of the map and the large scale granitoid features of the rest of the map-area (see Figure 1).

Qualitative Interpretation

Numerous positive and negative regional and residual anomalies of different shapes, sizes and amplitudes occur throughout the survey area. Most of the positive regional anomalies are associated with the metavolcanic units of high density, 2.72 to 2.93 g/cm³. In addition, the metasediments belonging to both the Uchi (average density 2.75 g/cm³) and English River (average density 2.74 g/cm³) Subprovinces, are associated with positive regional anomalies.

A good correlation between the residual gravity anomalies and the surface geology exists which suggests that the anomalies are clearly related to the upper crustal structure. The diorite (average density 2.75 g/cm³), gabbroic (average density 2.94 g/cm³) and ultramafic rocks (average density 2.80 g/cm³) in the area undoubtedly contribute to the overall shape and amplitude of the positive residual anomalies. However, it has been observed that many of the small known ultramafic bodies of the map area do not have an appreciable amount of positive gravity effect which suggests that they are either very thin or else they are highly serpentinized, or both. Similarly, the positive gravity effects, associated with thin units of ironstone, are too small to be detected by the present gravity survey.

Most of the negative residual anomalies correlate with various diapiric granitoid intrusives, ranging in density from 2.63 to 2.65 g/cm³ and in certain areas with diatexitic units (average density 2.63 g/cm³). Some of the intrusive bodies, for example in the vicinity of Killala-Medicine Stone Lakes, Linge Lake, Trout Lake, Odeil Lake, Allison-Siksanga Lakes, Gull Lake, and Shearstone-Kerswill Lakes, which are associated with areally large negative closures, strongly suggests that they are associated with bodies of batholithic proportions.

Uchi Subprovince

In the Red Lake belt, which also includes the Telescopic and Embryo Lake metavolcanic-metasedimentary areas, the anomaly contours trend from near NW to NNE to almost east. The belt is more than 64 km long and between 8 and 32 km wide. Along the widest portion of the belt, the positive gravity contours are interrupted by a circular gravity anomaly caused by the Dome stock. The southern boundary of the belt comes into contact with the Killala-Medicine Stone Lake batholith which is responsible for producing the sharpest gradient of the entire area at the contact with the Red Lake metavolcanics. Gravity profiles which cross the Red Lake belt have been modelled to show the depth of infolding of the metavolcanic rocks and their contact relationship with the surrounding granitoid rocks.

The Dixie Lake belt which is south of the Red Lake belt is characterized by a dominant, somewhat oblong shaped positive residual gravity anomaly of more than 16 mgal amplitude. The mapped geology shows that this anomaly is caused by mafic to intermediate metavolcanics. The two-dimensional structure of the body has been modelled along a profile which passes through the axis of the anomaly.

The boundary of the Berens River Subprovince cannot be established on the basis of gravity data and is also not well defined by geological evidence. The Coli Lake belt, which is located in the area of the boundary, is represented by an 8 mgal positive residual anomaly which has...
Figure 1—Generalized residual or near surface component of the Bouguer gravity field.
a NW trend. The southern part of this anomaly has a steep gravity gradient which is quite typical of other “greenstone”-granite contacts and may be caused by local high density intrusive or metasedimentary rocks, however, the northern portion of the anomaly lacks such a style. The anomaly is approximately 18 km long and 13 km wide. Four gravity models, having different parameters, have been computed from a profile across the middle of the belt to help explain the anomaly.

The Birch-Uchi “greenstone” belt underlies an extensive gravity high with several local peaks, which by their amplitudes indicate deeper accumulations of mafic metavolcanics. The relatively lighter felsic to intermediate metavolcanics and metasediments do not have a consistent gravity expression, therefore, the lows which do appear in part to be associated with them may actually be due to deeper structures.

In general, the “greenstone”-granite contacts are marked by steep gravity gradients. In the Berens River, Keiget Creek and Papaonga Lake areas, however, moderate gradients extend the positive anomalies several kilometres beyond the boundaries of the metavolcanic units.

In the Berens River and Keiget Creek areas, these “Extensions” can qualitatively, at least, be accounted for by denser (2.73 g cm$^{-3}$) surface rocks. There is no apparent surface correlation, however, in the Papaonga Lake area, which suggests that the metavolcanics may have a significantly greater lateral extent at depth than the geological mapping indicates.

To the east and west, the Birch-Uchi “greenstone” belt is bounded by extensive granitic areas which are characterized by generally negative residual anomalies. The most prominent low is a ~17 mgal residual anomaly centered over Gull Lake, to the east of the “greenstone” belt. This anomaly is underlain by a uniform, low density granite and appears to represent a single major batholith.

The remaining negative anomaly areas are more complex. The Allison- Sesikanaga Lake batholith is considered to constitute a major portion of the granitic area to the east-southeast of the “greenstone” belt. Its dimensions have been estimated to be 15 km wide and 30 km long. The corresponding residual anomaly, however, averages only about ~8 mgals, with a minimum of ~11 mgals occurring less than 5 km from the “greenstone”-granite contact. The actual “batholith”, therefore, appears to be located to the north of Allison Lake, while the Sesikanaga Lake area represents a shallower marginal structure.

**English River Subprovince**

In general, the gravity field increases in value southward towards English River Subprovince from the Uchi Subprovince. A 145 km long linear gravity zone having a steep gravity gradient reaches a residual gravity maxima of 16 mgal over the northern part of the English River Subprovince. The linear zone trends almost east from the western edge of the map to Ear Falls and then swings to an east-northeast direction. This linear zone perhaps reflects, completely or in part, the northern boundary of the metasedimentary trough (average density 2.74 g cm$^{-3}$) of the northern part of the English River Subprovince. This zone also coincides with the Sydney Lake fault system which outcrops at various places as a zone composed of cataclastic rocks. The subprovince boundary is marked by a fairly uniform southerly increasing rise of 1.2 mgals/km over most of its length. The one interesting characteristic of the gravity anomaly over the English River metasediments is its almost total lack of response to the numerous, intrusive, trondhjemite-granodiorite bodies, the largest of which (the Bluffy Lake batholith) is 12 km wide and 60 km long. This would suggest that these bodies are extremely shallow, sheet-like features. Numerous gravity profiles across the English River Subprovince have been modelled to show the geometry and configuration of the linear gravity zone and other associated anomalies of this subprovince.

**References**

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In December 1977 an airborne electromagnetic-magnetic survey of the Red Lake metavolcanic-metasedimentary belt was flown for the Ontario Government by Questor Surveys Limited. The survey, 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, was planned and co-ordinated by staff of Geophysics/Geochemistry Section. An area of approximately 1870 km² was surveyed in two blocks using the Barringer/Questor Mark V1 INPUT R airborne electromagnetic system and the Geometrics G-803 Proton Precision Magnetometer.

A total of 9545 line kilometres of data was collected at a terrain clearance of 120 m, using a line separation of 200 m. The INPUT system will respond to conductive overburden and near-surface horizontal conducting layers in addition to bedrock conductors. Discrimination of conductors is based on the rate of transient decay, magnetic correlation, and the anomaly shape, together with the conductor pattern and topography. Some 3512 anomalies were detected, of which 52.3 percent were 6-channel responses, 12.4 percent were 5-channel responses, 14.1 percent were 4-channel responses, 12.4 percent were 3-channel responses, and 8.8 percent were 2-channel responses.

The anomaly results include many long-strike-length multi-line conductors which are indicative of graphitic schists and of sulphide mineralized horizons associated with metasediments and ironstone. Single line or 2- to 4-line conductors are scattered in clusters through the main trend in the central part of the metavolcanic-metasedimentary belt. Peripheral areas covering the east and west end of the belt are also favourable areas for the short-strike-length conductors. Together with the magnetic data the resultant conductive trends aid in outlining the detailed structural complexity with regard to folding and faulting in certain areas of the belt.

The information was released on photo mosaic based maps, Ontario Geological Survey Preliminary Maps P.1571 to P.1586 inclusive, on September 14, 1978.

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Mineral Deposits Section
Summary of Activities of the Mineral Deposits Section, 1978

J.A. Robertson

The Mineral Deposits Section comprises the Section Chief and five Mineral Deposits Geologists. During the year the following persons were added to the permanent staff: Clarence Kustra, Liaison Geologist, who is responsible for the relationship between the Ontario Geological Survey and those geologists attached to the Ministry’s regional staff; Dr. Janet Springer who is responsible for mineral potential maps and related studies; and Mrs. Iva Sherrett who has been appointed section secretary.

The permanent staff is supplemented as necessary by geologists and geological assistants particularly for programs undertaken under the sponsorship of Ministry of Northern Affairs or Ministry of Treasury, Economics and Intergovernmental Affairs.

Projects undertaken by the Section cover mineral deposit classification and distribution of mineral potential and reserve or resource analyses, research on metallogenic concepts and studies on ore deposits. These studies emphasize geological environment, development of guidelines for exploration and input to government planning in such sectors as land use, transportation corridors, and mineral management. The delineation of areas of natural radioactivity and significant frequency of uranium showings has become an important input to interministerial task forces concerned with radiation and radon studies.

During the year no new mineral distribution maps were published but maps for silver and for copper-lead-zinc deposits are in press. Work has started on revision of the “Ontario Mineral Map” and on a second edition of the “Radioactive Deposits of Ontario”, combined with revision of the Mineral Resources Circulars for uranium and thorium deposits of northern and southern Ontario.

Mineral Potential Maps (1:250 000) have been completed and published for the Grenville, Southern and Superior Provinces. New editions will be prepared for individual sheets as new data and concepts necessitate. During 1978 studies have begun on definition of quantifiable geological parameters which show statistically significant relationships to known mineral deposits (Umar, this volume).

J. Robertson, and on occasion, J. Gordon, co-operated with the fourth annual study of uranium reserves and resources of the province in conjunction with the uranium resource appraisal group of Energy, Mines and Resources Canada (EMR 1978; Robertson, this volume). The nickel reserve and resource study (D. Innes, and J. Birch, Mineral Resources Branch) is now past the halfway stage and concepts on the distribution of nickel in Ontario are being developed (Innes and Birch this volume).

Studies on lithium deposits (Vos), pegmatite deposits (Vos), industrial minerals of the Sudbury area (Smith and Vos, this volume), chromium deposits (Whittaker, this volume), have been started. Studies on the nature and distribution of “porphyry” type deposits of gold, molybdenum, copper, and possibly tin, and uranium are continuing under the guidance of A.C. Colvine (Colvine, this volume). H.D. Meyn has carried out an assessment of possible aluminum resources in Ontario and has concluded that under present technology and political-economic climate for the industry only anorthosite and syenite and possibly aluminous shale have any potential as alternative sources of alumina and that studies on such rocks should include an assessment of recoverable alumina.

The 1978 field season saw the completion of the field work under “Operation Pembroke”. Preliminary open file reports on the marble, base metal, and uranium deposits will be available shortly and during the current year the related laboratory studies will be completed (Gordon et al. this volume). These studies emphasize lithological, stratigraphic, structural, and metamorphic controls on the distribution and localization of mineral deposits.

1 Chief, Mineral Deposits Section, Ontario Geological Survey, Toronto.
R.B. Graham (1976, 1977) has completed a report on the peat and peat moss deposits near major transportation corridors in northern Ontario (Graham 1978). Investigation of thermal characteristics of peat has been added to these studies and at least one of the deposits may be further studied to determine possible fuel resources. Vos, and Eric Blunden (Mineral Resources Branch) have documented the history and production of industrial minerals of Ontario with a view to preparing an industrial minerals program for the ministry.

Fyon and Kariinen (this volume) have completed the field work on the distribution of carbonates, porphyries and related gold deposits in the Timmins camp. This work has stimulated both exploration and several research projects supported from the Ontario Geological Research Funds. Studies on gold deposits in the vicinity of Atikokan (MacRae, this volume) are the first phase of a two-year study to define the mineral resource potential near Atikokan and to define possible targets for exploration during and after the closure of iron mines. Gold studies are contemplated for Red Lake, and Kirkland Lake — Larder Lake and silver studies for the Cobalt camp. Base metal relationships to the Port Coldwell Complex are being investigated by Wilkinson and Colvine (this volume).

Joint projects with other sections of the Ontario Geological Survey have been undertaken. Preliminary maps (Closs and Colvine) are in press for the pyritic/graphitic volcanogenic sedimentary rocks and related massive sulphide deposits in northwestern Ontario. The Mineral Deposits Section has sponsored assistants on selected Precambrian Geology Section field parties in order to facilitate studies on porphyry type deposits (Colvine and Studdmeister, this volume). The Elliot Lake diamond drill file has been completed and was demonstrated by the Geoscience Data Centre at the Ontario Geological Survey workshop. The file will be updated on a yearly basis. Similarly the iron deposit computer test file has been completed and the experience gained will be used in developing future commodity files.

Staff members took part in the Ontario Geological Survey workshop, the workshops on uranium deposits at McGill University, as well as participating in field trips and workshop papers for Toronto ‘78, the combined meeting of the Geological Society of America, the Geological Association of Canada, and the Mineralogical Association of Canada. Several other technical meetings and field trips were attended. A.C. Colvine has become Geology Division representative on the Canadian Institute of Mining and Metallurgy’s publications committee. Considerable technical data and discussion were provided for exploration personnel particularly in the uranium and industrial minerals sections.

References

EMR

Graham, R. Bruce, and Associates Ltd.
Introduction

At the request of the Ministry of Treasury, Economics and Intergovernmental Affairs, the Ontario Geological Survey has undertaken an integrated program of geoscience surveys and mineral resource studies within the Pembroke-Renfrew region (NTS 31F) to encourage mineral exploration and development by private enterprise and for governmental planning and policy guidance. The Mineral Deposits Section is compiling available data, on and examining the known mineral deposits of the region. The objectives are to determine the relationship between mineral deposits and the geological setting, to assess the potential for discovery of additional deposits and to provide guidelines for exploration.

During the 1978 field season, 8 uranium, 17 base and precious metal and 30 industrial mineral occurrences were examined, sampled and described. The main thrust of the program in 1978 however was in selected studies related to stratigraphy and metallogenesis. The interim results are noted in the following subsections: Uranium and Thorium Deposits (Gordon and Masson), Industrial Mineral Deposits (Vos and Storey), Mineral Deposits of Metals Exclusive of Uranium (Carter and Colvine).

Previous work in the area by the former Ontario Department of Mines and Division of Mines included examination of mineral deposits (Satterly 1944; Thompson 1943), detailed and reconnaissance mapping (Hewitt 1953, 1954, 1955, 1957; Smith 1956; Peach 1956; Evans 1964; Lumbers 1968, 1976, 1977; Themistocleous 1978) and mineral potential studies (Springer 1976). The work carried out during 1977 is summarized in Gordon et al. 1977.

Location

The Pembroke-Renfrew area for purposes of this project is bounded by Longitude 78°W, the Ottawa River and Longitude 76°W and by Latitude 45°N, the Algonquin Provincial Park and Latitude 46°N. It encompasses an area of approximately 14 000 km². The communities of Almonte, Arnprior, Bancroft, Carleton Place, Eganville, Renfrew and Pembroke are included in the area.

Mineral Exploration

The area has been prospected for a great variety of mineral deposits including apatite, asbestos, barite, celestite, clay, copper, corundum, feldspar, fluorite, garnet, gold, graphite, iron, magnesium, marble, marl, mercury, mica, molybdenum, nepheline, nickel, peat, pyrite, quartz, rare earth minerals, sillimanite, strontium, talc, uranium and zircon. Production has been attained from deposits of celestite, clay, corundum, feldspar, graphite, iron, lead, mica, magnesium marble, molybdenum, nepheline, zinc and uranium. The current mineral producers are Chromasco Limited (magnesium), TMF Mineral Resources (magnetite), W.R. Barnes Company Limited (marble) and Madawaska Mines Limited (uranium). Limited production of sodalite (Princess mine) and rose quartz (Wall Gem Lapidary Company) has been used by the lapidary trade.

General Geology

The consolidated rocks of the area range from Middle Precambrian to Paleozoic in age. The Paleozoic rocks form a generally flat lying to gently dipping sequence of limestone, dolostone, and sandstone that unconformably overlie the Precambrian basement. They occupy the eastern portion of the Pembroke area and often form large outliers within the Precambrian basin complex, particularly in the northeastern portion of the area.

The Precambrian rocks of the area consist of two distinct complexes of Middle and of Late Precambrian ages. The Middle Precambrian rocks occupy the northwest portion of the area and form the basement complex in this area (Wynne-Edwards 1972). These rocks comprise orthogneisses of monzonite, quartz monzonite and quartz syenite composition that are part of a large intrusive complex known as the Algonquin Batholith (Lumbers, in preparation). This complex contains xenoliths of paragneiss of sedimentary origin. The Late Precambrian rocks form a supracrustal succession, the Grenville Supergroup that unconformably overlies the Middle Precambrian basement complex. The supracrustal succession consists mainly of rocks that are sedimentary in origin and includes dolomitic limestone, sandstone (principally feldspathic wacke) and calcareous sandstones. Metavolcanic rocks, consisting principally of mafic to intermediate flows with minor amounts of felsic flows and pyroclastics commonly form thin interbeds within the dominantly sedimentary sequence. There are two major volcanic belts of which the best known is the Hermon Group (Lumbers 1967) which
trends northeasterly through Faraday, Denbigh and Lyndoch Townships in the southwest part of the study area. The other belt trends southwesterly through Bagot, Darling and Lavant Townships in the southeastern portion of the area. The supracrustal rocks were intruded by numerous plutonic rocks ranging in lithology from gabbro to granite and syenite.

The Precambrian rocks of the area were subject to the Grenville orogeny (950 m.y.) and as a result have been recrystallized and are complexly folded with a dominant northeasterly structural trend. The regional metamorphic grade within the Grenville Supergroup is normally of amphibolite facies but it attains granulite facies in the

Middle Precambrian basement complex and is as low as greenschist facies within a small area in Lavant and Darling Townships. Lumbers (1964) has related the nature and distribution of mineral deposits to metamorphic grade as well as to the original composition of the host rocks. Most of the important mineral deposits are contained within rocks of the Late Precambrian supracrustal succession (Grenville Supergroup). Minor occurrences of iron, lead, copper and uranium are present in the Paleozoic cover rocks and deposits of feldspar and thorium in pegmatites are found in the Middle Precambrian basement orthogneisses.

Uranium and Thorium Deposits

J.B. Gordon1 and S. Masson2

The main objective of this study is to establish the genetic relation of uranium mineralization to the host rocks and adjacent country rocks. Samples of the occurrences, host rocks and adjacent country rocks were analysed for uranium, thorium, niobium and rare earths, to determine (i) the distribution of these elements for the different types of deposits, adjacent intrusive rocks and host paragneiss, and (ii) the U/Th ratio which may be useful in establishing a sedimentary or igneous source and which may also indicate regional zoning.

The major uranium occurrences in the Bancroft area occur within a broad carbonate-rich sedimentary succession in the Grenville Supergroup. Bright (1976) suggested that pegmatite, derived from partial melting of the basal arkose and/or other units, intruded the Supergroup, leaching and incorporating uranium from uraniferous horizons of the metasediments to form calc-silicate deposits. Numerous pegmatites occur above and below this sedimentary sequence but only a few are anomalously radioactive. Similar views are held by Allen (1971) and Tremblay (1975) for the genesis of uranium deposits associated with the Grenville orogeny in the Province of Quebec. Lumbers (1975) working in the Pembroke-Renfrew area recognised the importance of the Middle Precambrian—Late Precambrian unconformity as a potential source of uranium. Elsewhere in the Canadian Shield the role of unconformities in localizing uranium deposits has been well established (Sibbald et al. 1976).

In all, there are 114 reported radioactive occurrences in the study area and of these, 96 have been examined during the field seasons of 1977 and 1978 (Figure 1). Sixteen occurrences were not found and for the most part they are believed to be very small and of little economic importance. Several locations are believed to be incorrectly reported.

Early in the 1978 field season eight radioactive occurrences in Miller, North Canonto and South Canonto Townships were examined. The occurrences examined in Miller and North Canonto Townships are small and are considered to be of little economic importance. In South Canonto, the Bordun and Honsberger properties appear to represent an important area of uranium-thorium and rare-earth mineralization. Although reported uranium values are sub-economic and U/Th ratios are low, the area may have potential for large, low grade deposits. Mineralization in this region is related to fracture zones occupied by granite pegmatites. Only those pegmatites which have been later sheared and fractured show important uranium mineralization. Also in the 1978 field season, a detailed study was made of the lithologies, stratigraphy and mineralization of a selected area (see Figure 1) in the northern part of Faraday and Dungannon Townships. In particular the area including and flanking the “Faraday Granite” was studied. Fifteen geological cross-sections were measured in order to correlate the narrow uraniferous horizons present. The succession studied encompasses the basal portion of the Grenville Supergroup, up to a distinctive marker horizon extending the length of the study area which is referred to in this report as the Derry Lake Marble. The York River and Eagle Nest properties, as well as numerous unreported occurrences all lie within the area. The Faraday and Greyhawk deposits lie within units stratigraphically above and south of the study area.

The rocks of the area comprise a succession of northeasterly trending and southeasterly dipping, granite gneiss, granite, biotite gneiss, amphibolite gneiss, syenitic gneisses, gneissic syenite and silicicated marbles. The “Faraday Granite” which dips southeastward off what is interpreted as the Middle Precambrian basement complex in the Faraday Lake area, is tentatively correlated with the

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basal subunit (arkose, arkosic sandstone and siltstone + magnetite) of the Anstruther Lake Group (Bright 1977). In the Eagle Nest section (Figure 2), the Faraday Granite overlies younger paragneiss and marble. The contact is believed to mark a major thrust fault near the base of the granite gneiss. The contact or fault zone is defined by thin biotite gneiss layers and by granite which may have been formed anatectically from mylonitized granite gneiss. This unit can be mapped to the Faraday Lake section where paleo-overthrusting shows an exaggerated thickness to the section of Faraday Granite in the area (see Figure 3). This paleo-thrust marks a significant horizon because it is within this granite (anatectic) and associated pegmatites that the important radioactive occurrences of Eagles Nest and the York River D and E Zones are associated. Other less important uraniferous horizons are sheets of pegmatitic syenite which are also tentatively interpreted as paleo-faults.

Overlying the Faraday Granite gneiss (meta-arkose?) is a thin sequence composed of highly foliated biotite syenitic gneiss and a thin marble unit (8 to 12 m thick), which contains numerous bodies of granite, granite pegmatite and syenite pegmatite. This zone forms the second most important uranium bearing horizon and it is within this horizon that the York River B zone occurs. It is apparently conformable in the Faraday Lake section, but in the Eagle Nest section it may represent another paleo-thrust zone (Figure 3). Unfortunately the zone is usually represented by a depression. This horizon is overlain by a relatively thick section of biotite amphibolite gneiss which serves as a marker horizon. No significant radioactive occurrences were observed within the amphibolite gneiss.

The amphibolite unit is succeeded by thinly layered syenitic gneisses, which only rarely contain radioactive mineralization. Succeeding the syenite gneiss is a thin layer of amphibolite also barren, which is in turn overlain by a thin (3 to 6 m thick) layer of mylonitic apatite marble. This apatite marble is a distinctive marker horizon containing up to 20 percent apatite.

The marble is overlain by calcareous syenite gneisses interlayered with 1 m layers of apatite marble. This syenite forms the third radioactive horizon of the section studied. Granite sills and pegmatites which cut this unit are anomalously radioactive. The York River G zone is in this syenite. The interlayered apatite marble in the syenitic sequence may represent a sedimentary phosphatic facies. Phosphatic sediments are known to be associated with uranium mineralization (Udas and Hahadevan 1974), and this hints at a possible stratigraphic source bed for the uranium. On the other hand mylonitic marble suggests that there has been a major structural adjustment along this zone, as with the other uraniferous zones described.

The phosphatic layer is followed by a pink pegmatitic syenite occasionally nephelion-bearing which gives only
Faraday Lake-Derry Lake Section

Faraday Gabbro
Hornblende Amphibolite
Syenitic Hornblende Biotite Gneiss
Hornblende Amphibolite Gneiss
Syenitic Biotite-Hornblende gneisses
Foliated Pink Equigranular Syenite

Leucocratic nepheline and feldspar syenites grading up section to mafic rich syenites

Foliated to Gneissic pink equigranular syenite
Derry Lake Marble Unit — Marble characterized by tectonic breccia of pyritic calc-silicate gneiss fragments and layers with minor graphitic rusty gneiss
Foliated Pink Equigranular Syenite
Biotite rich syenite gneiss with minor apatite marble units
Apatite mylonitic marble (3-6 m)
Syenitic gneiss and minor amphibolite — with up to 25% granite (sills)

Amphibite Gneiss
Granite, in part Pegmatitic
Marble
Granite pegmatite and minor syenite gneiss
Magnetite Granite Gneiss

Granite - minor pegmatite
Biotite rich gneiss
Magnetite Granite Gneiss

Pegmatitic Granite
Magnetite Granite Gneiss

Biotite Gneiss
Pegmatite Granite

Migmatitic Rocks (Middle Precambrian Sequence)? Biotite hornblende and hornblende biotite gneisses, minor quartz-feldspathic gneiss with many granite sills and dikes

Figure 2—Stratigraphy of the Grenville Supergroup in northern Faraday and Dungannan Townships.
Figure 3—Composite and simplified stratigraphy of the York River — Eagles Nest radioactive horizons.
occasional “spot highs” of radioactivity and then by the very distinctive marker horizon, the Derry Lake Marble, which presents a very low radioactivity profile except on the south contact where “spot highs” are present in pyritic granite pegmatites. The marble is overlain by pink, foliated equigranular biotite syenite, very similar to that below the marble. No radioactive occurrences were observed in this unit. Above the syenite, the stratigraphic succession has not yet been studied.

**Interim Conclusion**

The uranium in the granite zone (paleo-fault zone) e.g. the Eagle Nest occurrences, within the “Faraday Granite” is believed by the writer to have been deposited, in a first stage concentration, within the fault zone prior to formation of the granite. The granite has the same chemical composition as the granite gneiss and is characterized by variable textures and composition. This suggests an origin by partial melting or re-crystallization during high grade, regional metamorphism.

The formation of mineralized pegmatites within the granite horizon may, in part, be dependant on the availability of carbonate, as evidenced by the abundance of sphene and calcic pyroxenes which characterize the mineralized pegmatites, e.g., the York River D Zone. Carbonate mobilized during regional metamorphism may have assisted the formation of pegmatite by providing an environment of high gaseous pressure. The association of uranium with pyroxene and carbonate veins suggest that CO₂ has acted as a collecting agent for uranium. pegmatites which formed within an already enriched uranium environment would also become enriched in uranium. Radioactive pegmatites within or derived from the granite which occur in a zone at the base of the “Faraday Granite”, also appear to be controlled by fracture systems within the granite. It is suggested that events leading to the formation of the more important deposits of the “Faraday Granite”, i.e., The York River D Zone and Eagle’s Nest Zone, may have included multiple stage faulting and fracturing with the uranium content being upgraded at each level.

Uranium mineralization in the study area is believed by the writers to have two important modes of genesis.

- a) A complex enrichment process involving faults, recrystallization, partial melting, recrinning fracturing and shear and pegmatite development by anatexis.
- b) Enrichment in pegmatites or granites which intrude a uraniumiferous horizon in phosphatic marbles and syenites.

During the latter part of the 1978 field season the writer revisited several uranium occurrences along the north and northeast contact of the Hurd Lake granite, which lies south of the town of Renfrew. The area is of interest in that the granite may have been anatectically derived from arkosic sediments which may also have been the source of the uranium mineralization in the area.

**Industrial Minerals**

**M.A. Vos¹, and C.C. Storey²**

**Introduction**

The 1978 field season was spent examining additional mineral occurrences and reviewing previous work. Marble, pegmatite, graphite, garnet, apatite and fluorite, talc and tremolite, barite, zircon, sillimanite, and non-pegmatitic mica were investigated. The last seven are grouped together under miscellaneous occurrences, including the Princess sodalite mine (see also Vos and Storey 1977 for background information on the various mineral deposit types).

**Marble**

A marble prospect in Mayo Township, the Tatlock quarry in Darling Township and the stratigraphy in southern Dar-
Pegmatite (Feldspar, Quartz, Mica, Beryllium, Rare Elements)

Nine pegmatite deposits were investigated. These include the Quadeville rose quartz berylmine and rare element pegmatites, several past-producing feldspar mines (the Five Mile mine in Dickenson Township, the Whytlock-Grey-Ellington mine in Miller Township) and prospects in Brudell, Dickens, Bangor and Montague Townships. Granitic intrusions in Lanark and Drummond Townships east of the village of Lanark mapped by Reinhardt (1973) were examined, particularly for beryllium, lithium, and rare elements. Pegmatite bodies found near or associated with other mineral deposits were also investigated. The work consisted of examination of available exposures and sampling the material for analyses of Li, Be, Ta, Cs, Cu, Sn, rare earths. Many of the samples were slabbbed and stained by the sodium cobaltinitrate method.

The zoned pegmatites are granite or quartz monzonite but their coarse grain size and irregular mineral development often give problems in estimate of their composition. Pegmatites have been grouped into zoned and unzoned by many investigators (e.g. Cameron et al. 1949; Jahns 1955). Problems arise because many pegmatites have only rudimentary zoning. Quartz cores are common. They are well defined and often the only sign of zoning present. Otherwise homogeneous pegmatites often contain small cores and occasionally small discontinuous zones of radioactive materials and plagioclase feldspar. Pegmatite bodies often change along strike from homogeneous quartz feldspar mixtures to discontinuously zoned to fully zoned pegmatites. The above description applies to pegmatites that have been worked or prospected for their feldspar, mica, or quartz content. Radioactive and rare element minerals are common accessories and may make up a sufficient portion of the body to warrant exploration for these minerals alone. The minerals occur in both zoned and unzoned pegmatites. The ‘granitic’ pegmatites can be further divided into two groups: pink pegmatites and white pegmatites. The pink variety contains abundant pink microcline which produces the characteristic colour. The white pegmatites contain white orthoclase, albite and quartz with varying amounts of biotite, hornblende, etc. All the zoned pegmatites and all the feldspar prospects are pink pegmatites. The white pegmatites tend to be small homogeneous irregularly shaped bodies. A major concentration of these occurs in the Mountain Chute area of Brougham Township. The white pegmatites classify as quartz monzonite; they have less potassium feldspar than the pink pegmatites.

Graphic intergrowth of quartz in feldspar is a common feature of pegmatites. The scale of this intergrowth varies from a few millimetres to several centimetres. The intergrowth varies from well defined regular check-marks to rough blobs of quartz and feldspar mixed. The latter is often difficult to differentiate from fine grained homogeneous pegmatite. The quartz-feldspar mixture often contains small (2 to 5 cm) masses of fine grained graphic granite.

In addition to granite pegmatites there is also an extensive group of syenite pegmatites associated with the syenite belt that extends from Bancroft to Dacre. This belt contains many radioactive, rare element and corundum occurrences. These pegmatites are of the unzoned type.

The zoning in granitic pegmatites is similar all through the Pembroke-Renfrew area. The pattern is as follows: border zone of graphic-granite or quartz-feldspar mixture; wall zone of albite, mica, and quartz, and quartz core. The albite-microcline-quartz zone is found in the larger pegmatites but tends to be missing or incomplete in narrow bodies. Replacement zones are found in the Quadeville beryllium pegmatites and possibly in the MacDonald mine (calcite pods in core). The size of the body has little effect on zoning. Some of the largest pegmatites are homogeneous or only show rudimentary zoning. Rose quartz is well developed in the Quadeville pegmatites but is found only in minor amounts of pale colour elsewhere. Beryl is found only at Quadeville. Quartz cores often contain large microcline crystals and biotite, particularly in small cores. The large quartz cores tend to be all quartz except near the contacts where biotite is frequently present. Hematite is common in fractures in the quartz and often is responsible for a slight rose tint. Spodumene has been reported from a pegmatite (?) near Perth (Hoffman 1889, p.597). The Lanark pegmatites (located east of the village of Lanark) were sampled with this in mind.

Graphite

Graphite is commonly associated with metasediments, either marble or gneiss (arkose). Graphite in disseminated flakes and powder is common in marble e.g. in Brougham, Ross and Darling Townships. Disseminated graphite, flute and powder is associated with pyritic arkose wacke. In both types the graphite is stratigraphically controlled. Rusty weathering pyritic arkose wacke units are common throughout the sedimentary sequences of the area. They range from less than one to several metres in thickness. These often contain small amounts of graphite. Several thick units of graphic pyritic arkose occur north of the Madawaska River in Lyndoch, Brougham and Matawatchan Townships. As they contain large amounts of pyrrhotite, pyrite, and traces of other sulphide minerals along with several percent graphite they weather rapidly, giving a thick gossan. This disseminated type deposit is similar to the Alabama graphite deposits (Graffin 1975). Recent exploration (e.g. Little-Bryan deposit in Lyndoch Township) was directed at this type of deposit. Graphite in marble occurs in both disseminated and in massive form (Beidleman and Lyall deposit, Lyndoch Township). Graphite in marble occurs in metasomatic carbonate hosted deposits (Kenelly Lake, Brougham Township), carbonate hosted vein deposits (Green Lake, Brougham Township), and in one deposit in a pegmatite cutting graphic marble (Little Birch Lake, Denbigh Township).

The metasedimentary deposits are probably developed from organic material incorporated with the sediments (Weis 1973; Graffin 1975). The origin of the other
types of deposits is more obscure and may involve complex, metamorphic and chemical reactions (Salotti et al. 1971).

**Garnet**

Garnet is a common mineral in the Grenville paragneisses. Garnet also occurs in the contact zones of the York River nepheline gneiss belt (Hewitt 1954) and is a frequent accessory mineral in pegmatites.

Garnet was extracted from the Ruby deposit in Ashby Township for a brief period during the 1920s. This deposit was reinvestigated by C.C. Allen in 1976. The deposit consists of dark red garnets (probably andradite) disseminated in black biotite hornblende gneiss. The host rock is part of a series of metavolcanic and metasedimentary rocks that extend from the northeast corner of Ashby Township into Raglan Township and then swing east toward Lyndoch Township. A similar but much smaller deposit was found in the northwest corner of Ashby Township in metavolcanics that form part of an extensive belt of metavolcanic and metasedimentary rocks of the Hermon Group (Evans 1964). Evans indicated that the rocks containing the Ruby deposit may also belong to the Hermon Group. Numerous minor occurrences of garnet are listed in rock collecting guides (Peterson 1978; McMurray 1977; Sabina 1964).

**Apatite and Fluorite**

Apatite and fluorite are often found together in Late Precambrian calcite veins or dikes associated with gneissic quartz monzonite and syenite bodies (Lumbers 1976). Lumbers (unpublished compilation) has grouped these chronologically with the late pegmatites. There are two types of these veins, one of which consists of calcite with abundant apatite and pyroxene with accessory sphene, scapolite and zircon, primarily in Sebastopol Township, Renfrew County.

The other type is similar but carries moderate amounts of fluorite. Themistocleous (1978) has mapped several of the first type in the Clontarf area. The fluorite bearing variety occurs primarily in Ross Township, Renfrew County. These veins are of mineralogical rather than of economic interest. Work other than mineral collecting was last done on the fluorite occurrences during World War II. The Turners Island apatite mine in Lake Clear was re-opened for specimen material in 1977 by the National Museum in Ottawa.

A second type of apatite deposit is disseminated in
marble of the Bancroft uranium area. This type of deposit contains several percent apatite in an impure calcitic marble or calc-silicate gneiss. It can be found in the Bancroft area and in northwest Brougham Township associated with important uranium mineralization (see Gordon and Masson, this volume).

Apatite also occurs as an accessory mineral in pegmatites particularly in the Mountain Chute area. Spence (1930) mentions a few other locations. Fluorite occurs as a minor accessory mineral in a few pegmatites (Wilson 1929) and also in the Wolfe nepheline belt (Hewitt 1960). Lumbers (1977) mentioned a carbonatite deposit in Sullivan Island in the Ottawa River with considerable apatite and possibly uranium and rare earths.

Barite and celestite occurrences lie in the southeast part of the area and are veins of early Paleozoic age (Lumbers in preparation). Barite-celestite mineralization occurs in the Dempseys (Virgin) Lake occurrence, but the other occurrences are barite often with minor galena. The barite mineralization of the Clyde Forks deposit is apparently a conformable syngenetic hot spring deposit (Colvine et al. 1977).

Zircon

Zircon is common as an accessory mineral in granitic and syenitic pegmatites. The altered radioactive variety, cyrtolite, is frequently found as dark red to brown bipyramidal crystals in the radioactive mineral occurrences. Zircon also occurs in the York River nepheline pegmatites and the calcite-apatite veins. The Kuehl Lake deposit in Brudenell Township was developed for mineralogical specimens (Satterly 1944) and is the only one developed for zircon alone.

Sillimanite

Sillimanite occurrences consist of small to moderate (up to 30 percent) amounts of sillimanite in high grade metamorphic gneisses. The occurrences in the Pembroke-Renfrew area are minor and have no economic significance.

Mica (Non-pegmatitic)

Three types of mica occur in the area (McMurray 1977; Hewitt 1968; Thompson 1943): muscovite, phlogopite and biotite. Muscovite occurs in granitic pegmatites but is also found in green metamorphic pyroxenite (Hewitt 1968; Thompson 1943). There was minor production of mica during the 1920s and renewed interest in World War II. The deposits examined are associated with small irregular pink granitic dikes and veins. These granitic bodies appear to have influenced the formation of pyroxenite. Two muscovite deposits unrelated to pegmatite were examined. In Lanark Township a lens of muscovite is contained in pyritic paragneiss and micaceous quartzite occurs along the Fernleigh-Clyde Fault Zone (Smith 1956).

Talc and Tremolite

Talc is a common accessory mineral in the marbles of the area. Locally talc has been altered to talc by hydrothermal alteration and shearing (Hewitt 1972). A large belt of tremolitic dolomitic marble near Lanark (Smith 1956) was examined for potential as a mineral filler.

Recommendations for Exploration

Most of the mineral occurrences examined are of mineralogical interest only. However, they are sources of specimen material and decorative stone for the tourist and rock shop trade. Rock-hounding and semi-professional inspecting should be encouraged to enhance local business as such activities may well lead to significant mineral discoveries. Tourist oriented guidebooks (Petersen 1978; McMurray 1977; Sabina 1964) help focus attention on the mineral deposits of the area.

Marble, particularly in the Marble Bluff Tatlock area, offers good potential for use as terrazo aggregate and filler. Recent work in Darling Township (Vos and Storey 1977) and Dungannon Township (Trussler 1978) indicates a continued demand for marble.

Recent exploration work has focussed on disseminated graphite deposits in paragneiss in Lyndoch Township. The area north of the Madawaska River and Black Donald Lake warrants investigation for deposits of this type.

There is a possibility of further production of various commodities from developed and undeveloped pegmatites.

A demand exists for a small tonnage of potassium feldspar since it is required for certain ceramic applications. Pearse (1976) indicates that this market may increase in the future. Combined feldspar, rare earth and uranium deposits may provide a source of all these commodities in the future.
The field work performed during the 1978 field season was a continuation of, and an enlargement upon the 1977 work when the majority of the mineral deposits of the area were examined (Colvine et al. 1977). Two zinc deposits were visited and studied in some detail, and two gold-silver, three lead, eight molybdenum, and three iron were revisited or visited for the first time. Field laboratory and analytical studies indicate that 77 significant iron, base metal and precious metal deposits are present in the study area (Table 1); studies of the molybdenum deposits are in progress. A reconnaissance of the regional geological setting of some of these deposits was undertaken. Detailed mapping, on a scale of 1:15,840 or 1 inch to ¼ mile, of a group of nine related Cu-Sb-Au-Ag deposits in the southeastern portion of the area was also undertaken.

Iron
There are 50 iron deposits in the Pembroke area, including two pyrite, three hematite, and 45 magnetite deposits. The magnetite deposits are the most promising as potential sources of iron ore. The largest deposit for which reserve figures are known is the Calabogie iron deposit, near the village of Calabogie. The deposit contains 24.7 million t of ore grading 22.8 percent iron in an orebody 835 m long and 44 m in width, proven by diamond drilling. Tonnage of other deposits are small for conventional blast furnace feed but should feed for electric ore furnaces be required they may be of interest. Heavy mineral aggregate is a potential use particularly if nuclear power stations continue to be built in southern Ontario (Khan 1972).

The deposits have been classified according to their geological relationships (Table 1). Twelve deposits occur as stratabound, carbonate-calc-silicate hosted magnetite ore bodies at intrusive contacts, three deposits form stratiform ore bodies of magnetite within carbonate and calc-silicate rocks, three deposits occur as stratiform magnetite bodies hosted by calcareous mudstones.

Figure 5—Mineral deposits of minerals exclusive of uranium in the Pembroke area.
within sandstone units, and fourteen deposits consist of concentrations of magnetite hosted by intrusions of either syenitic or gabbroic compositions. The geological relationships at thirteen other magnetite deposits are unclear. In addition to the magnetite deposits there are three hematite deposits in brecciated fault zones within carbonate rocks, and two pyrite deposits.

The two hematite deposits (the Fahey and White Lake deposits) on White Lake were revisited. A lakeshore reconnaissance survey indicated little likelihood of additional significant hematite deposits in the area, although there are several minor occurrences. These two deposits are probably too small to be viable iron deposits but may provide a source of high grade hematite for use as pigment in the paint industry.

**Copper-Lead-Zinc-Nickel (Base Metals)**

Field work carried out during the 1978 field season has made possible more accurate classification of the copper-lead-zinc-nickel deposits based on their geological associations (Table 1).

1a. The two lead-zinc deposits present in the area were visited in 1978. These are stratiform deposits that occur as layers of disseminated to massive sphalerite contained within dolomitic marble. The Renprior deposit, near the town of Renfrew, contains abundant pyrite and minor amounts of galena, and the host marble contains an abundance of calc-silicate minerals. Neither deposit is associated with significant gold or silver. The Renprior deposit is far larger of the two deposits with a mineralized zone 60 to 90 m in width and about 1000 m in length. The mineralization is very low grade throughout the zone and somewhat erratic in distribution. The best lens investigated by drilling contains 14 500 t averaging 10.5 percent Zn over widths averaging 5 m (Satterly 1944). The similarity of these deposits to the zinc-lead ore bodies of the Balmat Edwards district of New York State (Lea and Dill 1968) indicates that there is a good potential for additional mineralization of this type in the Pembroke-Frontenac Axis area.

1b. Seven lead deposits are located near the Ottawa River Valley and consist of cross-cutting calcite veins containing disseminated galena and minor pyrite and sphalerite that cut the Grenville marbles and overlying Paleozoic limestones. The mineralized fractures are probably related to the Ottawa Valley graben system. The Kingdon Mine near Arnprior closed in 1931 after producing 820 000 t of ore grading 3.32 percent lead and an unspecified content of zinc (Source Mineral Deposits Record. Ontario Geological Survey, Toronto).

2a. Nine Cu-Sb-Au-Ag deposits in Lavant and Darling Townships form a series of stratabound bodies within a narrow, north to northeast trending belt of intercalated marble and mafic volcanic rocks over a strike length of 21 km. The belt is bounded to the west by a sill of quartz monzonite and to the east by a conformable gabbroic intrusion that contains numerous small irregular bodies of trondhjemite. All the rock units dip eastward between 25 and 70 degrees.

The mafic volcanic rocks in the southern part of the area are dark green, very fine grained, chloritic to amphibolitic. Texturally they vary from massive to weakly foliated and often have a well developed rubbly texture that is interpreted to represent autobrecciation of individual flows. In the northern part of the belt the mafic volcanic rocks are amphibolitic and form a fine to medium grained, black, massive to foliated rock. Some of the rocks retain the rubbly texture.

The marbles are either calcitic or dolomitic. Dolomitic marbles predominate: these are very fine-grained, massive, light to dark grey and often have reddish brown weathered surfaces. Calcitic marbles are fine-grained, usually thinly bedded, light grey in colour and are interbedded with the dolomitic marbles.

The quartz monzonite is a fine-grained, pink rock which forms a sill, 900 to 1200 m thick in the map-area, and is continuous along strike south to the town of Tweed, a distance of nearly 100 km. The quartz monzonite is linearized to weakly foliated near the centre of the intrusion.

**TABLE 1  CLASSIFICATION OF IRON, BASE METALS, AND PRECIOUS METALS DEPOSITS IN THE PEMBROKE-RENFREW AREA.**

<table>
<thead>
<tr>
<th>Type</th>
<th>Number of Deposits</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Iron</strong></td>
<td></td>
</tr>
<tr>
<td>a. Stratiform, carbonate-hosted, at intrusive contacts</td>
<td>12</td>
</tr>
<tr>
<td>b. Stratiform, carbonate-hosted-silicate</td>
<td>3</td>
</tr>
<tr>
<td>c. Stratiform, sandstone-mudstone-hosted</td>
<td>14</td>
</tr>
<tr>
<td>d. Intrusion-hosted</td>
<td></td>
</tr>
<tr>
<td>e. Geological relationships unclear</td>
<td>13</td>
</tr>
<tr>
<td><strong>Hematite Deposits</strong></td>
<td></td>
</tr>
<tr>
<td>a. Carbonate-hosted, fault related</td>
<td>3</td>
</tr>
<tr>
<td><strong>Pyrite Deposits</strong></td>
<td></td>
</tr>
<tr>
<td>a. No consistent geological association</td>
<td>2</td>
</tr>
<tr>
<td><strong>Copper-Nickel Deposits</strong></td>
<td></td>
</tr>
<tr>
<td>a. Gabbro-hosted</td>
<td>4</td>
</tr>
<tr>
<td><strong>Gold-Silver Deposits</strong></td>
<td></td>
</tr>
<tr>
<td>a. Stratabound, volcanic-hosted, Au-Ag</td>
<td>2</td>
</tr>
<tr>
<td>b. Stratabound, volcanic-hosted, Au-Ag-Au</td>
<td>1</td>
</tr>
</tbody>
</table>

The two hematite deposits (the Fahey and White Lake deposits) on White Lake were revisited. A lakeshore reconnaissance survey indicated little likelihood of additional significant hematite deposits in the area, although there are several minor occurrences. These two deposits are probably too small to be viable iron deposits but may provide a source of high grade hematite for use as pigment in the paint industry.
but has a very strong foliation along its eastern contact.

The gabbro forms a massive to foliated, fine to very coarse grained black rock composed essentially of amphibole and plagioclase. It contains primary, compositionally graded layering in some places and has several different phases which intrude each other with complicated interrelationships. The trondhjemite bodies within the gabbro are white to pink, medium grained and are gradational into the gabbro and appear to have intruded the trondhjemite.

The mineralization is contained in small, stratabound zones within the dolomitic marble and consists of blebs and disseminated fine grains of tetrahedrite, chalcopyrite, and occasional pyrite and bornite. The sulphide minerals are associated with narrow, discontinuous veins, pods and lenses of white quartz and or coarse grained white dolomite within the dolomitic marble. The veins often cross-cut the marble and vary in size up to 0.5 m in width and several metres in length, but more commonly the veins are 1 to 2 cm in width, discontinuous along strike, and form a criss-cross network occupying fractures and joint planes. Grab samples from two separate deposits contained 78.5 ppm silver and 5.49 ppm gold respectively.

2b. There is one Cu-Sb-Ag-Hg deposit in Lavant Township that contains reserves of 54 000 t averaging 0.67 percent Cu. 0.37 percent Sb, 0.03 percent Hg, and 45.3 ppm silver over an average width of 1.76 m (Source Mineral Deposits Record, Ontario Geological Survey, Toronto). The mineralization consists of tetrahedrite with associated pyrite, chalcopyrite, and barite forming conformable disseminated layers within dolomitic and calcitic marbles. There are probably undiscovered deposits of this type in the area.

2c. There is one deposit in Denbigh Township that consists of conformable lenses of pyrite, pyrrhotite, chalcopyrite and sphalerite contained within mafic volcanic rocks. Reserves of 230 000 t grading 1.09 percent copper have been outlined by drilling (Source Mineral Deposits Record, Ontario Geological Survey, Toronto).

3a. Four copper-nickel deposits are known to occur in the Raglan Gabbro in Raglan Township. The largest is reported to contain approximately 1 percent combined Cu-Ni in a conformable lens 45 by 90 m in area and 6 to 7 m in thickness (The Northern Miner, Sept. 20, 1956).

Gold and Silver

The gold and silver deposits are all small and low grade and are of two types.

4a. Gold-bearing arsenopyrite disseminated within interbeds of volcanic tuff within marble units.

4b. Gold with disseminated sulphide mineralization in a geological environment similar to category 2a, above.

Molybdenum

Molybdenum deposits are numerous and occur throughout the southern half of the map-area, all located in amphibolite facies metamorphic rock. The deposits are generally small (<100 000 tons) but often a fairly high grade (0.5 percent MoS₂).

Some of the deposits consist of coarse flakes of molybdenite disseminated within pegmatite dikes and sills. The majority of the deposits, however, appear to be metamorphogenic in origin (Karvinen 1973). The mineralization is typically located within mixed carbonate and clastic sedimentary assemblages, particularly at the lithological contacts between the units where the mineralization consists of coarse flakes of molybdenite disseminated within assemblages of pyroxene ± actinolite ± pyrrhotite ± pyrite (the latter two minerals occur as separate massive sulphide lenses and segregations).

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Evans, A.M.

Freeman, B.C.

Giblin, P.E.

Gordon, J.B., Colvin, A.C., and Vos, M.A.

Griffin, G.D.

Grasty, R.L., Charbonneau, B.W., and Steacy, H.R.

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Khan, M.A.

Lea, E.R., and Dill, D.B.

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in preparation: Compilation Map of Pembroke Area, Ontario Geol. Survey Map

in preparation: Renfrew Area, Ontario Geol. Survey Map, scale 1 inch to 1 mile.

McMillan, R.H.

McMurray, V.A.

Nikols, C.A.

Park, F.B.

Peach, P.A.

Pearse, G.H.K.


URANIUM DEPOSITS

No.43  Uranium Deposits of Ontario
J.A. Robertson

The writer represented the Ontario Ministry of Natural Resources in the 1977 annual study of the "Uranium Reserves and Resources" of the Province in conjunction with the "Uranium Resources Appraisal Program" of Energy, Mines and Resources, Canada. In order to protect confidential company data only aggregate data are published. Table 1 is derived from EMR (1977, 1978) and indicates the current status of Canada and Ontario Resources.

The Royal Commission on Electric Power Planning in the document "A Race Against Time", (Interim Report on Nuclear Power in Ontario, Porter 1978) has addressed itself to the relationships between the resource data for Canada and Ontario, the level of production which these resources can support, and the projected needs for Ontario Hydro both for committed power stations and for additional nuclear power stations to meet the power needs projected on the basis of population increase, per capita increase in power usage and the desired mix of generating stations. The commission concluded that "neither the currently known uranium resource base in Canada and Ontario nor the projected maximum production capacities likely to be available for Ontario use are sufficiently secure to guarantee the long term viability of a large 'once through' nuclear programme in Ontario". It should be pointed out that discoveries have been made in Saskatchewan since the data used was compiled and that there remain several areas in Ontario where there are both known mineralization and active exploration. The Porter Commission stresses the need for active exploration to discover and develop the further resources to meet Ontario Hydro's projected program beyond the commitments already made, to contribute to nuclear fuel or power export, to maintain the necessary nuclear industry, as well as the need to develop the energy conservation ethic.

The national figures reflect the continuing discovery and development of deposits in the Athabasca region of Saskatchewan, and the decline in Ontario's proportion of Canadian and World resources. The Ontario data shows a slight decrease in resources reflecting production (1977 production, Table 2, is 3400 t U although shipments are estimated as 4320 t U. MNR 1978 and minor changes in cost and price reflected in slightly higher cut-offs, and a lack of new discoveries.

Nevertheless, exploration for uranium continues at a high level in Ontario being principally directed towards the pegmatite deposits of the Grenville Province and the Elliot Lake type pyritic quartz pebble conglomerates of the Southern Province. Less intense activity is directed towards the pegmatites of the Kenora area, the Late Precambrian and Phanerozoic unconformities of the Lake Superior Basin, and the James Bay Lowlands, and the alkaline complexes.

The Uranium Resources Appraisal Group conducted a survey of uranium exploration expenditures in 1976 and 1977. The national figures were $43.5 million and $71.7 million respectively, with 49 percent of the 1977 expenditure being devoted to Saskatchewan. In both years Ontario ran fourth behind Saskatchewan, North West Territories and Quebec, with expenditures of $3.0 million and $2.6 million. Early indications for 1978 suggest a possible further slackening of expenditures in Ontario.

In the period under review all producing mines, the Quirke, Denison, Faraday, and Agnew Lake were visited. Uranium exploration sites or showings visited included Agnew Lake (quartz pebble conglomerate), Kirkland Lake (Archean alkaline metavolcanics), Gogama (pegmatite with mineralization restricted to sparse mafic inclusions), the Silver Crater (calcite-apatite-betafite vein?), MacDonald (red pegmatite zoned). Eagles Nest, and Greyhawk (red pegmatite unzoned and showing stratigraphic control) in the Bancroft area and the pegmatite showings of the Kenora-Dryden area.

During the year the writer took part in several workshops and one formal field trip:

a) Ontario Geological Survey workshop — brief description of Ontario uranium deposits;
b) prospector's classes, Special Topics — the role of government geologists with emphasis on resource evaluation;
c) uranium deposits special course at McGill University — the pyritic quartz pebble conglomerate uranium deposits (Robertson 1978a);
d) Mineralogical Association of Canada's short course on geology and mineralogy of uranium deposits — the uranium deposits of Ontario, short course notes (Robertson 1978b) and Ontario Geological Survey Miscellaneous Paper in press);

In light of new data available, the Mineral Deposits Section has embarked on a program to provide second editions of the "Uranium and Thorium Deposits of Southern Ontario and of Northern Ontario" and the "Uranium Deposits of Ontario" map (Hewitt 1967; Robertson 1968-75). The compilation map for the Blind River — Elliot Lake area (scale 1:126 720) has been revised and the distribution of known mineralization in the Elliot Lake camp has been indicated (Giblin et al. 1977).

Figure 1 indicates the schematic distribution of uranium in Ontario and Table 3 a revised classification of the

1 Chief, Mineral Deposits Section, Ontario Geological Survey, Toronto

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TABLE 1

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>A</td>
<td>79 000 t*</td>
<td>78 000 t</td>
<td>88 000 t</td>
<td>94 000 t</td>
<td>238 000 t</td>
<td>243 000 t</td>
<td>154 000 t</td>
<td>161 000 t</td>
</tr>
<tr>
<td>B</td>
<td>4 000 t</td>
<td>4 000 t</td>
<td>11 000 t</td>
<td>13 000 t</td>
<td>6 900 t</td>
<td>75 000 t</td>
<td>195 000 t</td>
<td>227 000 t</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>83 000 t</strong></td>
<td><strong>82 000 t</strong></td>
<td><strong>99 000 t</strong></td>
<td><strong>107 000 t</strong></td>
<td><strong>307 000 t</strong></td>
<td><strong>318 000 t</strong></td>
<td><strong>349 000 t</strong></td>
<td><strong>388 000 t</strong></td>
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</tbody>
</table>

Ontario (Percentage of Canadian Total)

|          | 59% | 60% | 77% | 69% | 80% | 74% | 52% | 46% |

Ontario Recoverable Uranium Resources (1000 tonnes U)

| A        | 49 76 74 246 236 |
| B        | 49 76 74 246 236 |

$104/kg U$ $110/kg U$

U$104-156/kg U$ $110-160/kg U$

Uranium deposits of Ontario. Clearly geological features reflecting major physical and chemical changes are prime controls on distribution of uranium deposits, e.g. geological province and subprovince boundaries (including the major unconformities), major faults, higher metamorphic grades, domain boundaries related to quartz monzonite batholiths, distribution of carbonate rocks.

For each deposit type a systems analysis identifies parameters critical to: 1) source area; 2) transportation; 3) deposition; 4) modification; 5) preservation; to which could be added, 6) extraction. These parameters can then be used to identify areas of high exploration potential and to attempt resource evaluation on a broad scale. Provincial and federal government maps, reports, assessment files, summaries of field work and the "Provincial-Federal Uranium Reconnaissance Program" provide a wealth of data on which exploration personnel can base their program strategies. Ontario has many environments favourable for uranium concentration (some of which are also favourable for thorium). Viability of individual deposits depends on the price/cost ratio, grade, tonnage, and amenability to extraction. In present conditions deposits with an overall grade in excess of 0.5 kg/t U$_3$O$_8$ (1 pound per ton) (recoverable) are of economic interest whereas deposits between 0.2 and 0.5 kg/t (¼ and 1 pound per ton) U$_3$O$_8$ are of lesser interest. Many people have been dazzled by recent high uranium prices but the costs have also risen markedly and consequently cut-off ore grades (particularly for new deposits or new areas) have not dropped appreciably.

TABLE 2
PRODUCTION OF URANIUM IN ONTARIO, 1977.

<table>
<thead>
<tr>
<th>Mine Company Report</th>
<th>Elliot Lake Area</th>
<th>Bancroft Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agnew Lake</td>
<td>Denison</td>
<td>Quirke</td>
</tr>
<tr>
<td>(Kerr Addison Mines Ltd.)</td>
<td>(Denison Mines Ltd.)</td>
<td>(Rio Algom Ltd.)</td>
</tr>
<tr>
<td>Start up June 1977</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

|                    | 195 199 922 kg |
| U$_3$O$_8$ produced| 31 900 kg      |
| Average grade      | 1.03 kg/t      |
| Mill recovery       | 94%            |

* Recovered grade

Note: Ontario production 3400 t
Canada (EMR 1978) Production 5794 t
Shipment 5953 t

$t = \text{metric tonne}$
URANIUM DEPOSITS

URANIUM PRODUCING AREAS

I Elliot Lake
II Agnew Lake
III Bancroft

LEGEND

Paleozoic & Mesozoic
PRECAMBRIAN

Superior Province
Southern Province
Grenville Province

Unclassified

Type of Deposit

Alkalic Complexes
Pegmatitic
Calc Silicate
Veins
Conglomerate
Other

Figure 1—Uranium deposits of Ontario.
### TABLE 3
CLASSIFICATION OF ONTARIO URANIUM DEPOSITS.

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAGMATIC</td>
<td>1. Carbonatite-alkalic complexes, fenites</td>
</tr>
<tr>
<td></td>
<td>2. Calc-alkaline extrusive rocks</td>
</tr>
</tbody>
</table>
| MAGMATIC-METAMORPHIC        | 3. Pegmatite  
|                             |   a) red zoned                                                               |
|                             |   b) red unzoned                                                             |
|                             |   c) white                                                                   |
|                             | 4. Calc-silicate (skarn), pyroxenite                                         |
| SEDIMENTARY (DETRITAL)      | 5. Quartz-pebble conglomerate  
|                             |   a) pyrite-uranium                                                         |
|                             |   b) iron oxide-thorium                                                     |
|                             | 6. Polymictic conglomerate, semipelitic rocks                                |
| CIRCULATING MINERALIZED SOLUTIONS* | 7. a) Pitchblende Athabasca type                                          |
|                             |   b) Pitchblende Bohemia type (5-element)                                   |
|                             |   c) Mineralization (exact nature often unknown) generally related to unconformities and found in argillite, wacke, sandstone, carbonates, and lignite |
|                             |   d) Uraninite – calcite-apatite-fluorite veins                             |
|                             | 8. UNCLASSIFIED  
|                             |   Usually small occurrences about which little is known.                   |

*largely equivalent to vein deposits OECD 1977, Robertson, 1975 or hydrogenic deposits McMillan, 1977.

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EMR  


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McMillan, R.H.  

OECD  

MNR  

Porter, Arthur  

Rio Algom Limited  

Robertson, J.A.  


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No. 44 Industrial Minerals, Vicinity of Sudbury

B.A. Smith and M.A. Vos

Introduction

This project is directed at establishing the potential for industrial mineral deposits in the area and is funded by the Ministry of Northern Affairs. Commodities included are building stone, silica, feldspar, kyanite sillimanite, garnet and vermiculite. The area under investigation is bounded (Figure 1) by Latitudes 45°15', and 47°00'N; by the Ottawa River to the northeast and Georgian Bay to the west. Arterial Highways 69, 17, 533, 535, 537, 545, and numerous township and secondary bush roads provide easy access to most of the deposits.

Field work involved location, description and mineralogical examination of each site. Samples were taken for laboratory analysis where required. Results of the present work will determine the possible need for follow up studies.

Building Stone

Building stone in the Sudbury area includes monumental stone, with blocks, slab facing stone, aggregate for concrete facing and landscape aggregates. Invariably quarry operator's knowledge and choice of marketing techniques has proven as much a directive for application of quarried materials as has lithology or geological structure.

The Late Precambrian anorthosite in Dana and McWilliams Townships supports an array of active and abandoned quarries (Lumbers 1973; Isacksen 1969). Erana Mines Limited uses a coarse grained anorthosite for a crushed aggregate operation but Nipissing Black Granite Company Limited quarried the same rock for massive building stone. The recently opened pit of Dana Black Granite Company Limited is shipping a slightly finer grained anorthosite for building slabs while options on the neighbouring and lithologically similar pit are held for monumental stone production by Rock of Ages Company Limited. Pits quarried for curling stone fabrication at River Valley Stone Manufacture and for building stone by Larched Black Granite were also visited and investigated.

An extensive Middle Precambrian micaceous quartzite in McAuslin Township operated by McLaren Bay Mica Stone Quarry presents simpler marketing and quarrying techniques (Lumbers 1971). A detailed stratigraphic section of this spectacular red, green and satin metasedimentary sequence was examined. The stone is currently used as block aggregate for facing in the North Bay hinterland. Dormant pits of a slightly varied lithology were investigated in Garrow (Eagle Mountain), McAuslin (Three Tails Lake quarry) and Jocko Townships (L. Ross and Niemetz). Their history of operation is unknown.

Lastly a brecciated carbonatite vent type deposit in Aylmer Township was examined. It is speculated that exploration may lead to discovery of similar occurrences to replace this depleted facing stone operation.

The bedded deposits found in McLennan and Goschen Townships and operated by Erana Mines Limited and Panache Lake Quartz Limited respectively are both used as a source of crushed aggregate for cement slab facing. Investigation of associated carbonates may define the origin of these quartzite deposits currently designated as Mississagi Formation (Meyn 1966; Card 1965, 1978). The Birch Island quarry of similar age feldspathic quartzite was visited.

Silica Deposits

Silica deposits in the Sudbury area are widespread and varied in commercial application. Lithology is a crucial factor in determining the use of these deposits.

Two orthoquartzite properties of Middle Precambrian age in Dill Township and on the Cosby-Delamere Township border have both been developed for silica flux production (Lumbers 1975; Hewitt 1963). The Canadian Copper Company has virtually exhausted the accessible reserves of the former exposure whereas the latter remains intact.

Quartzite of Middle Precambrian age (Huronian Supergroup) as mapped by Card (1974, 1978) has great exposure in the west portion of the project area. Chemical composition of the quartzite is slightly variable (Vos 1978). Careful quarry techniques allow the separation of intrusive diabase trap rock, rendering a high grade silica product (Hewitt 1963). Inco Limited's Lawson quarry in Curtin Township produces silica flux used in both the converter and reverberatory plant while a similar rock extracted from the Sheguiandah quarry in Howard Township by Canadian Silica Corporation Limited was used for ferrosilicon production. High grade silica is quarried by Indusmin Limited from the Bar River Formation on Badgeley Island for ferrosilicon production while the adjacent Badgeley Point quarry in Lorrain quartzite, previously operated by Union Carbide Canada Limited, no longer produces.

Due to problems of accessibility the Mississagi Formation quartzite at Isaac Burns quarry was not visited (Hewitt 1963). To the authors' knowledge none of the intrusive quartz associated with numerous pegmatite vein deposits is being used for silica production.
Pegmatite Vein Deposits

The Late Precambrian granitic pegmatite dikes of the Sudbury area intrude clastic metasedimentary biotite gneiss of the Grenville Province. As Spence (1930) noted these intrusions are of undetermined origin but uniformly display white albite feldspar towards the peripheral contact zone and pink microcline spar towards the interior. This suggests a possible albitization of the original microcline pegmatite (Hess and Schaller 1927). As accessory mineralization is varied and dependant on the host rock, the most functional economic classification is based on the nature of quartz-feldspar intergrowth e.g. massive spar and quartz segregation, graphic intergrowth of spar and quartz and fluctuation of massive segregation and graphic intergrowth (Spence 1930).

Massive segregation of feldspar and quartz was noted in dikes located in Dill Township (Weisman Hill feldspar mine, Wanup Feldspar Mine Limited and Elizabeth feldspar mine) Ratter Township (Lee’s feldspar mine, Consolidated Feldspar Mines Limited, two properties of G. Perrenoue and G. Vise, and Eden’s feldspar mine), Cleland Township (undeveloped property) and Servos Township (Graham Lake quarry). The developed properties were thoroughly mined in the 1920s and 1930s but rejuvenated interest has been expressed for this ore to be used as glaze in the electrical insulation refractory business.

Graphic intergrowth of quartz and feldspar made deposits less economic in the past. Consequently the deposits found in Hugel Township (Carrmichael property), Cleland Township (Oscar Pelto quarry), Dryden Township (McMaster Feldspar quarry), and Awrey Township (Donnen Feldspar Company) contain residual ore. The pink spar of the Carrmichael property is periodically used as a source of building stone aggregate by Erana Mines Limited.

A fluctuation from well segregated massive mineralization to graphic mineral intergrowth was noted in Cleland Township (Weisman Hill feldspar mine, Loughlin Township (Industrial Minerals of Canada Limited) and Burwash Township (Mount Pleasant mine). Operations in these deposits ceased no less than twenty years ago.

Associated garnet, tourmaline, and hornblende mineralization were noted in varying degrees within the wall zones of many dikes while biotite (and occasionally muscovite) comprises a substantial proportion of every pegmatite examined. Structural and lithological features in the host rock invariably control the orientation and extent of the intrusions thus dating them late in the Grenville Province metamorphic sequence (Lumbers 1971).

Kyanite/Sillimanite

Kyanite is a high grade metamorphic alumina-rich mineral often found in close association with garnet of commercial value. In the Sudbury District two such properties of close proximity to the Grenville Front Boundary Fault have received considerable geological and developmental attention. The milling and extraction of kyanite from the ore must be fully examined before a mining operation is initiated. The most promising of these properties is the Kyanite Corporation of Canada Limited’s Crocan Lake kyanite deposit. The three bands of ore in Middle to Late Precambrian amphibolite schist straddles the Butler-Antoine Townships border (Lumbers 1967). The presence or absence of garnets in these ore zones is of economic importance as biotite and garnet are both recovered during the milling process (Hewitt 1952b).

The kyanite bearing amphibolite gneiss of Northern Kyanite Mines’ Wanapiti kyanite deposit consists of one northerly and one southerly deposit, both trending easterly and extending 900 m in central Dryden Township (Hewitt 1952b). The lithological similarities of these two zones are obvious excepting a noted presence of sillimanite and pegmatite intrusions in the southern deposit plus an abundance of garnets in the northern band. Development of the ore lenses of this property was initiated by Pioneer Consultants Limited with the technical and financial aid of the Department of Mines and Technical Surveys, Ottawa (Pearson 1962).

A similar occurrence of kyanite occurs in Dill Township close to the Grenville Front Boundary Fault (Lumbers 1975).

Garnet Deposits

Garnet, the parent name for a family of complex alumina silicates has a distinctive pattern of occurrences within biotite gneisses and schists adjacent to and south of the Grenville Front Boundary Fault zone. Considerable industrial research has been performed on garnet deposits associated with kyanite in the area (Ross 1959), particularly with reference to separation of the ore minerals and demand for garnet as an abrasive.

To date the only productive garnet property in the Sudbury area is located in Dana Township. This deposit extends over 40 ha of cleared outcrop with alternating bands of biotite granite gneiss, garnetiferous biotite gneiss and green hornblende gneiss. Although the garnets are poorly formed 8 cm diameter dodecahedrons with some twinning and biotite inclusions, their concentration in the rock (25 percent) and the size of the occurrence has rendered this property economically important to the Industrial Garnet Company Limited. Between 1943 and 1949 the Niagara Garnet Company produced garnet concentrates for the Sturgeon Falls mill from this property.

Garnets of the Northern Kyanite Mines property in Dryden Township are small (2.5 cm) and highly concentrated in the ore body. They display pitting on the crystal faces. Comparative industrial testing has designated the quality of this ore inferior to that found in Dana Township (Ross 1959).

Loughrin Township hosts two occurrences of garnet in the biotite gneisses of the area. The southerly MacDonnell deposit has well formed dodecahedral garnets measuring up to 4 cm in diameter (Ross 1959). The northerly Page deposit of the Industrial Garnet Company Limited
has smaller garnets with kyanite in a quartz-biotite gneiss. The pink colour of the garnets and noted absence of inclusions in them has been attributed to a higher degree of metamorphism.

Lastly the Coulis deposit in Dill Township contains garnet in biotite schist (Eardley-Wilmot 1927). Numerous inclusions of quartz, hornblende and chlorite alterations has led to the abandonment of this property. The genesis of these garnets is attributed to the reaction of granite pegmatite dikes with regional biotite gneiss.

Vermiculite Deposits

Vermiculite, a versatile industrial mineral is used as fireproof insulation, concrete aggregate, plaster aggregate, soil conditioner and shipping filler. Vermiculite is a hydrated derivative of mica alteration. Upon heating to 980°C the water portion is driven out causing expansion of the micaceous sheets to 20 times their original size and resulting in an extremely light weight heat and weathering resistant inorganic filler.

There are two known deposits in the Sudbury area. The Millar vermiculite deposit in Butler Township lies in Middle Precambrian hornblende gneiss of the Grenville Province locally altered by hydrothermal activity related to pegmatite intrusions (Guillet 1962).

The Jenmac Company Limited deposit in Ventura Township is associated with carbonatite (Ayres, et al. 1971) within metadiorite in the Superior Province. Little development appears to have been carried out on either property in the last two decades.

Recommendations

Continued investigation of mineral genesis is required. Additional occurrences of pegmatite, kyanite/garnet and vermiculite may be discovered. Improvement of quarry techniques, additional processing equipment may further the viability of an industrial minerals industry in the Sudbury area.

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Meyn, H.D.

Pearson, W.J.

Ross, J.S.

Spence, H.S.

Vos, M.A.
No. 45 Volcanic Environment of Gold Mineralization in the Timmins Area
J.A. Fyon¹ and W.O. Karvinen²

Introduction
As a part of the regional and semi-detail mapping of carbonatized rocks, gold deposits and porphyries in the Timmins area initiated in 1976 (Karvinen 1976, 1978), detailed mapping and lithogeochemical sampling have been carried out by J.A. Fyon during the summers of 1977 and 1978.

The following description summarizes the detailed stratigraphy, alteration and mineralization in two selected areas near Timmins (Figure 1). Rock names used are to be considered as field terms only.

Geology of Area A
The Goose Lake and Schumacher Formations as defined by Pyke (1975) are the main stratigraphic units in this area. The Goose Lake Formation consists of komatiitic periodotite and basalt flows, minor tholeiitic basalt flows, and discontinuous, irregular bodies of porphyritic quartzfeldspar-sericite schist (Figure 2). The felsic schists occur along one distinctive horizon and are spatially associated with thin (1 m) lenses of exhalative, cherty material and a locally derived, immature polymictic conglomerate. Overlying the Goose Lake Formation are high magnesium and high iron tholeiitic basalts of the Schumacher Formation (Figure 2). The proportion of high magnesium to high iron tholeiitic basalt decreases towards the top of the Schumacher Formation, where high iron variolitic basalts (“Vipond Series”, Ferguson et al. 1968) appear. From the base of the Goose Lake Formation to the base of the variolitic basalt sequence, is approximately 975 m.

Preliminary reconnaissance and detailed mapping by Karvinen (1976, 1978) revealed the existence of two stratigraphic units containing carbonatized metavolcanics (an upper iron carbonate and a lower magnesium carbonate). The present mapping indicates that stratabound, carbonatized, metavolcanics occur throughout the Goose Lake and Schumacher Formations in both study areas. Within the Goose Lake Formation in “Area A”, carbonatized, tholeiitic pillow basalts are enclosed conformably between carbonatized, komatiitic, peridotite flows. This carbonatized section, which averages 60 m in thickness, constitutes the ore horizon of the Delnite, Aunor and Buffalo Ankerite mines (Figure 2).

Fuchsite-bearing rocks occur only near the top of the komatiitic sequence where they consist of carbonatized peridotite flows averaging 2 m in thickness. They are exposed intermittently over a strike length of 750 m and are found stratigraphically above the main ore horizon.

At least three separate sections within the Schumacher Formation contain carbonatized, tholeiitic basalts, of which the best exposed (Upper Unit, Karvinen 1978) has been traced along a strike length of 3 km.

Within the Schumacher Formation, the carbonate alteration of tholeiitic rocks is characterized by the development of iron carbonate, calcium carbonate (indicative of incipient carbonatization), quartz, minor sericite and trace pyrite whereas magnesium carbonates, quartz, minor iron carbonates and sericite characterize the carbonate alteration of the komatiitic rocks within the Goose Lake Formation.

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LOCATION MAP

3 Generic rock classifications are determined by plotting the author’s chemical data on a Jensen cation plot (Jensen 1976) and by visual comparison with type samples classified by Pyke (Precambrian Geology Section personal communication), to whom the authors are indebted.
Mineralization

Ore zones within the main ore horizon at the Delnite, Au- nor and Buffalo Ankerite mines consist of stratiform lenses localized at flow tops. The lenses are generally layered, 0.5 to 1 cm thick, consist mainly of quartz, ankerite, tourmaline and pyrite and are cut by quartz ladder veins. They are best developed near large bodies of felsic schist (e.g. Buffalo Ankerite and Delnite) where the tourmaline to ank- erite ratio and the amount of quartz is the greatest. All gold production from “Area A” has come from these stratiform lenses and their pyritized wall rocks. Although the fuchsite-bearing carbonate rocks locally contain disseminated auriferous pyrite, they generally lack any stockwork quartz veining and have not been sources of gold ore.
Geology of Area B

Interbedded komatiitic peridotite and basalt flows and high magnesium tholeiitic basalt flows constitute the lowest stratigraphic section (Goose Lake Formation) of this area (Figure 3). Overlying this basal section, which averages 450 m in thickness, are thin (3 to 15 m) vesicular, pillowed and thick (15 to 60 m) partly differentiated, high magnesium, tholeiitic flows of the Schumacher Formation. This sequence is overlain by a series of alternating iron and magnesium tholeiitic basalts. Variolitic pillowed basalts occur at three stratigraphic levels within the entire volcanic section.

The sequence, which averages 1600 m thick, is a homoclinal succession of south-facing, steeply dipping volcanic flows. There is no evidence of repetition through folding.

Both lensoidal, stratabound and funnel-shaped, discordant carbonate alteration zones occur throughout the Goose Lake and Schumacher Formations. Some discordant alteration zones (e.g. Davidson-Tisdale) are flanked by one or more stratabound sections of carbonitized flows.

Within the crosscutting alteration zones, the incipient carbonatization is marked by moderate chloritization of the volcanic rocks. The proportion of iron carbonate in these chloritic rocks increases rapidly along a strike length of 1 to 3 m culminating with the development of a rusty weathering, iron carbonate rich-rock. In contrast, within the stratabound alteration zone, incipient carbonatization is characterized by a zone of calcium carbonate which grades rapidly into the typical, rusty weathering, iron carbonate rich rocks.

Figure 3—Generalized stratigraphic section across Area B illustrating the location of the carbonate alteration zones. Geology after Ferguson et al. (1968) and Pyke (1978, personal communication).
Mineralization

At least two generations of quartz veining are present. One type appears to be synvolcanic (e.g. concordant; stockwork; a stringer type wall pyritization), whereas the other is related to regional deformation (e.g. breccia filling; quartz and quartz-calcite veins along foliation planes).

Within the stratabound, carbonatized rocks, erratic gold values occur in synvolcanic quartz veins and in the pyritized wall rock. Quartz veins formed during deformation often contain native gold; however, gold tenor is generally very low.

In this area, the mineral potential of the discordant alteration zones is not adequately known, primarily because of poor exposure. However, erratic, weak pyritization of the carbonatized flows, might be related to unexposed, synvolcanic quartz veining. Quartz veining related to regional deformation is not abundant.

Origin of the Carbonate Alteration

The field data indicate that the carbonate alteration was developed on the sea floor by numerous geothermal systems. Areas of discordant, carbonate alteration represent fossil vent areas of localized, high heat flux and solution discharge onto the ocean floor. The thin, concordant carbonatized zones probably represent alteration about the flanks of the vent areas. The felsic schists of “Area A” represent local felsic volcanic centres, about which auriferous, exhalative sediments (Fryer and Hutchinson 1976) (e.g. quartz-ankerite-tourmaline lenses) have been precipitated. “Area B” lacks the felsic volcanism and the associated banded quartz-ankerite-tourmaline-pyrite lenses. It is proposed that “Area B” represents a subsiding basin, filled by periodic, effusive, mafic volcanism, which was developing adjacent to a topographically higher region dominated by felsic volcanism (Area ‘A’ and Hollinger-McIntyre areas).

Exploration Criteria

The following criteria would define areas in the Timmins region which are most likely to host quartz-ankerite-tourmaline, exhalative type gold deposits of Early Precambrian (Archean) age.

1) Tholeiitic, basaltic groups and their associated basalt komatiitic volcanics define gross target areas.
2) The stratigraphic interval containing synvolcanic, felsic centres, associated with extensive carbonate alteration, within the komatiitic or tholeiitic package defines the optimum target area.
3) Geophysical techniques (e.g. V.L.F. and I.P.) could be used to outline unexposed carbonatized rocks and to delineate disseminated, gold bearing sulphide zones.

It is contended that intense structural deformation only enriches areas of syngenetic gold mineralization; hence, areas lacking such deformation (e.g. Aunor mine) should not be overlooked. Furthermore, the distribution of the quartz-ankerite-tourmaline lenses, from the Goose Lake Formation into the highest levels of the Schumacher Formation (e.g. Hollinger and McIntyre mines), implies that both komatiitic and tholeiitic volcanic rocks have equal potential to host this deposit type.

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Ferguson, S.A, Buffan, B.S.W., Carter, O.F., Griffis, A.T., Holmes, T.C., Hurst, M.E., Jones, W.A., Lane, H.C. and Longley, C.S.
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Jensen, L.S.

Karvinen, W.O.


Pyke, D.R.
No. 46 Mineral Deposits of the Atikokan Area
W. MacRae

Introduction

In May 1978, the Mineral Deposits Section of the Ontario Geological Survey initiated a study of the mineral deposits of the Atikokan Area, the first phase of which comprised a study of the gold mineralization and its associations.

Mining and prospecting in the area has been carried out since the early 1890s. Iron is being mined in the Steeprock Lake area but closure of these operations is imminent. In the Atikokan district gold was discovered and most major occurrences were worked from 1895 to 1904. Intermitte. work has been carried out since 1904 and some production was achieved by Atiko Gold Mines Limited (Sapawe mine). The continuance of a mineral industry may well depend on discovery of viable gold or base metal deposits.

<table>
<thead>
<tr>
<th>Reference Number</th>
<th>Prospect Name</th>
<th>Host Rock</th>
<th>Strike and Dip of Vein</th>
<th>Width and Length of Vein</th>
<th>Approximate Grade*</th>
<th>History</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Golden Winner</td>
<td>altered trondhj</td>
<td>strike N25E dip 45SE</td>
<td>width 1.5 m length 190 m</td>
<td>7.89 ppm Au</td>
<td>1899 to 1900: shaft sunk to 19 m 1951: 6 DDH's (Noranda)</td>
</tr>
<tr>
<td>2</td>
<td>Hawk Bay</td>
<td>altered trondhj</td>
<td>strike N25E dip vertical</td>
<td>width 0.6 m length 3200 m</td>
<td>not known</td>
<td>1898: 2 shafts sunk to 23 m and 37 m</td>
</tr>
<tr>
<td>3</td>
<td>Manley, J. (Sawbill Lake Mine)</td>
<td>trondhj cut by mafic dikes</td>
<td>strike N25E dip 85SE</td>
<td>width 1.1 m length 600 m</td>
<td>6.51 ppm Au</td>
<td>1895 to 1899: 3 shafts sunk 1936 to 1941: main shaft dewatered DDH's 175 m</td>
</tr>
<tr>
<td>4</td>
<td>Plator Gralouise</td>
<td>altered trondhj</td>
<td>strike N35E dip vertical</td>
<td>width 0.3-0.6 m length 120 m</td>
<td>not known</td>
<td>1948: shaft sunk to 84 m 1954: shaft dewatered and sampled; 15 DDH's 1112 m</td>
</tr>
<tr>
<td>5</td>
<td>Reserve Island</td>
<td>altered trondhj cut by mafic dike</td>
<td>strike N45E dip 45NW</td>
<td>width 1.8 m length 150 m</td>
<td>7.89 ppm Au</td>
<td>1931: shaft sunk to 21 m</td>
</tr>
<tr>
<td>6</td>
<td>Roy mine</td>
<td>altered trondhj</td>
<td>strike N52E dip 55NW</td>
<td>width 1.8-2.4 m length 150 m</td>
<td>not known</td>
<td>1898 to 1899: shaft sunk to 32 m</td>
</tr>
<tr>
<td>7</td>
<td>Sunbeam mine</td>
<td>altered trondhj</td>
<td>strike N57E dip 65SW</td>
<td>width 0.9-2.4 m length 150 m</td>
<td>12.86 ppm Au</td>
<td>1896 to 1899: shaft sunk to 43 m 1899 to 1902: shaft deepened to 63 m 1902 to 1905: shaft deepened to 125 m</td>
</tr>
<tr>
<td>8</td>
<td>Tripp, B.W.</td>
<td>contact between trondhj &amp; volcanics</td>
<td>strike N30E dip 85SE</td>
<td>width 0.3 m length 210 m (2 parallel veins 60 m apart)</td>
<td>15.4 ppm Au</td>
<td>1897: shaft sunk to 14 m 1939: sampled by Steep Rock Iron Mines</td>
</tr>
<tr>
<td>9</td>
<td>Ventures Claims Ltd. (Hammond Reef mine)</td>
<td>trondhj cut by mafic dikes</td>
<td>strike N45E dip 80SE</td>
<td>width 60 m length 1600 m</td>
<td>7.89 ppm Au</td>
<td>1895 to 1898: 3 test shafts sunk to 15 m, 24 m and 39 m 1899 to 1900: inclined shaft to 18 m adit 17 m</td>
</tr>
<tr>
<td>10</td>
<td>Wicheruk M. (Jack Lake mine)</td>
<td>altered trondhj</td>
<td>strike N85E dip vertical</td>
<td>width 3-4.5 m length 120 m</td>
<td>15.4 ppm Au</td>
<td>1900 to 1902: shaft sunk to 59 m 1945 to 1946: 32 DDH's 1961: DDH's 700 m</td>
</tr>
</tbody>
</table>

*OGS Reports and Files
Figure 1—Gold prospects in the Atikokan area.
Location and Previous Work

The area of interest is bounded by Longitudes 91°00' and 91°50'W and by Latitudes 48°45' and 49°00'N (Figure 1). Access is via lumber and mining roads in the south and east, and Marmion Lake provides a good water route to the central portion of the area. Geological mapping has been done in the area by J.E. Hawley (1929), E.S. Moore (1939), R. Shklanka (1972), K.G. Fenwick (1976), and J. Pirie (1978). Mining property investigations have been reported since 1895 in the annual reports of the Ontario Bureau of Mines and successor organizations.

Gold Properties

Figure 1 shows the gold occurrences investigated and sampled to date. Table 1 summarizes the available data on the sample properties and Table 2 shows the assay results from samples submitted in the first half of the field season. Grab samples were taken from obviously mineralized veins. At six of the properties, i.e., the Golden Winner mine, Hawk Bay occurrence, Plator Gralouise prospect, Ray mine, Sunbeam mine, and Wichenuck occurrence (Jack Lake mine) the host rock is trondhjemite of the Marmion Lake batholith. Near the quartz veins, the trondhjemite has a light green colour due to epidotization of the feldspar. The veins contain quartz with minor amounts of carbonate, pyrite, and chalcopryite.

At three properties, i.e. the Manley prospect (No. 3) Sawbill Lake mine), the Ventures Claims prospect (No. 9) (Hammond Reef), and Reserve Island prospect (No. 5), trondhjemite is similar in appearance to the occurrences in the first group but is cut by andesitic dikes which are conformable with pre-existing foliation.

At the Tripp (No. 8) and the Atiko (No. 11) properties the deposits are located at or near trondhjemite-mafic metavolcanic contacts. Numerous felsic dikes cut massive mafic metavolcanic flows. The felsic dikes are the late phases of the Marmion Lake Batholith.

Ashrock Formation

The Ashrock Formation is one of the most extensive units of the Steep Rock Group. It lies on the hanging wall of the ore zone and extends through the Steep Rock and Caledon mines and southward to Strawhat Lake. Small outliers have been preserved against the Quetico Fault. Riley (1969) described the Ashrock Formation as a massive to highly sheared, greenish black fragmental rock. Alteration of the Ashrock ranges from intense shearing with no recognizable features to hydrothermal alteration with fragments clearly visible. Chemically the Ashrock appears to be mafic to ultramafic (Riley 1969) and the tendency for

<table>
<thead>
<tr>
<th>Reference Number</th>
<th>Prospect Name</th>
<th>Sample Number</th>
<th>Gold in ppb</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Hawk Bay</td>
<td>78-WM-86</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td></td>
<td>78-WM-87</td>
<td>825</td>
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<td></td>
<td>78-WM-88</td>
<td>325</td>
</tr>
<tr>
<td>3</td>
<td>Manley, J.P.</td>
<td>78-WM-80</td>
<td>2025</td>
</tr>
<tr>
<td>(Sawbill Lake</td>
<td></td>
<td>78-WM-61</td>
<td>20</td>
</tr>
<tr>
<td>mine)</td>
<td></td>
<td>78-WM-62</td>
<td>855</td>
</tr>
<tr>
<td></td>
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<td>78-WM-63</td>
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<td>78-WM-64</td>
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<td>78-WM-65</td>
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<td></td>
<td></td>
<td>78-WM-66</td>
<td>&lt;10</td>
</tr>
<tr>
<td>4</td>
<td>Plator</td>
<td>78-WM-47</td>
<td>16400</td>
</tr>
<tr>
<td>Gralouise</td>
<td></td>
<td>78-WM-48</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td></td>
<td>78-WM-49</td>
<td>&lt;10</td>
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<td></td>
<td></td>
<td>78-WM-50</td>
<td>30</td>
</tr>
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<td></td>
<td></td>
<td>78-WM-51</td>
<td>&lt;10</td>
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<td>78-WM-52</td>
<td>230</td>
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<td></td>
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<td></td>
<td>78-WM-85</td>
<td>6565</td>
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<td>8</td>
<td>Tripp, B.W.</td>
<td>78-WM-89</td>
<td>7890</td>
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<td></td>
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<td>78-WM-90</td>
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<td>78-WM-93</td>
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<td>425</td>
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<td></td>
<td></td>
<td>78-WM-95</td>
<td>55</td>
</tr>
<tr>
<td>9</td>
<td>Ventures Claims Ltd. (Hammond Reef)</td>
<td>78-WM-67</td>
<td>1915</td>
</tr>
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<td></td>
<td></td>
<td>78-WM-68</td>
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<td>78-WM-69</td>
<td>170</td>
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<td>78-WM-70</td>
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<td>78-WM-73</td>
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<td>78-WM-74</td>
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<td>30</td>
</tr>
<tr>
<td>9</td>
<td>Southern</td>
<td>78-WM-76</td>
<td>20</td>
</tr>
<tr>
<td>Extension</td>
<td></td>
<td>78-WM-77</td>
<td>20</td>
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<tr>
<td></td>
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<td>78-WM-78</td>
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<td></td>
<td></td>
<td>78-WM-79</td>
<td>87</td>
</tr>
<tr>
<td>10</td>
<td>Wicheruk, M.</td>
<td>78-WM-59</td>
<td>17850</td>
</tr>
<tr>
<td>(Jack Lake mine)</td>
<td></td>
<td></td>
<td>(one sample near shaft; others to follow)</td>
</tr>
</tbody>
</table>
the rock to become talcose upon alteration would tend to support this information. Because of the possible association of gold deposits with ultramafic rocks (Pyke 1975) forty samples of ashrock were collected on a reconnaissance scale. Four samples contained values of gold averaging 35 ppb, which is well above expected background levels. A detailed sampling program was undertaken to determine whether the higher values were random or if there were any distinct areas containing anomalous gold values.

Conclusions
Most gold deposits in the area lie along northeast-trending faults that cut the Marmion Lake Batholith. The faults are filled with quartz veins containing minor carbonate and sulphide mineralization. Detailed diamond drilling is the most likely method for adding to the resource potential of the area.

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Pyke, D.R.

Shklanka, R.
No. 47 Sulphide Mineralization in the Marginal Phases of the Coldwell Alkalic Complex

S. Wilkinson¹ and A.C. Colvine²

Introduction

Several significant occurrences of sulphide mineralization were discovered in the gabbroic marginal phase of the Coldwell Alkalic Complex during the period 1952 to 1967. Reserve estimates are in excess of 50 million t containing 0.4 percent copper and significant platinoid group metals. Two companies, Lakehead Mines Limited and Anaconda Canada Limited, have retained large claim groups in the northern and eastern portions of the complex, respectively. These areas and an area of minor sulphide mineralization (near Middleton), were mapped and sampled during 1978 (Figure 1). Mapping at 1:15840 scale established the locations and geological settings of mineralized zones and occurrences. More detailed mapping and sampling at 1:7920 and 1:240 were undertaken to define the extent and style of mineralization.

Previous Work

The nepheline bearing rocks of the Coldwell Complex were first described by Logan (1863). Kerr (1910) was the first to map and study the syenites. Mine (1967) and Walker (1967) mapped portions of the eastern and western areas of the complex, respectively. Recently, Currie (1977) completed a detailed petrographic examination of selected areas of the complex with particular emphasis on the nepheline bearing rocks.

Sage is currently compiling a comprehensive documentation of the economic history of the complex.

General Geology

The Coldwell Alkalic Complex is located in the Thunder Bay Mining Division of Ontario, on the northeast shore of Lake Superior. The intrusion has a roughly circular outline with a radius of approximately 25 km (Figure 1). (Currie 1977). The rocks hosting the complex are of Early Precambrian age. The intrusion cuts an east-trending "greenstone" belt which includes a sequence of metamorphosed mafic and felsic volcanic rocks and clastic and chemical sedimentary rocks. To the north of the "greenstone" belt, Early Precambrian granitoid rocks have also been intruded by the complex (Puskas 1967).

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² Geologist, Mineral Deposits Section, Ontario Geological Survey, Toronto.
Figure 1—Geology of the Coldwell complex (adapted from Puskas 1967 and Currie 1977).

Rock Units of the Coldwell Complex
Within the Detailed Map-Areas
Contact Zone and Country Rocks

Early Precambrian metavolcanics and metasediments from the contact zone of the complex, in most of the area mapped, are commonly highly foliated to schistose, strike east and dip vertically.

The mafic to intermediate flow units consist of plagioclase-chlorite/amphibole schist; pillowed units are located to the west of the complex and on the north shore of Wullie Lake. Large mappable blocks of mafic volcanic rocks contained as xenoliths within intrusive rocks are recrystallized to an assemblage of pyroxene, plagioclase, minor magnetite, biotite, and pyrrhotite.

Felsic volcanic rocks consist of lapilli tuff and tuff-breccia with intercalated massive flow and pyroclastic breccia units; quartz-sericite ± chlorite schists predomi-
Gabbroic Suite

The Coldwell gabbro is divisible into six map units, which in order to intrusive sequence, are: fine grained, heterogeneous, melanocratic, 'common', pegmatitic, mottled, and diontic.

Fine grained gabbro occurs peripherally to the main gabbro mass and as rib-like dikes intruding the country rock, subparallel to the intrusive contact. This unit is interpreted as a chilled marginal phase. It consists of plagioclase, pyroxene, magnetite and olivine with accessory pyrrhotite and rare chalcopyrite and has a distinctive rusty brown weathered surface. Large surface areas are underlain by fine grained gabbro but drill logs (Assessment Fleses Research Office, Ontario Geological Survey, Toronto) show that coarser grained gabbro is normally present at depth. Where the fine grained gabbro is in contact with country rocks, there is a hybrid zone up to several metres thick.

The melanocratic gabbro has very limited exposure and is bounded on both its upper and lower contacts by fine grained gabbro, with gradational contacts over less than 1 m. The melanocratic gabbro consists of pyroxene, plagioclase, olivine and magnetite with trace pyrrhotite, and is massive to weakly banded, dark grey to charcoal in colour.

The heterogeneous gabbro occurs immediately above the fine grained unit. The contact between the two gabbros is gradational over distances of a few centimetres to several metres. Small irregular dikes of heterogeneous gabbro intrude the fine grained unit and occasionally large angular blocks of the fine grained gabbro are included in the heterogeneous gabbro. It is characterized by highly variable grain size and mineralogy but most commonly consists of medium to very coarse grained plagioclase, pyroxene and magnetite, with trace amounts of pyrrhotite and chalcopyrite disseminated throughout. Sulphide mineral content increases to a maximum of 5 percent of the rock, in lensoidal zones from a few metres to several hundred metres in length, average sulphide mineral content of these is about 3 percent. Pyrrhotite to chalcopyrite ratios vary from 1:1 to 4:1 and average approximately 3:1. Apatite is present as fine to coarse grained, pale green rods and constitutes less than 1 percent of the rock.

Lenticular zones, greater than a metre long, containing hydrous minerals, biotite, fibrous amphibole (uralite) and saussuritized plagioclase, are sporadically distributed throughout the heterogeneous gabbro. Miarolitic cavities filled with quartz, carbonate and chalcedony are also associated with these zones. The occurrence of hydrous mineral and high sulphide mineral concentration are spatially related in at least one instance, but this association is not a diagnostic characteristic of the sulphide mineralization.

The heterogeneous gabbro grades upward into the 'common' gabbro over several tens of metres, with mottled or anorthositic gabbro as an intermediate phase. The mottled gabbro crops out in sinuous bands trending subparallel to the contact of the complex and country rocks. Instances of sharp intrusive contacts rather than gradational contacts with the other gabbroic rocks were noted. The mottled gabbro is a massive, medium to very coarse grained plagioclase-rich rock. Pyroxene and magnetite occur in clusters of 2 to 13 cm in diameter, resulting in a spotted or mottled appearance. Subangular xenoliths of the mottled gabbro occur in the overlying gabbroic rocks.

The 'common' gabbro is medium grained with alternating leucocratic and mesocratic layers. Near the base of the common gabbro, the layering is wispy and trough-like but the upper and lower contacts of layers are distinct. Grain sizes between layers are similar and it is only the relative content of mafic minerals that varies. Upwards in the gabbro the layering becomes more regular or rhythmic, and has a sedimentary appearance: each layer is graded, with the mafic minerals concentrated at the base. Layers are continuous so they can be traced across large outcrops.

The 'common' gabbro consists of plagioclase, pyroxene, magnetite, biotite, and olivine. Sulphide minerals are rare except near the base of the gabbro within very magnetic rich mafic bands, up to 2 m thick and which may be continuous for hundreds of metres. Biotite is present as fine grained rims about grains of sulphide minerals, andapatite is also present.

Gabbro pegmatite occurs most commonly cutting the fine grained and heterogeneous gabbros, and is also associated with the mottled unit and more rarely, the common gabbro. It is composed of plagioclase and pyroxene with intergrown magnetite. Sulphide minerals may be present. Apatite and quartz are common accessory minerals and biotite occurs as rare coarse books and rims to sulphide grains.
Near the top of the gabbro section, dioritic gabbro is present either interlayered with or in small dikes cross-cutting the ‘common’ gabbro. The dioritic gabbro is a light grey rock with granitic texture and composed of plagioclase and amphibole with lesser amounts of alkali feldspar and trace quartz. Magnetite and pyrrhotite are rarely present.

**Syenitic Suite**

The syenitic suite is subdivided into diorite, augite syenite, monzonite, and syenite pegmatite. In the detailed map areas the contact between the main mass of the syenites and the gabbro is not exposed but structural relationships within the two rock types suggests that the syenite intrudes and cross-cuts the gabbro.

The lowermost unit of the syenite group is a thin (10 to 24 m) continuous horizon of medium to coarse grained diorite which is massive to weakly layered and greyish buff in colour. It consists of plagioclase, alkali feldspar, pyroxene and/or amphibole and magnetite with minor biotite.

The diorite grades into augite syenite through a 10 to 120 m thick xenolith rich zone. The xenoliths are identical to fine grained gabbro in hand specimen and range in size from subangular cobbles to blocks hundreds of metres in length. The augite syenite has a distinctive olive or hematite red colour and is medium to coarse grained and is commonly banded. The layering is subtle and can be identified only in large, clean outcrops or lakeshore exposures and, like the common gabbro, it consists of alternating mafic and felsic rich layers which achieve maximum thickness of approximately 1 m. The mineralogy of the augite syenite includes alkali feldspar, pyroxene or amphibole, biotite, and magnetite. Olivine is present in the mafic rich layers.

Near the base of the augite syenite, mafic layers are most common and consist of magnetite, pyroxene, plagioclase, biotite, apatite, and sulphide minerals. Pyrrhotite and chalcopyrite are the most common sulphide minerals and represent up to 3 percent of the rock. The average pyrrhotite to chalcopyrite ratio is approximately 3:2.

The monzonite is not directly related to the augite syenite but rather occurs only in the northernmost portion of the Coldwell Complex. It is an equigranular, medium grained, pale grey rock composed of plagioclase, alkali feldspar and pyroxene with rare quartz, magnetite, chalcopyrite, and pyrite. The monzonite contains fragments of fine grained gabbro and metasediments. It is not clear whether or not this rock is a member of the Coldwell intrusive sequence or an intensively recrystallized Early Precambrian felsic plutonic rock.

Syenite pegmatite is present as dikes intruded into gabbroic rocks and as pods within the syenites. The pegmatite consists of very coarse grained pink alkali feldspar and amphibole. Varieties of the pegmatites contain either microlitic cavities filled with quartz and carbonate, or, coarse grained nepheline and its alteration product, hydronepeline. In one area a dike of syenite pegmatite and aplite has been found to contain anomalous uranium and thorium plus minor molybdenite.

The quartz syenites occur at the complex contact. They are classed into two groups, quartz or red syenite and rheomorphic breccia.

The quartz syenite is characterized by its bright red colour and its highly variable grain size and consists of alkali feldspar, amphibole and quartz. It occurs as irregularly shaped pods which intrude both complex and wall rocks. It is typically very deeply weathered precluding the collection of fresh samples.

The rheomorphic breccia is a buff coloured, medium grained rock composed of equigranular alkali feldspar, amphibole, biotite, and rare quartz. The breccia consists of elongate to subangular to subrounded, pebble to boulder sized fragments of wall rock debris. The fragments have amphibolitized rims up to 2 cm thick and are frequently folded or bent.

**Economic Geology**

The three map-areas were selected so that complete sections through the Coldwell gabbro, including the major occurrences of sulphide mineralization, could be examined.

**Coubran Lake Area**

Most of the Coubran Lake map-area is held under a mining lease by Lakehead Mines Limited. Seemar Mines Limited held three patented claims along the south shore of Wullie Lake from 1919, but released the ground after re-examination during the 1960s. The map-area can be divided into two distinctive parts on the basis of topography and geology. The eastern half of the map is characterized by high relief and abundant outcrop and is underlain by layered common gabbro, principally. The western half of the map is a flat plateau where there is only scanty outcrop along stream valleys and lakeshores. Fine grained gabbro predominates. During the mapping of the Coubran Lake area, seven showings and one major zone of sulphide mineralization were delineated; two additional zones have been delineated by geophysical surveys and diamond drilling.

Lakehead Mines Limited drill logs of Zone No. 1, discovered as a geophysical anomaly, suggest that the mineralization occurs primarily as disseminated pyrrhotite and chalcopyrite in magnetite-rich gabbroic rocks. The mineralization consists of 1 to 2 percent chalcopyrite and approximately 2 percent pyrrhotite as fine disseminated grains in medium grained gabbro host. The remainder of the zone was delineated by geophysical survey and diamond drilling by Lakehead Mines Limited. The sulphide showings immediately east of Zone No. 2 are all characterized by disseminated, fine grained chalcopyrite and pyrrhotite in small (30 cm x 10 cm) pods of magnetite rich
gabbro hosted by fine grained gabbro.

Seemar Mines Limited originally prospected Zone No. 3 for its iron ore potential nearly 60 years ago. The main rock type is heterogeneous gabbro with lensoid pods (less than 44 cm x 24 cm) rich in magnetite. Sulphide minerals are unevenly distributed throughout the zone as fine to medium grained blebs of pyrrhotite with rims of chalcopyrite. Biotite commonly forms rims about sulphide grains. Fine needles of apatite occur with the magnetite-rich pods and constitute up to 2 to 3 percent of some samples. The three showings east of Zone No. 3 are identical in form to that major occurrence but are very limited in surface extent.

Bamoos Lake Area

During the early 1950s, Bamoos Lake Mines Limited was incorporated to evaluate the magnetite showings near Beaver Lake, east of Bamoos Lake; chalcopyrite was discovered associated with the magnetite mineralization. Anaconda American Brass Limited staked a large claim group during the early 1960s, including the original Bamoos Lake Mines property.

The 10 km² area mapped covers much of the Anaconda property. The main zone of sulphide mineralization occurs in the east-central portion of the area and is well exposed with large portions cleared and trenched.

The mineralization occurs in patches within heterogeneous gabbro and continuity of the patches forms a conformable zone up to 25 m in thickness and over 1.4 km in length. The principle sulphide minerals are pyrrhotite and chalcopyrite, intergrown as fine to medium grained blebs, occasionally rimmed by fine biotite flakes similar to Coubran Zone No.3.

There are no extensive occurrences of magnetite-rich pods in the heterogeneous gabbro in the main mineralized zone. Rather, the base of the 'common' gabbro contains layers of magnetite rich rock, commonly enriched with pyrrhotite and chalcopyrite; this is the association of the sulphide showings, north and south of the main zone.

The average sulphide mineral content of the heterogeneous gabbro in the main zone is approximately 3 percent. Ratios of pyrrhotite to chalcopyrite vary greatly but average 1:1 to 2:1. The relative chalcopyrite content of the magnetite-rich bands in the 'common' gabbro is higher than the main zone but total sulphide content is seldom greater than 1.5 to 2 percent.

Middleton Area

Near the western contact of the complex, there is a small area underlain by gabbroic rocks which has been prospected from time to time for base metal sulphides, but little significant mineralization has been found.

The area mapped consists mainly of 'common' gabbro which has been extensively intruded by dikes of syenite pegmatite. Fine grained gabbro outcrops in the northwest quadrant of the area, but gabbro pegmatite does not crop out within the area. Heterogeneous gabbro occurs in three small lensoidal bodies and is composed of medium to fine grained plagioclase, pyroxene, magnetite, biotite and apatite with disseminated fine pyrrhotite and chalcopyrite.

The zone of mineralization is confined to the central portion of the map-area and consists of a horizon, 300 m long by 15 to 20 m wide, with an average content of 2 to 3 percent sulphide minerals, principally chalcopyrite and pyrrhotite in approximately equal proportions.

Four other sulphide showings occur within the map-area. Three consist of disseminated sulphide grains in magnetite-rich bands at the base of the 'common' gabbro. The fourth showing occurs in the diorite at the base of the syenite and is located in a road cut along Highway 17 at the eastern edge of the map-area. This showing consists of a magnetite-rich band, less than a metre thick and continuous over several metres; the band is composed of magnetite, alkali feldspar or plagioclase, pyroxene olivine and apatite. The sulphide minerals pyrrhotite and chalcopyrite are disseminated throughout the layer. The average sulphide content for the showing is approximately 2 percent with pyrrhotite to chalcopyrite ratios averaging 3:2.

Summary

Three types of sulphide mineralization are recognized as occurring in the marginal phases of the Coldwell Alkalic Complex:
1. concentrations within heterogeneous gabbro;
2. with magnetite rich layers in layered gabbro;
3. with magnetite rich layers in syenites.

The third type was not examined in detail. Dip needle readings taken across gabbro-syenite contacts, however, showed magnetic highs indicating magnetite and, by analogy, possible sulphide concentration.

The most significant mineralization outlined is of the first type. Low nickel content and Cu:Ni ratios are consistent with the sulphide being derived from the relatively feldspathic gabbro host. Detailed mapping has delineated hybrid contact zones and large quantities of partially resorbed xenolithic material. Contamination of the gabbro magma by assimilation of wallrock material has therefore taken place. Increase of silica content of the magma through assimilation of felsic wallrocks resulting in decreased sulphide solubility (Irvine 1975) is therefore considered a possible cause of sulphide concentration in the heterogeneous gabbro; all major showings are adjacent to relatively siliceous wallrock. These deposits will be the subject of continuing study through 1978 and 1979.

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No. 48 Early Precambrian Porphyry Deposits

A.C. Colvine

Large, low grade copper and molybdenum deposits associated with porphyritic felsic intrusive rocks in Mesozoic and Cenozoic orogenic systems have become a major worldwide source of production of these metals. Their economic importance has led to intensive geological study and to great advances in the understanding of their nature and genesis.

Some features of mineral deposits associated with Early Precambrian felsic to intermediate intrusive rocks have been recognized as similar to those seen in more recent mineralized porphyry systems, in recent years many workers have designated specific mineralized areas as "Precambrian porphyries". Kirkham (1972) outlined the features of ten deposits in the Superior Province which he considered to be either porphyry deposits or of a porphyry affinity.

Field work in a project to study the geology and mineral potential of possible Early Precambrian porphyry deposits commenced during 1977. The approach to this project has been to emphasize field mapping with follow-up geochemical and petrographic work. The full extent of the intrusive body and also an adequate portion of its wallrocks are mapped in order to determine geological relationships and associations. Particular care is taken in recording the following field information to adequately assess the property:

- full extent of mineralization, both major and minor;
- nature of intrusive phase(s);
- mineralogical alteration assemblages of both intrusive rocks and wallrock;
- thermal and regional metamorphism;
- relative deformation of both intrusive rocks and wallrocks;
- spatial and genetic relationship of intrusive to volcanic activity.

The follow up work required is determined for each specific area. In addition samples are analysed to provide orientation data on metal associations other than copper and molybdenum, including gold, tin, tungsten, and uranium.

Figure 1 shows the three areas which have been studied to-date:

1. The Lateral Lake stock (Colvine and McCarter 1977) is an elongate granodiorite to quartz monzomite body which appears to have been intruded into an anticlinal structure during deformation resulting in development of concordant antiformal foliation. A mesozoan depth of intrusion is indicated by the separated, yet contained, aplite and quartz-potassic feldspar phases.

Molybdenum mineralization is associated with the latter and is concentrated at the eastern end of the intrusion at its margin, and locally intruding wallrocks. More distinct pegmatites at the western end of the intrusion are associated with minor molybdenite and one lithium-ceesium occurrence. This implies that the eastern end of the body was emplaced at a higher level. As there is no indication of widespread disseminated mineralization or hydrothermal alteration, the eastern contact zone of the stock, to depth, would appear to be the prime exploration target.

2. The relatively fine-grained nature of the Bamaji Lake Complex, examined during reconnaissance mapping, indicated that it was an epizinal equivalent of the batholith body to the north (Sage and Breaks 1976). Local molybdenite concentrations, wide-spread disseminated pyrite, and apparent alteration assemblages suggested a porphyry origin for the mineralization. Detailed mapping of the whole body (Sutherland, this volume; Wallace, this volume) demonstrated that the "Complex" is part of the northern batholith but that it achieved finer grained appearance through increasing intensity of deformation. The extent of molybdenum mineralization was found to be relatively minor; it was formed after deformation and is related to fracture and shear zones in the granitoid rocks and their recrystallized equivalents. This mineralizing event may have been related to the emplacement of the batholithic body to the south. A possible association with pegmatites originating in the southern body is recognized.

3. The Gutcher Lake Stock (Studemeister and Colvine, below) appears to have been intruded during volcanic activity. Some volcanogenic exhalative mineralization pre-dated stock emplacement, but the stock appears to have played a role in sulphide re-concentration and possibly copper introduction. A close spatial relationship between mineralization and both the stock and volcanic derived breccia-mudflow unit are recognised. Both gold and molybdenum mineralization appear to be genetically related to the stock and are localized near its contact at a deeper level of emplacement.

It is clear that none of the above can be considered true porphyry deposits. Their study has however, demonstrated geological controls of mineralization and hence provided guidelines for exploration and indications of potential for additional mineralization. Ore controls in these deposit types were previously very poorly understood.

Similar results were found from the study of seven other possible porphyry deposits in Ontario. Varying degrees of similarity to true porphyry deposits were found. Setting Net Lake, Canoe Lake, and High Lake are examples of widespread mineralization within relatively large intrusive bodies. Beidelman Bay (and possibly McIntyre) demonstrate the economically significant nature of "porphyry affinity" mineralization in the volcanic environment found at Gutcher Lake; this association will receive

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particular attention.
Systematic investigation of these deposits will continue over the next three years. In order to give comprehensive coverage of significant deposits the study is better considered as “mineralization associated with Early Precambrian felsic to intermediate epizonal intrusive rocks”.

Figure 1—Some Early Precambrian felsic intrusion-related mineral deposits. (Most comprehensive or most recent references shown).
Geology and Mineralization of the Gutcher Lake Stock

P. Studemeister¹ and A.C. Colvine²

Introduction

The Gutcher Lake Stock is a small (2 km diameter) Early Precambrian granodioritic body which intrudes a "greenstone" sequence, in Abotossaway Township, approximately 29 km northeast of Wawa. An area of 18 km² covering the intrusion, its wallrocks and associated mineral deposits was mapped at a scale of 1:15 840 (1 inch to 1/4 mile) (Figure 1); more detailed mapping was carried out where necessary, particularly in mineralized areas along the north contact of the stock. A comprehensive suite of samples (including sections of diamond drill core) was collected for petrographic and geochemical study.

Mineral Exploration

In 1921 gold mineralization in a quartz-carbonate vein was discovered west of Murphy Lake. During the 1930s production from the three shafts of the Amherst (Algold) Gold Mines Limited property amounted to 75.49 kg Au (Bruce 1940). This discovery resulted in intensive exploration which led to the discovery of other gold bearing quartz-carbonate veins, but none resulted in production (Moore 1931; Bruce 1940).

The Ego Mines Limited property consists of a group of 37 claims, 25 purchased in 1959, and 12 staked in 1961. By 1968 several sections of copper-gold mineralization had been discovered, along the north contact of the stock; at this time a reserve estimate of 450 000 t containing 1.84 percent Cu and 4.63 ppm Au was made (Source Mineral Deposits Records, Ontario Geological Survey, Toronto). Additional work between 1974 and the present has included geophysical surveys, diamond drilling and underground exploration. United Canso Oil and Gas Limited has held an option on the property since 1976.

General Geology

The area mapped (Figure 1) is located in the north-central part of the Michipicoten metavolcanic-metasedimentary belt, Superior Province. It is underlain by a sequence of volcanic, sedimentary, and intrusive rocks which have been metamorphosed to greenschist, and locally amphibolite facies and subsequently intruded by diabase dikes.

Four texturally distinct varieties of mafic metavolcanics are recognized: 1) Fine grained to aphanitic vesiculated, pillowed flows; 2) aphanitic vesiculated and unvesiculated massive flows; 3) fine to medium grained massive flows; 4) minor mafic hyaloclastic and pillow breccia. These units consist of a chlorite-albite assemblage with quartz and carbonate; vesicles are commonly quartz, carbonate and/or chlorite filled.

The felsic metavolcanics consist of large rhyolitic lenses with very fine grained quartz-sericite schist margins and generally less fine grained cores with medium grained quartz eyes. Interbedded felsic tuff and minor sedimentary units are common, but local crosscutting relationships with wallrocks are also present. This indicates that the rhyolites are partially vented high level intrusions.

The sedimentary rocks can be subdivided into three types:

a) Calcareous wackes which are medium- to fine-grained and consist of a carbonate-chlorite-quartz-feldspar assemblage.

b) Chemical metasediments which consist of interbedded ironstone-chert are are associated with mudstone (calcareous and non-calcareous schists), lapilli-crystal tuff (sileiceous seneite schist) and reworked tuff (chlorite-senicate-quartz schist). Gradational changes in ironstone composition and mineralogy are recognized. Westward from Mall Lake the pyrite content of the pyrite-magnetite ironstone decreases. Eastwards from Mall Lake transition is to a pyrite-pyrrhotite-chalcopyrite mudstone. Southwestwards from Ruth Lake the pyrite content of the pyrite-magnetite unit increases towards the margin of the stock and chalcopyrite content increases.

c) A chaotic breccia unit is present along the north contact of the stock to the south of (stratigraphically below) the ironstone. Fragment matrix ratios are highly variable. Felsic fragments are most common, consisting of very fine grained quartz-sericite with fine, occasionally medium, grained quartz eyes. Both highly siliceous (chert) and chlorite fragments are also present but no ironstone fragments were observed. The matrix is highly chloritic, wrapping around fragments and contains very small felsic fragments and fragmented feldspar phenocrysts. Fragments are angular to subangular except west of Ruth Lake where they are subrounded in a poorly-layered chloritic matrix; the unit appears to grade into an immature conglomerate, eastwards. Westwards from Mall Lake both fragment size and fragment matrix ratio decrease and the unit appears to be thickening. The unit is a volcanic derived breccia and is interpreted as a subaqueous mud flow, triggered by volcanic activity and containing locally-derived material.

Locally pillow and graded bedding top determinations indicate a younging northwards sequence, but there are insufficient data to determine if this is consistent through-

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Figure 2—Geology and mineralization of the Gutcher Lake stock. Location is shown on Figure 1.
The Gutcher Lake Stock consists of quartz (20-30 percent), feldspar (50-70 percent), and chlorite (10-20 percent). Sodic and potassic feldspar are present in a ratio of about 2:1. Quartz is variably recrystallized and occurs as clear to blue eyes; chlorite is fine-grained and has probably replaced biotite. The intrusion is therefore interpreted as having been biotite granodiorite.

Grain size varies from medium to fine near the less deformed margins to medium to coarse in the core. Consistent margin to core compositional variations are recognized; in addition to the small chlorite clots which have replaced biotite (or amphibole), found in the core, the margin contains large irregular patches and irregular fracture linings of chlorite. The intensity of feldspar alteration to sericite and clay minerals appears to decrease inwards.

The stock has extremely irregular contacts and contains large xenolithic blocks of country rock, except on the western margin where it is truncated by the Tremblay Fault which locally disrupts both stock and country rock. A narrow thermal aureole, represented by amphibolite schist, is best developed on eastern and southern contacts.

The stock has been affected by the deformation which produced the strong east-trending foliation in all of the above units. It is intensely deformed on the north and south contacts to a quartz-eye sericite schist; intensity of deformation decreases gradationally to a virtually undeformed core. This is consistent with a north-south regional compression and the stock being more competent and resistant to deformation.

Close to the stock contact, small to medium scale isoclinal folding was noted within the ironstone. Axial trends are locally uniform, east-northeast near Mall Lake and southeast near Ruth Lake, precluding their formation by soft sediment slumping. Cross cutting granodiorite dikes also produce minor folds in ironstone; axes parallel dike contacts and their amplitude and intensity decrease away from the contacts. This indicates local deformation produced by forceful intrusion of the stock. Traceable units are domed slightly around the north (upper) contact of the stock.

The north-northwesterly trending diabase dikes, which with the above units are unmineralized and unfoliated.

Mineralization

The greater part of the copper-gold mineralization occurs in a 1 km zone eastwards from Mall Lake, close to the north contact of the stock. Three main concentrations of mineralization have been outlined by drilling, the B, C and W8 zones; the latter two have been investigated by underground workings, but the C zone is presently flooded and inaccessible. In addition to the W8 zone workings, numerous surface showings were examined, many of which are well exposed through stripping and trenching.

Mineralization occurs principally within the "mudflow" unit, as irregular patches and discontinuous veins and stringers. It occurs as massive to irregular pyrrhotite-pyrite-chalcopyrite with quartz, carbonate and chlorite. Within this fragmental unit sulphide mineralization forms the matrix to fragments which are barren to rarely sulphide impregnated. Near Mall Lake mineralization is overlain by a pyrrhotite-chalcopyrite-pyrite-chlorite schist (sulphidic mudstone) and a pyrite-chlorite schist: in this unit sulphides occur as stringers and lenses which appear conformable or semi-conformable with relict bedding. Discontinuous crosscutting sulphide stringers and veins are also present, with a higher chalcopyrite:pyrite ratio.

Irregular sections of pyrrhotite-chalcopyrite-pyrite mineralization are also present within the stock along part of its northern contact. This usually occurs adjacent to wallrock mineralization and close to the contact. In one instance, however, mineralization was traced about 300 m in an apophysis of granodiorite and into the main body of the stock apparently along a fracture or fracture system. Mineralized wallrock blocks found within the stock were enclosed by barren granodiorite.

The field evidence clarifies several aspects of the geological association of the mineralization:

- Syngenetic volcanic exhalative activity resulted in deposition of the sulphidic mudstone during a quiescent period, following deposition of the main breccia, "mudflow" unit. Subsequent chemical sedimentation resulted in deposition of the ironstone.
- The upper part of the stock cuts this mineralization in places. Stock emplacement therefore postdates deposition of exhalative mineralization but the possibility of more than one phase of stock intrusion is not excluded.
- The emplacement of the stock has resulted in some remobilization and reconcentration of sulphides.
- The emplacement of the stock may have been responsible for introduction of some copper and gold into the sulphide system. Marginal alteration of the stock and mineralization within it are consistent with the development of a hydrothermal system about it. The cause of localization and concentration of the main copper-gold zone has not yet been determined.

Further investigation of the geological and geochemical association of the mineralization will be the subject of continuing study through 1978-1979.

The gold bearing quartz carbonate veins at the east and south of the intrusion are located within granodiorite or its thermal aureole. Bruce (1940) considered the metavolcanics to be the best host for gold veins. The molybdenite-pyrrhotite-pyrite-minor chalcopyrite occurrence is within a highly siliceous vein, 2 m in width, cutting granodiorite near its eastern contact. It is associated with barren quartz-carbonate veins of similar trend. The association and proximity to the contact would indicate that the gold and molybdenum mineralization are related to local concentration in a hydrous phase during the cooling of the stock.
Additional mineralization in the "mudflow" unit and near the stock contact at depth particularly in the embayment area east of Mall Lake would appear to be the prime target for additional sulphide mineralization. The gold association of the eastern contact may also warrant further investigation.

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**No. 49 Nickel Deposits of Ontario**

D.G. Innes\(^1\) and J. Birch\(^2\)

**Introduction**

In 1977, D. Innes and J. Birch began a study of Ontario’s nickel resources and reserves. This project is the second phase of a base metal reserve inventory initiated in 1975 with a zinc-copper study. During 1977 and 1978, all major nickel-producing mines in Ontario had been visited at least once. The data gathered during these visits is being analyzed and compiled. The inventory is expected to be completed by early 1980.

**Sudbury Area**

Selected sections of the Sudbury Nickel Irruptive and basin rocks are being mapped in detail. The results of this work will supplement data from the inventory and provide the framework for the assessment of potential nickel-copper resources for the Sudbury camp. Interim findings from this mapping are given below.

1. A gabbroic intrusion occurs near the contact between the Onwatin and Chelmsford Formations and has been observed along this contact in both the north and south ranges. This sill-like body, which is up to 30 m in width, is locally intensely carbonate altered. Commonly quartz-ankerite veins carrying minor galena, sphalerite, chalcopyrite, and pyrite mineralization occur in rocks of the Onwatin Formation near the intrusion. Anthraxolite occurs marginal to and just above the intrusion northeast of Vermilion Lake. In relatively unaltered exposures, the intrusion is a green weathering, coarse-grained, quartz-rich pyroxene gabbro.

2. Amygdaloidal and spherulitic andesite (Thomson 1956) outcrops in rocks of the Onaping Formation along the north shore of Whitewater Lake. Thomson suggested a volcanic origin for these rocks while more recently these lithologies have been attributed to the melt phase of meteoric impact (Dence 1972, and Peredery 1972). A sill-like intrusion similar to the amygdaloidal andesites described by Thomson (1956) has now been observed intruding rocks of the Nickel Irruptive. The sill is up to 15 m in width, has chilled contacts and contains abundant quartz and carbonate filled amygdules. Minor pyrite, pyrrhotite and chalcopyrite occur as disseminations and associated with the amygdules. This intrusion appears to maintain its stratigraphic position below the oxide-rich gabbro of the transition zone and is continuous along strike for at least 2.5 km.

3. Much of the contact between the transition zone and the granophyre of the Nickel Irruptive is, in the south range at least, a breccia zone. This breccia which is up to 200 m thick, is remarkably similar to the coarse basal breccias in the overlying Onaping Formation. In the south and east ranges, a massive dark grey, medium-grained phase of the granophyre composed essentially of quartzfeldspar and biotite is distinct from the normal pink quartzfeldspar-hornblende granophyre of the north range. This phase varies in thickness from 1000 m south of Whitewater Lake to 100 m in Capreol Township. Where observed, this phase occurs at the top of the granophyre and commonly extends as indentations and tongues for up to 200 m into the overlying Onaping Formation. Stevenson (1963) described a similar unit of granophyre in the east range which he termed pepper and salt micropegmatite. In the northeast range (Capreol Township) a very coarse grained pink to purple syenitic phase of the granophyre was observed. The distribution and nature of this phase has not as yet been determined.

4. On Map 2170, the Sudbury Mining Area (Cord. 1969), the transition zone in the east-central part of the south range is shown as a relatively wide unit up to 2000 m thick. The oxide-rich gabbro defining the transition zone (Naldrett et al. 1970) is up to 300 m thick within this unit. Much of the unit is a coarse to very coarse grained felsic quartz-rich gabbro. Intense alteration (feldspathization, silicification and epidotization) is evident throughout these rocks. Numerous felsic intrusions from a few centimetres up to 30 m in width cut this unit. These felsic dikes which generally trend with the intrusive rocks include: coarse grained pink granitic dikes; fine grained pink and grey aplitic dikes; and coarse-grained granite pegmatites. The abundance of these intrusions which are accompanied by intense host rock alteration appears to increase towards the granophyre. One such intrusion is cut by the amygdaloidal matic intrusion previously described.

**Other Areas**

Other areas having potential nickel resources were visited during 1978 and are shown on the accompanying map. Nickel mineralization associated with gabbroic-anorthosite suite rocks were examined at Big Trout Lake (Cu-Ni-Cr), East Bull Lake (Cu-Ni) and River Valley (Cu-Ni). Nickel mineralization associated with mafic and ultramafic intrusive rocks was examined at Werner Lake — Gordon Lake (Cu-Ni-Co), Puddy Lake (Cr-Ni-Fe), Hal-kirk-Watten area (Cu-Ni), Kenbridge property (Ni-Cu), Nipissing Diabase in the Sudbury area (Cu-Ni-platinum).
Figure 1—Nickel deposits of Ontario.
Nickel group metals), Temagami (Ni-Cu-platinum group metals), Kamiskotia complex (Cu-Ni), Alexo (Ni), Shebandowan (Ni-Cu) and in the Thunder Bay area (Cu-Ni-Cr). Nickel mineralization associated with mafic extrusive volcanic rocks (mainly pillowed and massive iron-rich tholeiites) was examined at Nickel Island (Ni-Zn), and Grassy Portage Bay (Cu-Ni).

A very distinct sericitic alteration (bleaching) of wall rock intermediate and mafic lavas about nickel deposits associated with the ultramafic lavas at the Alexo, Texmont, and Langmuir deposits was examined. Bleaching is irregular and varies from a narrow zone about the contact to as much as 100 m wide. Similar alteration from nickel deposits of Western Australia has been described by Barrett et al. (1977) who suggested prograde metamorphism between two differing rock types as being the cause. Chemical and petrographic work on samples collected at the above properties will be carried out to further define the nature and significance of this type of alteration.

References


Introduction

During 1977, a reconnaissance survey was carried out on a recently recognized suite of ultramafic and tholeiitic rocks in the southern part of Newton Township (Innes 1977). Representative samples of the main lithologies have now been studied. Table 1 contains chemical analyses of the komatiitic and tholeiitic lavas from this suite, and Figure 1 is the Jensen cation plot (Jensen 1976) derived from the chemical data.

High iron tholeiitic basalt, high magnesium tholeiitic basalt, basaltic komatiite and ultramafic komatiite are present. The basal cumulates of peridotitic komatiite flows (Samples 2, 6, 7, 13, 14, 17, 18) are the most ultramafic (SiO$_2$ < 45 percent, MgO > 30 percent with low CaO, Al$_2$O$_3$, TiO$_2$ and alkalies). Less mafic peridotitic komatiites (15-16) include the spinifex textured rocks (unit 4 on figure, p.203 of Innes 1977). Basaltic and pyroxenitic komatiites...
# Table 1

## Analyses of Komatiites and Tholeiites in Newton Township

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### Notes

A. Major oxides expressed as weight percent.
B. Trace elements expressed in ppm.
1. Porphyritic metagabbro.
2. Cumulate peridotite of peridotite komatiite flow.
3. Komatiitic basalt flow.
4. High magnesium tholeiitic basalt flow.
5. High magnesium tholeiitic pillowed basalt flow.
7. Cumulate peridotite of peridotite komatiite flow.
8. High iron, tholeiitic basalt flow.
9. Pillowed komatiitic basalt flow.
10. High iron komatiitic basalt flow.
11. Pillowed komatiitic basalt flow.
12. Komatiitic basalt flow.
13. Serpentinized cumulate peridotite of peridotite komatiite flow.
15. Pyroxenitic spinifex textured komatiitic flow.
16. Pyroxenitic spinifex textured komatiitic flow.
17. Pyroxenitic komatiite flow.
18. Pyroxenitic komatiitic flow.
19. Pyroxenitic gabbro.
(Samples 3, 9, 11, 12) form a core to the peridotitic komatiites (unit 5 on figure, p.203 of Innes 1977). Within this core are the high magnesium tholeiitic basalts (Samples 1, 4, 5, 19). High iron tholeiitic basalts occur along the north margin of the komatiitic sequence (Samples 8, 10).

Additional reconnaissance mapping in late 1977 has shown that the ultramafic suite continues eastward into Dale and Marion Townships. In Dale Township there is a marked decrease in the peridotitic komatiite component and relative increase in the basaltic and pyroxenitic component. The peridotitic komatiite flows generally exhibit cumulate bases with spinifex and polysutured tops. Basaltic komatiite occurs as pillowed flows (tops south) up to 4 m thick and commonly contain fine to coarse light-grey hackly spinifex textures and occasionally polysuturing. Large pillow structures (or lava tubes) up to 6 m in length and 1.5 m in width commonly display thin outer selvages (2 cm) and an inner margin of fine spinifex with massive cores. Commonly a thin zone of hyaloclastite is developed along the flow contacts.

The komatiitic suite is bordered on the north by thick, massive, high-iron tholeiitic basalt flows with minor pillowed flows and intercalated finely laminated tuff. Coarse grained porphyritic gabbro occurs to the south of the komatiitic sequence.

Conclusions

1. All of the lavas in the area examined are of the komatiitic and tholeiitic suites.
2. Within the komatiitic peridotites, pyroxenites and basaltic komatiites are recognised.
3. High magnesium tholeiites are associated with the pyroxenitic komatiites. High iron tholeiites occur stratigraphically below the komatiitic sequence.
4. Peridotitic komatiites generally form thin continuous flows with coarse cumulate bases and finer spinifex-textured tops. Polysutured chilled flow contacts are common. Less mafic pyroxenitic komatiites and basaltic komatiites are generally pillowed with spinifex textures and polyhedral jointing. Commonly hyaloclastite is developed at the tops of flows. High iron tholeiites are generally massive thick flows with little internal structure.
5. In the komatiitic sequence, all units analysed have low FeO′/ (FeO′ + MgO)\(^{1}\) ratios, low TiO\(_2\) content and high MgO, NiO, and Cr\(_2\)O\(_3\) content. However samples 2, 6, 7 and 13 which represent cumulus peridotite, have low Cr values associated with relatively high Ni values.

CaO/Al\(_2\)O\(_3\) ratios are generally less than 1, however some samples have CaO/Al\(_2\)O\(_3\) ratios ideal for komatiites according to Brooks and Hart (1974).

6. The komatiitic sequence in Newton and Dale Townships is similar to those described by Arndt et al. (1973), and Pyke et al. (1977) in the Abitibi Belt where they are known to host significant nickel deposits (Coad 1976-1977; Naldrett 1976). These deposits are most commonly associated with peridotitic komatiites having 35 percent MgO. Since peridotites in Newton Township contain as much as 39.3 percent MgO (Table 1), these rocks are considered to have potential for nickel sulphide mineralization. To date, this sequence has not been explored in any detail.

7. A grab sample of quartz-feldspar porphyry, mineralized with pyrite failed to show any significant values in gold (Innes 1977, p.204).

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Naldrett, A.J.
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Pyke, D.R., Naldrett, A.J., and Eckstrand, O.R.

\(^{1}\) FeO′ = total iron.
Reconnaissance work on chromium-bearing rocks across Ontario indicates that chromium occurs principally in mafic and ultramafic rocks. Chromite, the oxide, occurs most often in serpentinitized ultramafic rocks ranging from dunites to pyroxenites of Early Precambrian age. One exception, in Pardee Township, is a fractionated Late Precambrian ( "Keweenawan") olivine gabbro (Figure 1, No.4) (Geul 1970). Chrome may also occur in silicate phases, such as pyroxene and the chrome mica fuchsite. Chrome in pyroxenes accounts for all of the chrome in some of the ultramafic rocks (Naldrett et al. 1968) in the Dundonald intrusion (Figure 1, No. 10).

Within ultramafic and mafic rocks chromite occurs in both disseminated and massive layered form. The disseminated chromite usually develops adjacent to the chromite layers. In serpentinites, such as at Chrome Lake (Figure 1, No.5), chromite forms the intercumulate phase to cumulate olivines as well as being a disseminated mineral. A typical sequence is described as follows:

Base. 0.0 cm: Fine to medium grained serpentinite which may exhibit a cumulate olivine texture. Where the serpentinite has been sheared talc and magnesite are usually developed.
5.0 cm: Serpentinite in sharp contact with fine-grained massive chromite layer. Chromite is equigranular and anhedral, generally ovoid or spherical in shape.
7.5 cm: Massive chromite with approximately 10 modal percent medium + grained serpentinitized olivine phenocrysts. The olivines are serpentinized to lizardite and antigorite.
11.5 cm: Serpentinitized olivine phenocrysts become gradationally more abundant and form approximately 90 modal percent of the rock. Patchy areas with about 20 modal percent chromite occur irregularly through the dunite.

Top. 15.5 cm.

At the Chrome Lake occurrence samples of massive fine to medium grained aggregate chromite are texturally similar to chromite from the Bird River Sill (Figure 1, No.12) and from the Bushveld Complex of South Africa.

The other areas examined and sampled (Figure 1) include: Big Trout Lake, anorthositic gabbro (Hudec 1964); Werner Lake, sheared mafic metavolcanics; Hagey Township, peridotite (Morin 1973); Pardee Township, fractionated olivine gabbro (Geul 1970); Chrome Lake, serpentinitized dunite (Graham 1931; Hurst 1932; Kidd 1934); Midlothian Township, fuchsite (Bright 1970); Reaume Township, mafic metavolcanics; Mann Township, pyroxenite; Dundonald Township, peridotite and pyroxenite (Naldrett et al. 1968); Steele Township, serpentinitized dunite (Lumbers 1962); Elzevir Township, mafic metavolcanics; and the Bird River Sill, serpentinitized (Racevic 1977).

Representative samples for thin and polished sections, and for major and trace element chemistry were collected from known chromite bearing rocks (Figure 1). Samples of apparently chromite free ultramafic rocks, closely associated with the chromite bearing rocks, were also collected. Studies on these samples should aid recognition of anomalous chrome from normal chrome values.

More detailed work on chromite-bearing rocks will be undertaken in the 1979 field season. The studies will emphasize the petrogenesis of chromite-bearing rocks, and the Cr/Fe ratios of the chromite. The Cr/Fe ratio is a critical factor in determining the ore potential of chromite (Racevic 1976, 1977).

The author wishes to acknowledge assistance of D.G. Innes, Geologist, Mineral Deposits Section in formulation and implementation of this project.

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Morin, J.A.

Naldrett, A.J., and Mason, G.D.

Racevic, D.


1 Geologist, Mineral Deposits Section, Ontario Geological Survey, Toronto.
Figure 1 - Chromium deposits of Ontario.
Project Objective

The objective is to identify quantifiable relationships between known mineralization and associated geological parameters in northern Ontario for the purpose of providing exploration guidelines. The results should also assist regional planning and development.

Scope of Present Study

The region studied to date is the area covered by the Geological Compilation Series Map 2205 (Pyke et al. 1973) for the Timmins-Kirkland Lake region. Evaluation of copper, gold, silver, zinc, and nickel mineralization has been made using multivariate statistical techniques of factor and discriminant analyses. The study was carried out in Toronto using the Queen’s Park Computer Centre facilities.

Data Base

A grid of 444 cells (see Figure 1), each 5 miles square (8 km) was superimposed over Map 2205 and in each cell, measurements were made of the presence and absence of a set of 26 variables including all geological formations, faults in general directions of northeast, north, and northwest, dikes, synclines, anticlines, lineaments, and iron formation. Also recorded were the presence or absence of copper, gold, silver, zinc, nickel, and asbestos mineralization.

General Geology

The bedrock in the Timmins-Kirkland Lake map region is composed of Early Precambrian metavolcanic and intrusive rocks ranging in composition from felsic to ultramafic and metasediments that include greywacke, conglomerate, siltstone, and argillite. In the southern part of the region, unmetamorphosed greywacke, arkose, and quartzite unconformably overlie the bedrock. Paleozoic limestone, dolomite, sandstone, and shale occur in the southeast part of the region. The region has been folded, faulted, and intruded by dikes of different ages. There is a widespread cover of Pleistocene glacial deposits in the region (Jensen 1976, 1977; Pyke 1975, 1976, 1977; Pyke and Middleton, 1970).

Results Overview

The results in Table 1 show sets of geological variables the joint presence of which provides for a favourable environment for the occurrence of the particular mineralization associated with them. The results are based on factor analyses with varimax rotation (Joreskog et al. 1976). The figures in parentheses are “factor loadings” or measures of the relative importance of the contribution of individual variables. Where more than one set is listed for a commodity, it indicates the presence of more than one mode of mineralization for that particular commodity. A high value of a commodity in a factor indicates its greater affinity for the geological environment represented by the set of variables in that factor. The relative importance of a variable in the occurrence of a mineralization can be estimated from the factor loading value in the set. Figure 1 shows the potentially favourable cells for gold mineralization as determined by applying discriminant function analysis (Lachenbruch 1975).

The sets of variables presented in Table 1 are useful as conceptual guidelines in mineral exploration. They must be incorporated in a computer model to obtain a valid assessment of their joint and relative contributions. This has been done using the presence of gold mines as calibrators. The close indicated association of felsic metavolcanics and ultramafic rocks such as peridotite and dunite has been confirmed in the field and reflects the cyclic volcanic activity in the region.

The reliability of projects such as the present one depends on the objectivity and accuracy of the information base, and a continuous process of updating the model itself. On the basis of the results obtained and with the newer information being compiled, the model will be updated. Refinements will include 1) identification of redundant and of geologically invalid, though apparently statistically significant, parameters, 2) the use of measured data rather than presence or absence for the selected parameters, subjective probability encoding based on discussion with geologists with a good working knowledge of the area.

1 Geologist, Mineral Deposits Section, Ontario Geological Survey, Toronto
Figure 1—Favourable target areas for gold mineralization in the Timmins-Kirkland Lake region as determined by discriminant analysis. See text for explanation. Cells marked with an X are known mineralization cells that are misclassified by discriminant analysis. Each cell is 8 km square.
### TABLE 1
RECLUSIONS BETWEEN MINERALIZATION OCCURRENCE AND HOST GEOLOGY BASED ON FACTOR ANALYSES.
SEE TEXT FOR EXPLANATION.

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References

Jensen, L.S.  


Lachenbruch, P.A.  

Pyke, D.R.  


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