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**Ontario Geological Survey
Open File Report 5868**

Precambrian Geology of the Coldwell Alkalic Complex

1993



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ONTARIO GEOLOGICAL SURVEY

Open File Report 5868

Precambrian Geology of the Coldwell Alkalic Complex

By

E.C. Walker, R.H. Sutcliffe, C.S.J. Shaw, G.T. Shore and R.S. Penczak

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Precambrian Geology of the
Coldwell Alkalic Complex

by

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LOCATION AND ACCESS

The 580 km² Coldwell Alkalic Complex is situated between Pic River and Dead Horse Creek, on the north shore of Lake Superior, 275 km east of Thunder Bay. The town of Marathon is located within the eastern part of the complex. The southern part of the Coldwell Alkalic Complex is accessed by Highway 17, the Canadian Pacific Railway and the Lake Superior shore. Access to the northern part of the complex is obtained by exploration and logging roads leading north from Highway 17. Parts of the complex which are inaccessible from roads are best reached by helicopter from the Marathon Airfield.

MINERAL EXPLORATION

Mineral occurrences in the Coldwell Alkalic Complex include: base (Cu,Ni), platinum group metals (PGE) and associated metals (V,Ti) rare metals (Nb, Y, Zr, rare earth elements (RE)), building stone, industrial minerals (nepheline), and semi-gemstones (spectrolite). The information on exploration activity reported here is taken from the Resident Geologist's Files, Ontario Ministry of North Development and Mines, Thunder Bay and the Ontario Geological Survey's Geological Data Inventory Folio.

Base and Precious Metals

The gabbroic intrusion on the eastern margin of the complex, named the Eastern Gabbro, hosts the most significant Cu-PGE occurrences and has been extensively explored since the mid 1950's. Exploration work within the Eastern Gabbro has focused on four regions, the Marathon Cu-

PGE occurrence, the Dunlop occurrence, the Willie Lake occurrence and the Lacobeer Lake area. Other gabbro hosted Cu-PGE occurrences are present in the central and western parts of the Complex.

Exploration work in the Marathon Cu-PGE occurrence and surrounding area began in 1954 with Bamooos Lake Mines Limited completing geological mapping and diamond-drilling three holes (600 m) southwest of Bamooos Lake. They intersected pyrrhotite, pyrite, chalcopyrite and magnetite mineralization. In 1963, Falconbridge Nickel Mines Limited reported magnetite mineralization in three diamond-drill holes (396 m) along the Pic River east of the Marathon Airfield. Marathon Mines Limited found pyrite mineralization in two diamond-drill holes (671 m) at the southwest end of Bamooos Lake. An extensive exploration program between 1964 and 1966 by Anaconda American Brass Limited completed 52 diamond-drill holes (11,137 m) in the Marathon Cu-PGE occurrence and surrounding area. They reported intersections of pyrite, pyrrhotite, chalcopyrite, and magnetite mineralization with copper grades between 0.05 and 2.5%. During the mid-1980s Fleck Resources Limited explored the Marathon Cu-PGE occurrence for its Cu-PGE potential. With an additional 37 diamond-drill holes and extensive trenching and surface sampling, Fleck outlined 37 million tons of 0.31% Cu, 0.04% Ni, 0.007 ounce per ton platinum, and 0.027 ounce per ton palladium.

The Dunlop occurrence was originally diamond-drilled by Kinasco Mining and Exploration Limited in 1956. They completed nine holes (1,783 m) and found pyrite, chalcopyrite, pyrrhotite, and magnetite mineralization. Additional drilling in the Dunlop occurrence was completed by Conwest Exploration Company Limited in 1964 (two holes, 307

m) and Noranda Exploration Limited in 1992 (two holes, 400 m). Noranda intersected weakly disseminated chalcopyrite mineralization that contained up to 0.35% Cu. Diamond-drilling near the Dunlop occurrence was completed by Mentor Exploration Limited in 1956 (two holes, 316 m), Zulapa Mining Corporation (three holes, 173 m) and Anaconda American Brass Limited in 1965 (10 holes, 1,578 m). In 1956, Norgold Mines Limited diamond-drilled 12 holes (1,467 m) between the Dunlop occurrence and the Marathon Cu-PGE occurrence and reported pyrrhotite, chalcopyrite and magnetite mineralization.

Diamond-drilling in the Willie Lake occurrence began in 1954 by Head of the Lakes Iron Mine Limited and continued with a second phase in 1962 and 1963. In total the company drilled 32 holes (2,366 m) and found pyrrhotite, pyrite, chalcopyrite and magnetite mineralization with assay grades up to 1.42% Cu over 6 m and 86% FeO over 1.8 m. Lakehead Mines Limited from 1964 to 1966 continued diamond-drilling (25 holes, 884 m) in the Willie Lake occurrence. Lakehead Mines Limited reported magnetite, pyrite, pyrrhotite, and chalcopyrite mineralization with grades up to 0.75% and 1.05% Cu over 1.5 m. In 1965, Seemar Mines Limited diamond-drilled a single hole (153 m) and intersected 0.19% Cu across 37 m. Mr. J. Sweet diamond-drilled four holes (133 m) in 1963 in a magnetic anomaly southwest of the Willie Lake occurrence and reported pyrite and chalcopyrite mineralization. Mr. D. Fairbairn diamond-drilled three holes (292 m) in 1976 in the Willie Lake occurrence and reported only magnetite mineralization. In 1991, Redstone Resources Incorporated diamond-drilled four holes (443 m) in the Willie Lake occurrence and intersected chalcopyrite, pyrite, magnetite, and pyrrhotite

mineralization with grades up to 0.33% Cu, 262 ppb Pd, 100 ppb Pt, and 104 ppb Au over 26 m.

In the Lacobeer Lake area of the Eastern Gabbro, Anaconda American Brass Limited diamond-drilled (23 holes, 4561 m) in 1965 and 1966 and found pyrite, pyrrhotite, chalcopyrite, and magnetite mineralization. An additional eight diamond-drill holes (2,027 m) were completed by Placer Development Limited in 1979 and 1980. They reported magnetite, pyrite, pyrrhotite, and chalcopyrite mineralization with grades of 0.31 % Cu over 4 m and 215 ppb Pt and 315 ppb Pd over 2 m. Hathaway Metal Mines Limited in 1965 diamond-drilled three holes (345 m) southwest of Lacobeer Lake near Seeley Lake and found pyrite mineralization.

The MacRae Cu-PGE occurrence is hosted in a gabbro within the central part of the Coldwell Alkalic Complex south of Geordie Lake. St. Joe Canada Incorporated diamond-drilled along the footwall contact of the gabbro with the recrystallized quartz amphibole syenite. A surface grab sample collected by Mr. B. Schneiders, Resident Geologist, Hemlo-Schreiber Region, reported 1.73 % Cu, 0.04 % Ni, 2275 ppb Pd, 165 ppb Pt, and 1030 ppb Au.

The Middleton occurrence is hosted in the gabbro near the western contact of the Coldwell Alkalic Complex. In 1955, Moneta Porcupine Limited diamond-drilled five holes (291 m) and in 1956 Kinasco Mining and Exploration Limited diamond-drilled two holes (312 m), both Companies intersected magnetite, pyrrhotite, pyrite and chalcopyrite mineralization. Grab samples taken by the field crew from the Middleton occurrence host disseminated chalcopyrite, pyrite with minor sphalerite with Cu grades as high as 0.70%.

The Renshaw-Tripp Fe-Ti occurrence is a brecciated gabbro fragment of the gabbro hosted in iron-rich augite syenite northeast of the Middleton occurrence. Analysis of a grab sample taken by the field crew from the occurrence had 35.6% FeO and 2.2% TiO₂.

Rare Metals

Uranium exploration during the late 1940s and 1950s discovered rare metal (Nb, Zr, Th, U and Rare Earth) mineralization in the Coldwell Alkalic Complex. In 1949 Mr. T. Glowasky discovered the Port Munroe occurrence. Subsequent surface stripping, trenching and sampling by Mr. T. Gustafson uncovered rare metal mineralization from grab samples with grades of 1.35% Nb₂O₅, 0.08% U₃O₈, 3.00% ThO₂, and 1.2% Ce₂O₃. A grab sample from a small diklet south of the Port Munroe occurrence near Yser Point taken by Orchan Uranium Mines Limited is reported to have 0.60% Nb₂O₅.

Orchan Uranium Mines Limited in 1954 discovered the Marathon Niobium occurrence north of Craddock Lake and completed mapping, trenching and sampling along a syenite dike 1.5 m wide and up to 1 km long. A grab sample analysis taken by the company was reported to have 0.47% Nb₂O₅ and 2.44% ZrO₂.

Building Stone

Syenite from the Coldwell Alkalic Complex was extracted for the construction of railroad bridges over Pic and Little Pic Rivers by the Canadian Pacific Railway during the 1880s. Building stone was also extracted from small quarries within the complex by Peninsula Granite

Quarries Limited for 12 months in 1927, Cold Spring Granite Company Limited in the late 1930's, Lake Superior Stone Syndicate in 1960, and Angler Granite Limited in 1965.

In 1988 and 1989 a feasibility study was completed by Cold Spring Granite Company at two sites. One site is located north of Marathon along the Canadian Pacific rail at the old Cold Spring Granite Company Limited quarry and the other site is west of Port Coldwell along Highway 17 on claims optioned from Mr. D. Petrunka. A total of 37 diamond-drill holes (546 m) and the extraction of two large test samples were completed.

Industrial Minerals

Exploration for nepheline in the amphibole nepheline syenite has been undertaken at three locations within the Coldwell Alkalic Complex; Red Sucker Cove, Port Coldwell and Pic Island. Denison Mines Limited collected bulk samples and diamond-drilled 11 holes (220 m) at Red Sucker Cove in 1961 and five holes (158 m) at Port Coldwell in 1962. They reported that nepheline concentrates with iron contents below an acceptable level of 0.08% FeO could not be consistently produced. Coldstream Mines Limited also investigated the nepheline syenite in Red Sucker Cove for nepheline by diamond-drilling three holes (550 m) in 1972. Additional work by Commercial Management Services (2 holes, 32 m) was completed at Port Coldwell in 1956. Mr. W. C. Arrowsmith diamond-drilled 13 holes in 1953 along the west shore of South Bay on Pic Island and reported intersecting hornblende nepheline syenite with variable red coloration.

Semi-gems

Mr. and Mrs. J. Ferguson of Terrace Bay, Ontario have started extraction of very coarse-grained iridescent feldspars from several pegmatites hosted in the iron-rich augite syenite near Shack Lake. The polished minerals are being marketed as Spectrolite, the Marathon Gem Stone. In 1978 Mr. D. Wilkinson completed diamond-drilling 2 holes (39 m) in the Shack Lake pegmatite. Extraction of similar feldspars was also observed to have occurred in a pegmatite exposed on the eastern island within Bamooos Lake.

BEDROCK GEOLOGY

General

The Coldwell Alkalic Complex was emplaced in Archean rocks of the Wawa Subprovince of the Superior Province during the early stages of the Middle Proterozoic Mid-continent Rift at 1108 +/- 1 Ma (Heaman and Machado 1992). The complex is located at the north end of the Thiel fault, a zone of faulting which separates grabens with different subsidence history in the rift (Cannon et al. 1989). A north-trending magnetic high occurs between the rocks of the Coldwell Alkalic Complex and those of the Mid-continent Rift beneath Lake Superior (Gupta 1991). Samples of different magmatic suites from the Coldwell Alkalic Complex dated by the U-Pb zircon/baddeleyite method (Heaman and Machado 1992) are all within analytical error.

Kerr (1910) was the first to describe the nepheline syenites along the southern part of the Port Coldwell complex. Puskas (1967) completed a map of the entire complex at a scale of 1-inch-to-1/2-mile. This was

followed by a compilation map by Currie (1980) which included results of limited field investigation. Originally, the complex was considered to be a result of extensive fractional crystallization of a single batch of magma within a funnel-shaped intrusion (Lilley 1964) or lopolith (Puskas 1967). Subsequent work demonstrated that the complex was not emplaced as a single batch of fractionated magma. Currie (1980) proposed a model in which the Coldwell Alkalic Complex developed from three intersecting systems of ring dikes and cone sheets, defined by igneous layering. Mitchell and Platt (1977, 1978) used petrological characteristics and relative timing relationships to divide the complex into 3 centers of alkalic magmatism emplaced by cauldron subsidence associated with major faults.

Mapping during the present study supports the hypothesis of Mitchell and Platt (1977, 1978). The present authors consider the configuration of the majority of the rocks represent magma that was intruded as sheet-like bodies during cauldron subsidence. Consequently, the present erosional surface exposes a sub-horizontally stratified sequence of rocks situated near the top of the Coldwell Alkalic Complex.

Description of Rock Units

Archean Rocks

The Coldwell Alkalic Complex intrudes Archean metavolcanic, metasedimentary and granitic rocks (Unit 1 to 4). Detailed descriptions of the Archean rocks to the east and south-east of the complex are given by Milne (1967) and Muir (1982), and to the west and northwest by Walker (1967). Both eastern and western contacts of the complex truncate

bedding or fabrics within the Archean rocks. The eastern contact between the complex and the Archean rocks has a regular arcuate shape, however, the west contact is irregular and apparently modified by faults. Metamorphism of the Archean rocks to the pyroxene hornfels grade can be detected within approximately 50 m of the contact with the complex.

Proterozoic Rocks - Coldwell Alkalic Complex

Locally, on the eastern and western contacts of the complex, where gabbro is in contact with Archean rocks, metamorphism has caused suprasolidus recrystallization of the Archean rocks and development of rheomorphic breccia (Unit 6). The breccia consists of Archean metavolcanic and metasedimentary rock fragments and gabbroic clasts of probable Proterozoic age in a matrix of fine-grained quartz and feldspar with traces of biotite and amphibole. Clasts vary in size from less than 1 cm to more than 1 m, are commonly angular, and locally have 1-2 cm reaction rinds. In the area near Two Duck Lake (local name), the breccia contains diabasic gabbro clasts and Archean metavolcanic clasts which have been boudinaged and sheared. Local granitic veins cut the breccia and these commonly contain traces of tourmaline and prehnite. Rheomorphic rocks are also present along the northwest contact with Archean granites.

The mafic rocks of the Coldwell Alkalic Complex are divided into tholeiitic to sub-alkaline and alkaline types based on chemical composition and petrographic criteria. Tholeiitic to sub-alkaline mafic magmatism occurred throughout the complex, whereas, the alkaline mafic magmatism is spatially and genetically associated with only the

undersaturated syenites of Center 2. Based on gravity models, mafic rocks also appear to underlie the complex within 3 to 5 km of the current exposure (Mitchell et al. 1983). Mapping during the present study has demonstrated that there is a suite of volcanic to sub-volcanic mafic rocks that occur as a roof pendant to the syenites.

The intrusive rocks of the Coldwell Alkalic Complex are emplaced into a sequence of mafic volcanic and subvolcanic rocks (Unit 5). The intrusion of gabbroic and syenite magma into the mafic volcanics has caused large and small scale brecciation and assimilation of this unit, leaving mafic volcanic xenoliths from less than 1 m to over a km in size. The larger xenoliths form a roof pendant overlying the central part of the Coldwell Alkalic Complex. Varieties of this unit have been observed as xenoliths in many of the major rock units throughout the complex. Good exposures of basaltic xenoliths occur in the areas of Coubran, Bamooos, Wolf Camp and Penn Lakes, and Foster Island in Lake Superior.

The ocellar and fine-grained to aphanitic basalts are highly fractured and locally have magnetite-filled fractures up to 4 cm wide. The basalts are considered to be Proterozoic in age due to the absence of strong penetrative fabrics, dissimilarity to Archean rocks exposed outside of the complex, and presence of subhorizontal structural elements. The ocellar basalts are black, aphanitic to fine-grained and commonly contain amygdule-like ocellar structures which are rounded to elliptical, range from a few mm to 2 cm in diameter and are filled with fine- to medium-grained epidote and quartz. Well-defined zones with the ocellar structures dip 8° to the south-west in the Wolf Camp Lake- Port

Munroe area and increase in size and abundance toward the top of individual layers. In the southern parts of the Coldwell Alkalic Complex at Black Rock Island and on Penn Lake, the basalts exhibit fragmental textures similar to flow-top breccias.

Medium-grained basalt with diabasic texture occurs mainly on top of Bamooos Mountain and in the Coubran Lake area. The medium-grained basalt locally contains vesicles filled with feldspar and quartz. The medium-grained basalt commonly occurs in the northern part of the complex, whereas the fine-grained basalts with ocellar structures occur as xenoliths in the southern part of the complex.

Aphanitic- to medium-grained feldspar-phyric basalts containing lath-shaped feldspar phenocrysts up to 1 cm in length occur with both aphanitic to fine-grained and medium-grained basalts. The feldspar phenocrysts can occur either separately or in glomeroporphyritic aggregates.

A crescent-shaped tholeiitic to sub-alkaline gabbro intrusion (Unit 7) around the eastern and northern margin of the Coldwell Alkalic Complex is named the Eastern Gabbro. The Eastern Gabbro varies from massive to layered. The layered gabbro contains plagioclase, clinopyroxene, olivine and magnetite with biotite and amphibole. Layering in the Eastern Gabbro is typically continuous over distances of up to 50-60 meters. Layering in the northern part of Eastern Gabbro is folded, discontinuous, and interrupted by anorthosite inclusions.

An area of coarse-grained to pegmatitic gabbro, referred to as the Two Duck Lake Gabbro, occurs within the Eastern Gabbro south of Bamooos Lake in the vicinity of the Marathon occurrence. At the scale of mapping

the boundaries were not distinguished. According to Good (1992), the Upper zone is massive to well-layered with a lamination of feldspars and contains pegmatitic gabbro pods. The Lower zone of the Two Duck Lake gabbro is typically massive and coarse- to very coarse- grained ophitic to subophitic with common pegmatitic patches. The gabbro contains up to 3% sulphides and is the host to the Marathon Cu-PGE deposit. The Upper and Lower zones of the Two Duck Lake gabbro are separated by a xenolith of fine-grained gabbro.

Dikes of fine-grained ophitic to subophitic gabbro which intrude Archean rocks are common in the Two Duck Lake area and are cross-cut by both layered gabbro and Two Duck Lake gabbro. Xenoliths of similar rock type are found in the Two Duck Lake Gabbro, as clasts in rheomorphic breccia and sporadically throughout the northwestern part of the gabbro.

Feldspar-phyric gabbro occurs from Highway 17 along the shore of the Pic River and west to Malpa Lake where it is terminated by a fault. This gabbro is typically fine- to medium-grained with pyroxene, olivine and magnetite and has subhedral to euhedral feldspar phenocrysts 0.2-1 cm long.

Outcrops of gabbro were also found within steep-sided lineaments south and east of the Coubran Lake. These gabbroic outcrops may be xenoliths in the host syenite, or evidence of additional gabbroic sheets below the thin syenite cap rock.

Layered gabbro occurs within Center 2, east of Port Coldwell along the Lake Superior Shore. The rock is black, coarse-grained and layered. The layering is rhythmic, 10 cm thick, strikes to the northeast and dips approximately 85° to the southeast. The plagioclase in the gabbro is

tabular and defines a weak foliation that strikes to the east. This gabbro also occurs as submeter to outcrop scale angular enclaves within amphibole-natrolite syenite.

A gabbro sheet dipping approximately 10 to 20° to the west, named the Geordie Lake Gabbro, cuts the recrystallized amphibole quartz syenite. The intrusion of the sheet appears to be related to evolved gabbroic magmatism into the Archean, ocellar basalts, and recrystallized amphibole quartz syenite rocks which occur as a roof rock to the shallow level mafic magma chamber. The Geordie Lake Gabbro is medium- to coarse-grained, and in addition to pyroxene and plagioclase contains olivine, magnetite, potassic feldspar, and apatite.

A shallow dipping sheet of monzodiorite is emplaced into the basalts in the south-central part of the complex. The monzodiorite is 1.5 km wide by 13 km long and extends from Craddock Cove to Blondin Island. Contact relationships indicate that the monzodiorite was emplaced concordantly to the ocellar basalt. At the contact, the monzodiorite has a medium- grained sub-ophitic texture which grades upward into an intergranular texture. The basal contact of the monzodiorite with basalt is typically separated by a fine-grained red feldspar-phyric trachyte. In the middle part of the monzodiorite sheet, medium- to coarse-grained pegmatitic patches are present. Toward the top of the monzodiorite, the feldspars become reddened and the red monzodiorite is texturally very similar to the recrystallized amphibole quartz syenite. The contact between these two rocks is marked by the appearance of quartz within the quartz syenite.

An arcuate zone of disaggregated heterogeneous alkaline gabbroic

rocks (Unit 8) occur between Red Sucker Cove and Prisoner's Cove. The alkaline gabbro occurs through an area approximately 7 km in length and 1.5 km wide. Near Port Coldwell, measurements of foliation and layering strike west-northwest and dip 45° to 85° north-northeast. Based on mineralogical and textural criteria, the alkaline gabbro can be subdivided into; biotite- and olivine-bearing gabbros, heterogeneous enclave-rich biotite-olivine gabbro, and heterogeneous breccia zones comprised of fine-grained gabbroic enclaves.

Biotite- and olivine-bearing gabbros occur in distinctive tabular bodies of alternating gabbroic composition several cm wide and traceable over several meters. Two compositionally different gabbroic rock types produce a distinctive weathering profile. The more easily weathered type is coarse-grained, green olivine-rich gabbro. The harder lithology is a coarse-grained, dark gray to black biotite gabbro. Locally, the biotite gabbro cross-cuts the olivine-rich gabbro.

The heterogeneous enclave-rich biotite-olivine gabbro has a very distinctive highly-pitted weathered surface. Centimeter to decimeter scale pits are produced by the differential weathering of mafic enclaves from syenitic matrix. The enclaves vary in composition from biotite- and olivine-bearing gabbros to leucogabbro. The matrix generally occurs as veinlets (1-5 cm) of fine- to coarse-grained amphibole natrolite-nepheline syenite. In general, the enclaves are rounded to elliptical, weakly aligned, fine- to medium-grained, and comprise 80-95% of the rock.

The fine-grained gabbroic enclaves occur in heterogeneous breccia zones throughout the Coldwell Peninsula. The fine-grained gabbroic

enclaves are black, aphanitic to fine-grained and have lobe and cusped margins with a matrix of amphibole-natrolite syenite. Some enclaves show clinopyroxene alteration to amphibole suggesting hydration reactions. Locally, fine-grained gabbroic enclaves comprise up to 75% of the rock, although 20-30% is typical. In several localities, enclaves occur in elongated trains, a morphology suggestive of disrupted dikes. The fine-grained gabbroic enclaves may represent contemporaneous gabbroic and syenitic magmatism after the emplacement of the other alkaline gabbroic rocks.

The recrystallized amphibole quartz syenite (Unit 9) is the first major phase of syenite magmatism within the Coldwell Alkalic Complex. It outcrops in an area 2 km wide and 14 km long within the central part of the complex. The recrystallized amphibole quartz syenite intrudes the mafic volcanic xenoliths and is intruded by amphibole syenite. The recrystallized amphibole quartz syenite appears to be overlain by ocellar mafic volcanic xenoliths and has vertical contacts with younger rock types.

The recrystallized amphibole quartz syenite is typically red with medium-grained anhedral feldspar, quartz, alkali amphibole and a granular texture. Locally, the syenite has feldspar and/or amphibole phenocrysts, with a fine- to medium-grained groundmass. Locally along the east and west contacts segregation of the rock into melanosome (amphibole enriched) and leucosome (quartz-feldspar enriched) occurs.

Rheomorphic rocks are present at the contact between the recrystallized amphibole quartz syenite and amphibole natrolite-nepheline syenite contact along Highway 17 near Red Sucker Cove. These

rheomorphic rocks become progressively finer-grained with locally identifiable flow fabrics and intrude and brecciate the host rocks.

The iron-rich augite syenite (Unit 10) is a sheet-like intrusion that dips inward and thickens toward the center of the complex. Because of its size and form, it is the most dominant unit in the complex at the current levels of exposure. During the intrusion of the iron-rich augite syenite, the ocellar basalt, fine-grained gabbro and recrystallized amphibole quartz syenite acted as a cap rock. Crystallization of the iron-rich augite syenite inward from the margins resulted in mineralogical and compositional variations across the unit.

The basal contact of the iron-rich augite syenite dips approximately 30° inward and is in contact with gabbro. The presence of gabbro underlying the iron-rich augite syenite is clearly demonstrated by the topographical control of the gabbro-syenite contact and the occurrence of gabbros in topographical lows within the iron-rich augite syenite unit. Texturally and mineralogically, the lower part of the syenite, within 100 meters of the contact, is typified by black to olive brown layered syenite with abundant rounded anhedral fayalite, iron-rich augite, magnetite and perthitic feldspar. The layers are planar, rhythmic, up to 1 m wide, dip 25° to 45° toward the center of the complex, and grade from thin (<30 cm) melanocratic bases to mesocratic tops. Fine- to medium-grained, red to black, feldspar-phyric iron-rich augite syenite with variable proportions of amphibole occurs as inclusions from a few cm up to over 100 meters in size within the layered iron-rich augite syenite

The middle part of the iron-rich augite syenite which makes up the

majority of the intrusion, contains iridescent tabular to lath-shaped feldspars with cryptoperthitic intergrowths and up to 30 % interstitial iron-rich augite. Increasing amounts of fayalite, amphibole, aenigmatite, and rare quartz occur toward the top of the unit and in pegmatitic patches throughout. The occurrence of aenigmatite as a late stage crystallizing phase demonstrates that the iron-rich augite syenite becomes peralkaline with crystallization. Layering within the middle of the unit is rhythmic to chaotic and controlled by the relative proportion of interstitial iron-augite to feldspar.

The upper part of the syenite is marked by modal amphibole greater than iron-rich augite and/or the occurrence of feldspar-phyric amphibole-iron-rich augite syenite. On the east side of the complex, it can be determined that these two rock types occur within 200 m of the top of the upper contact of the syenite unit. The amphibole-iron-rich augite syenite is medium-grained, red, mesocratic with amphibole and iron-rich augite interstitial to perthitic feldspar. The feldspar-phyric amphibole-iron-rich augite syenite is medium-grained, red, mesocratic, with a groundmass of intergrown amphibole, iron-rich augite, and feldspar. The feldspar-phyric amphibole-iron-rich augite syenite typically occurs closer to the contact than the non-porphyrific syenite.

The amphibole syenite (Unit 11) intruded along the top of the iron-rich augite syenite, and into the roof pendant mafic volcanics, fine-grained gabbro, monzodiorite, and recrystallized amphibole quartz syenite. The intrusion of amphibole syenite into these units was accompanied by extensive assimilation and brecciation of the host rocks and the formation of rare metal-bearing pegmatites. The pegmatites occur

along vertical and sub-horizontal fractures within the roof pendant rocks and at the contact between the amphibole syenite and the iron-rich augite syenite.

The amphibole syenite unit can be divided into three texturally and mineralogically distinct rock types: 1/ aphanitic to medium-grained, feldspar-porphyritic amphibole syenite; 2/ medium-grained amphibole syenite with columnar feldspar; and 3/ medium- to coarse-grained, quartz-amphibole syenite. The first two types are intermingled and differ as a function of rates of cooling. The quartz-amphibole syenite occurs north of Bamooos Lake surrounded and apparently underlain by iron-rich augite syenite and overlain by fine-grained gabbro.

The pegmatites that occur in Units 10 and 11 range from small irregular shaped patches, to well-developed dikes with sharp contacts, up to 4 m wide. Acicular amphibole is commonly oriented perpendicular to the contact of the pegmatite and is intergrown with feldspar. Feldspar is the most common mineral, occurring as grains up to 25 cm long and 5 cm wide. The grain size within the pegmatites often varies from medium-grained to very coarse-grained. Although quartz is present in crystals up to 8 cm, it is not an abundant mineral in most of the pegmatites. The quartz-bearing pegmatites host Nb, Y, Zr and Rare Earth element mineralization.

Monzodiorite dikes (Unit 12) cut the gabbro, amphibole syenite and iron-rich augite syenite. The dikes are 1 to 5 m wide with sharp near vertical contacts. The dikes weather down and occur in lineaments up to 2 km long. They are medium-grained, pinkish black, and sub-ophitic with amphibole, clinopyroxene, and plagioclase rimmed by potassic feldspar.

The undersaturated syenites within the Coldwell Alkalic Complex are divided into two separate units, amphibole nepheline syenite and amphibole natrolite-nepheline syenite which outcrop primarily as two large contiguous areas centered over Pic Island and between Little Pic River and Red Sucker Cove. Both units consist of texturally variable rocks with sharp to gradational contacts. The amphibole nepheline syenite is the oldest and least variable of the two. Topographic relief within the complex indicate that the amphibole nepheline syenite is underlain by amphibole natrolite-nepheline syenite. Both the amphibole nepheline and amphibole natrolite-nepheline syenite intruded between the iron-rich augite and amphibole syenites and mafic volcanics and recrystallized quartz amphibole syenite.

The amphibole nepheline syenite (Unit 13) is white to red, mesocratic to leucocratic, medium-grained with variable proportions of feldspar, nepheline, amphibole, biotite, apatite and zeolites. Locally the nepheline syenite is well-layered with melanocratic olivine nepheline syenite grading into mesocratic syenite. Spectacular orbicular layering occurs on the south shore of Pic Island. An intergranular texture resulting from intergrown feldspar, amphibole, and nepheline is typical of the unit. Near lineaments and lithological contacts the amphibole nepheline syenite becomes red. Texturally different varieties of amphibole nepheline syenite occur near the contacts and include mesocratic nepheline-amphibole syenite with near-equant euhedral-amphibole prisms and mesocratic amphibole nepheline syenite with interstitial amphibole and euhedral columnar feldspar.

The amphibole natrolite-nepheline syenite (Unit 14) is an extremely

variable rock unit that intrudes the roof pendant mafic volcanics, gabbro, iron-rich augite syenite, amphibole syenite, and amphibole nepheline syenite. The main rock type within this unit is a gray to pink, mesocratic, amphibole natrolite-nepheline syenite with variable amounts of natrolite, lath feldspar and acicular amphibole. The textural complexities of the amphibole natrolite-nepheline syenite is considered to be a product of assimilation and mixing of a variety of rock compositions in a solid, semi-molten or molten state and synplutonic intrusion of the alkaline gabbro.

Pegmatitic amphibole natrolite-nepheline syenite host a diverse suite of minerals and textures. A common characteristic is the occurrence of natrolite that usually consists of 10 to 40 % of the pegmatite. Feldspars and amphibole are very coarse-grained, up to 20 cm long and 10 cm wide and range in texture from near-equant to acicular. A large natrolite pegmatite, almost 2 km long and 200 m wide, occurs along Highway 17, west of Little Pic River where it cuts gabbro. Typically, pegmatites are less than 10 m wide and less than 50 m long.

Prior to the present study, there had been no previous rare metal occurrences documented to occur in the amphibole-natrolite syenite. Elements concentrated in the natrolite pegmatites are similar to those in the quartz-bearing pegmatites, predominantly Nb, Zr and Rare Earths.

The amphibole quartz syenite (Unit 15) outcrops between Red Sucker Cove and the western contact of the complex and represents the final intrusion of syenite magmatism within the Coldwell Alkalic Complex. It appears to be a sheet-like intrusion which thickens to the west. Stratigraphically, the amphibole quartz syenite occurs below the

amphibole, amphibole nepheline, and amphibole natrolite-nepheline syenites and is at a similar level to the iron-rich augite syenite.

Near the contacts, the amphibole quartz syenite is associated with synplutonic mafic dikes and extensive brecciation and assimilation of the overlying host rocks. Contacts between the amphibole quartz syenite and the xenoliths are angular to very delicate serrated outlines and range in size from less than 1 m to over 1 km. The amphibole quartz syenite consists of dikes of an older fine-grained, pink to mauve feldspar-phyric amphibole quartz syenite and younger medium-grained olive-brown to pink, mesocratic to leucocratic amphibole quartz syenite.

A younger medium-grained, mesocratic, amphibole quartz syenite with intergrown feldspar, amphibole and quartz intrudes the fine-grained feldspar-phyric amphibole quartz syenite on Pic Island and west of Coubran Lake. Based on the greater modal abundance of quartz, amphibole with higher alkali content, and higher concentrations of rare metals, the younger amphibole quartz syenite appears to be the most evolved phase of the amphibole quartz syenite unit.

The central part of the amphibole quartz syenite is coarser-grained, more massive, and is not associated with breccia zones. The coarse-grained amphibole quartz syenite has poorly aligned tabular-feldspar phenocrysts up to 3 cm long, interstitial amphibole, and quartz blebs. Typically the trachytic texture strikes between 3° and 49°, and dips up to 45° to the south. Pegmatitic patches in this unit are present but rare.

Lamprophyre dikes (Unit 16) ranging in size from 10 cm to 3 m wide, are observed throughout the complex. The most common type of lamprophyre

is fine-grained, black to green with calcite, and locally quartz ocelli. Other types of lamprophyre were distinguished based on the presence of olivine, clinopyroxene or biotite phenocrysts. The lamprophyres are seen cutting all the rock units, and appear to be less abundant east of Red Sucker Cove. Black, olivine-porphyrific lamprophyre appears to be associated with the intrusion of amphibole natrolite-nepheline syenite into amphibole nepheline syenite. Results of detailed mineralogical and chemical investigations of lamprophyres in the Coldwell Alkalic Complex were recently reported by Mitchell et al (1991).

Three diatremes occur within Coldwell Alkalic Complex. The largest of these is the Neys diatreme which has been mapped by Balint (1977) and Sage (1982). This diatreme occurs on the west side of the Coldwell Peninsula. It is elliptical in shape and has sharp contacts with the host nepheline syenite. The breccia consists of rounded clasts of gabbro, syenite, nepheline syenite, amphibolite in communitated matrix (Sage 1982). The other two diatremes are smaller and were discovered during the present study. The first is located on Highway 17 northwest of Neys Lake and the other occurs on the west side of Red Sucker Cove. Both diatremes are small (few 10's of square m) and consist of angular, brecciated rock fragments in a hematized matrix. Fluorite mineralization is associated with the diatreme along Highway 17 and carbonated mineralization is associated with diatreme in Red Sucker Cove.

Emplacement of the Coldwell Alkalic Complex

Magmatism within the Coldwell Alkalic Complex occurred within three centers, referred to as Center 1, 2 and 3 by Mitchell and Platt (1977,

1978). Volcanic xenoliths, miarolitic cavities and porphyritic rock types with a fine-grained matrix occur at the present erosional level, indicating that the magmas forming each of the Centers was emplaced at low pressure. In such an environment, processes such as, caldera subsidence, ring dike emplacement and stoping are important structural processes controlling the emplacement of magma.

The extrusion and preservation of the basaltic xenoliths may have been controlled by the process of caldera collapse. During the collapse, the tholeiitic to subalkaline gabbroic rocks were intruded as ring dikes and probably occur beneath the syenites of the complex. Caldera collapse and ring dike intrusion may also be the process controlling the intrusion of the alkaline gabbro and amphibole natrolite-nepheline syenite. These latter units define the outer margin of Center 2 magmatism, and are coincident with the Red Sucker Cove and Little Pic River lineaments. Ring dikes do not appear to be related to the intrusion of Center 3.

Large and small scale block faulting caused by the stoping of roof rocks into intrusive magma from each Center, has resulted in extensive assimilation of the roof rocks and hybridization of the magmas near the roof. This process is important in the intrusion of Center 1 feldspar-porphyritic syenite into the basaltic xenoliths, and the intrusion of the Center 3 amphibole quartz syenite into both the Center 1 and 2. It appears that the present erosional level corresponds to the top of Center 3 in the west and the top of Center 1 in the east.

ECONOMIC GEOLOGY

Base and Precious Metal Mineralization.

Base and precious metal mineralization in the Eastern Gabbro is generally located near the contact of the gabbro with Archean rocks. The Dunlop copper occurrence is exposed in the Eastern Gabbro along Highway 17 approximately 100 m from the contact of the Eastern Gabbro with Archean metavolcanic and metasedimentary rocks. The occurrence is within massive gabbro which contains numerous xenoliths of Archean rocks and rheomorphic breccia. The gabbro is coarse-grained with plagioclase, clinopyroxene, olivine, magnetite, biotite and traces of apatite and up to 5 % chalcopyrite. The intersection of sulphide-rich inclusions in drill core by Noranda Exploration Limited indicates that assimilation of sulphur-rich Archean rocks is a viable mechanism for generating the mineralization.

The Marathon Cu-PGE occurrence of Fleck Resources Limited is located south of Bamooos Lake in the Two Duck Lake area within gabbroic rocks close to the east contact of the gabbro with Archean metavolcanic rocks. Cu-PGE mineralization is associated with chalcopyrite, cubanite, pyrrhotite, pentlandite and pyrite in the coarse-grained Two Duck Lake Gabbro (Good and Crocket 1989, 1990). PGE's are associated with the copper-rich sulphides in the gabbro (Ohnenstetter et al. 1989). Sulphides are commonly associated with biotite and lesser amphibole and chlorite in the Two Duck gabbro (Good and Crocket 1989, 1990). Sulphides also occur interstitial to fresh anhydrous silicates. The close association of mineralization with gabbro near the contact with

Archean rocks suggests that mineralization may be related to assimilation of Archean sulphide-bearing rocks (Watkinson et al. 1983).

Base and precious metal mineralization also occurs associated with pegmatitic gabbro south of Geordie Lake, within the central part of the complex. Mineralization at Geordie Lake is distinct from the Eastern Gabbro in that the former contains high Pd/Pt ratios (Pd/Pt = 19), and tellurides (Mulja and Mitchell 1991), and is in contact with the recrystallized amphibole quartz syenite rather than Archean rocks.

The Middleton Cu occurrence is a chalcopyrite rich zone with up to 0.73 % Cu, hosted in the Western Gabbro. The mineralization occurs in a medium-grained gabbro located near the contact of the Western Gabbro with Archean rocks. Unlike the Geordie Lake and Eastern Gabbro occurrences, the pegmatitic gabbro in the Western Gabbro does not have any base or precious metal mineralization and the main sulphide zone does not have any significant Pt or Pd mineralization.

A 1 m wide quartz vein with sphalerite and galena was discovered during the mapping. It is hosted in the alkaline gabbro, located along the Lake Superior shore line at Lone Pine Point, south of Port Coldwell. The mineralization consists of massive sphalerite and galena as veinlets within a north northwest striking fine-grained granular milky white quartz vein. A grab sample assayed 10.4 % Zn and 1.55 % Pb.

Rare Metals

The rare metal occurrences of the Coldwell Alkalic Complex are divided into 4 types: 1) Nb, Zr, RE pegmatites; 2) RE, Th pegmatites; 3) Nb, Zr, RE quartz-absent pegmatites and 4) RE phosphate-bearing

amphibole quartz syenite. Nb, Zr, Rare Earth pegmatites are located in and around the mafic volcanic xenoliths, and associated with the intrusion of the amphibole syenite (Unit 11). Rare metal mineralization is in the form of pyrochlore, columbite, bastnaesite and synchysite. The pyrochlore and columbite occur with quartz and zircon after the crystallization of perthite and aegirine. Rare earth elements are associated with a late-stage carbonate phase that crystallized bastnaesite and synchysite with pyrochlore.

Rare Earth-Th mineralized pegmatites intrude the Eastern Gabbro (Unit 7), along Highway 17. Typically it consists of green feldspar, quartz, carbonate, fluorite, galena and graphic feldspar. Rare Earth elements occur in bastnaesite and synchysite, and Th occurs in Thorite. This occurrence and 2 other less mineralized pegmatites near the Marathon Cu-PGE Deposit, were located using airborne radiometric data (Hentu and Ford 1990).

Nb, Zr, Rare Earth quartz-absent pegmatites are hosted in amphibole nepheline syenite (Unit 13) and may be associated with the intrusion of the amphibole natrolite-nepheline syenite (Unit 14). Rare metal-hosting minerals in these pegmatites are pyrochlore, bastnaesite and synchysite. Unlike the other two types of rare metal mineralization, these pegmatites may have a horizontal distribution related to the amphibole nepheline syenite instead of being controlled by vertical structures in overlying cap-rocks.

The fourth type of rare metal mineralization is hosted in massive fine- to medium-grained amphibole quartz syenite (Unit 15) located northeast of Geordie Lake. The analyses of rare metals from the

occurrence are not as high as the other types of pegmatites, however, this rock type has a much greater aerial distribution than the pegmatites. The rare metals are hosted in rare earth phosphates which crystallize after quartz and sodium-rich amphibole. Rare metal mineralization in pegmatites up to 1 m wide and 75 m long hosted in the amphibole quartz syenite are slightly higher than the host rock.

The majority of the rare metal occurrences are in pegmatites that are associated with the intrusion of amphibole syenite (Unit 11) between the iron-rich augite syenite (Unit 10) and the mafic volcanic roof pendant (Unit 5). The accumulation of pegmatitic fluids within cupolas at the base of the roof pendant are considered to have high potential for a rare metal ore body in the complex.

Building Stone and Industrial Minerals

Easily accessible syenite rocks with a variety of textures and colors may be suitable for small scale building stone projects in several of the rock units. Areas adjacent to Highway 17 and the Canadian Pacific Railroad were observed during mapping to have consistent texture and color with limited fracturing.

Based on the results from the present study, significant modal nepheline occurs in the amphibole nepheline syenite (Unit 13) and the amphibole natrolite-nepheline syenite (Unit 14). The amphibole natrolite-nepheline syenite is not considered to be a good source of nepheline owing to the degree of zeolitization commonly found in the rock and heterogeneous character of this unit. The nepheline in the amphibole nepheline syenite is also zeolitized but to a lesser degree

than the amphibole natrolite-nepheline syenite. The amphibole nepheline syenite along topographical highs on Pic Island and north of Highway 17 could be investigated for economic grade nepheline.

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**CONVERSION FACTORS FOR MEASUREMENTS IN ONTARIO
GEOLOGICAL SURVEY PUBLICATIONS**

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

OTHER USEFUL CONVERSION FACTORS

	<i>Multiplied by</i>	
1 ounce (troy) per ton (short)	20.0	pennyweights per ton (short)
1 pennyweight per ton (short)	0.05	ounces (troy) per ton (short)

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

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LEGEND

PHANEROZOIC
CENOZOIC
QUATERNARY
PLEISTOCENE AND RECENT
Fluvial silt and sand, and fill
unconformity

PRECAMBRIAN
PROTEROZOIC
MESOPROTEROZOIC (0.9 to 1.6 Ga)
COLDWELL ALKALIC COMPLEX* (1.1 Ga)

16 Lamprophyre Dikes
16a Pyroxene-phryc lamprophyre
16b Amphibole-phryc lamprophyre
16c Biotite-phryc lamprophyre
16d Lamprophyre dikes with monzonitic cavities
16e Lamprophyre with feldspar xenocrysts
16f Lamprophyre with quartz xenocrysts
16g Olivine-phryc lamprophyre

15 Amphibole Quartz Syenite
15a Quartz syenite (amphibole < 10%)
15b Amphibole quartz syenite
15c Fine-grained amphibole quartz syenite
15d Coarse-grained amphibole quartz syenite
15e Fayalite amphibole quartz syenite
15f Feldspar-phryc quartz syenite
15g Dikes of amphibole quartz syenite
15h Amphibole quartz syenite with pegmatitic patches and veins
15i Layered amphibole quartz syenite

14 Amphibole Natriolite-Nepheline Syenite
14a Amphibole natriolite-nepheline syenite
14b Fine to medium-grained amphibole natriolite-nepheline syenite
14c Feldspar-phryc amphibole natriolite-nepheline syenite
14d Amphibole natriolite-nepheline syenite pegmatites
14e Amphibole natriolite-nepheline syenite with biotite inclusions
14f Dikes of amphibole natriolite-nepheline syenite
14g Layered amphibole natriolite-nepheline syenite
14h Natriolite-nepheline syenite with pegmatitic patches and veins
14i Amphibole natriolite-nepheline syenite with near-equant amphibole

13 Nepheline Syenite
13a Amphibole nepheline syenite
13b Biotite amphibole nepheline syenite
13c Biotite amphibole syenite (nepheline < 10%)
13d Fayalite amphibole nepheline syenite
13e Layered amphibole nepheline syenite
13f Nepheline syenite with pegmatitic patches and veins
13g Amphibole nepheline syenite with near-equant amphibole
13h Nepheline syenite (amphibole < 10%)
13i Feldspar-phryc nepheline syenite

12 Monzonitic Dikes
11 Amphibole Syenite
11a Amphibole syenite
11b Fine-grained amphibole syenite
11c Amphibole-quartz syenite pegmatites
11d Feldspar-phryc amphibole syenite
11e Dikes of amphibole syenite
11f Amphibole syenite with quartz
11g Amphibole syenite with pegmatitic patches and veins
11h Amphibole syenite with biotite

10 Iron-Rich Augite Syenite
10a Augite syenite
10b Fayalite augite syenite
10c Layered augite syenite
10d Augite syenite with pegmatitic patches and veins
10e Augite syenite with quartz
10f Feldspar-phryc augite syenite
10g Augite syenite with quartz
10h Amphibole syenite with quartz
10i Amphibole syenite with pegmatitic patches and veins

9 Recrystallized Amphibole Quartz Syenite
9a Recrystallized amphibole quartz syenite
9b Feldspar-phryc recrystallized amphibole quartz syenite
9c Fine-grained alkali feldspar granite
9d Recrystallized amphibole quartz syenite pegmatitic patches and veins

8 Alkali-rich Gabbro
8a Gabbro
8b Biotite gabbro
8c Olivine gabbro
8d Biotite olivine gabbro
8e Enclave-rich biotite-olivine gabbro
8f Fine-grained gabbro
8g Olivine megacryst gabbro
8h Weirite
8i Olivine-phryc gabbroic rocks
8j Layered gabbroic rocks
8k Coarse-grained to pegmatitic gabbro

7 Gabbro*
7a Fine-grained gabbro
7b Medium-grained gabbro
7c Coarse-grained gabbro
7d Coarse-grained gabbro with pegmatitic patches
7e Feldspar-phryc gabbro
7f Leucogabbro (Cl 10 to 35)
7g Monzonitic quartz diorite, quartz monzonite
7h Layered gabbroic rocks
7i Anorthitic inclusions
7j Gabbro with ocean
7k Gabbro with ocean

6 Rheomorphic Breccia
5 Mafic Volcanic, Subvolcanic and Hypabyssal Intrusive Rocks
5a Ocellar basalt
5b Fine-grained to aphanitic basalt
5c Fragmental tuff
5d Diabase
5e Feldspar-phryc mafic rocks
5f Layered mafic rocks
5g Pyroxene-phryc phenocrysts mafic rocks

4 FELSIC TO INTERMEDIATE PLUTONIC ROCKS
3 Metasediments
3a Argillite
3b Biotite schist
3c Mica
3d Conglomerate

2 Intermediate to Felsic Metavolcanic Rocks
2a Flows
2b Pyroclastics

1 Mafic Metavolcanic Rocks
1a Flows
1b Pyroclastics

ABBREVIATIONS
am amethyst; Pb lead
carb carbonate; PGE platinum group elements
cp calcopryrite
cu copper; py pyrite
Fe iron; RE rare earths
gr garnet; flu fluorite
gn gneiss; gal galena; Ti titanium
mag magnetite; V vanadium
Nb niobium; Zr zirconium
ne nepheline; Zr zirconium

LIST OF MINERAL OCCURRENCES
1. Cold Spring Granite Company (building stone)
2. Doss Mine-Creek Balmite
3. Denison Mines Limited
4. Dunlop W.B.
5. Ferguson
6. Madras Cu-PGE Occurrence
7. Marathon Cu-PGE Deposit
8. Marathon Niobium Occurrence
9. Middleton Cu Occurrence
10. Peace Development Limited
11. Port Munro Nb,Zr,RE Occurrence
12. Renshaw-Tipp Fe-Ti Occurrence
13. Willie Lake Cu-PGE Occurrence

SOURCES OF INFORMATION
Base derived from Ministry of Natural Resources O.M. maps 5200, 5300, 5400, 5500, 5600, 5700, 5800, 5900, 6000, 6100, 6200, 6300, 6400, 6500, 6600, 6700, 6800, 6900, 7000, 7100, 7200, 7300, 7400, 7500, 7600, 7700, 7800, 7900, 8000, 8100, 8200, 8300, 8400, 8500, 8600, 8700, 8800, 8900, 9000, 9100, 9200, 9300, 9400, 9500, 9600, 9700, 9800, 9900, 10000, 10100, 10200, 10300, 10400, 10500, 10600, 10700, 10800, 10900, 11000, 11100, 11200, 11300, 11400, 11500, 11600, 11700, 11800, 11900, 12000, 12100, 12200, 12300, 12400, 12500, 12600, 12700, 12800, 12900, 13000, 13100, 13200, 13300, 13400, 13500, 13600, 13700, 13800, 13900, 14000, 14100, 14200, 14300, 14400, 14500, 14600, 14700, 14800, 14900, 15000, 15100, 15200, 15300, 15400, 15500, 15600, 15700, 15800, 15900, 16000, 16100, 16200, 16300, 16400, 16500, 16600, 16700, 16800, 16900, 17000, 17100, 17200, 17300, 17400, 17500, 17600, 17700, 17800, 17900, 18000, 18100, 18200, 18300, 18400, 18500, 18600, 18700, 18800, 18900, 19000, 19100, 19200, 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33600, 33700, 33800, 33900, 34000, 34100, 34200, 34300, 34400, 34500, 34600, 34700, 34800, 34900, 35000, 35100, 35200, 35300, 35400, 35500, 35600, 35700, 35800, 35900, 36000, 36100, 36200, 36300, 36400, 36500, 36600, 36700, 36800, 36900, 37000, 37100, 37200, 37300, 37400, 37500, 37600, 37700, 37800, 37900, 38000, 38100, 38200, 38300, 38400, 38500, 38600, 38700, 38800, 38900, 39000, 39100, 39200, 39300, 39400, 39500, 39600, 39700, 39800, 39900, 40000, 40100, 40200, 40300, 40400, 40500, 40600, 40700, 40800, 40900, 41000, 41100, 41200, 41300, 41400, 41500, 41600, 41700, 41800, 41900, 42000, 42100, 42200, 42300, 42400, 42500, 42600, 42700, 42800, 42900, 43000, 43100, 43200, 43300, 43400, 43500, 43600, 43700, 43800, 43900, 44000, 44100, 44200, 44300, 44400, 44500, 44600, 44700, 44800, 44900, 45000, 45100, 45200, 45300, 45400, 45500, 45600, 45700, 45800, 45900, 46000, 46100, 46200, 46300, 46400, 46500, 46600, 46700, 46800, 46900, 47000, 47100, 47200, 47300, 47400, 47500, 47600, 47700, 47800, 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129400, 129500, 129600, 129700, 129800, 129900, 130000, 130100, 130200, 130300, 130400, 130500, 130600, 130700, 130800, 130900, 131000, 131100, 131200, 131300, 131400, 131500, 131600, 131700, 131800, 131900, 132000, 132100, 132200, 132300, 132400, 132500, 132600, 132700, 132800, 132900, 133000, 133100, 133200, 133300, 133400, 133500, 133600, 133700, 133800, 133900, 134000, 134100, 134200, 134300, 134400, 134500, 134600, 134700, 134800, 134900, 135000, 135100, 135200, 135300, 135400, 135500, 135600, 135700, 135800, 135900, 1360

Mines and Minerals Division
Ontario Geological Survey
Map P3233
Precambrian Geology
PORT COLDWELL COMPLEX
EAST HALF

Scale 1:20 000
100 m 0 100
NTS References: 43 D/1, 42 D/10, 42 D/15, 42 D/16
Queen's Printer for Ontario, 1993
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LEGEND
PHANEROZOIC
CENOZOIC
QUATERNARY
PLEISTOCENE AND RECENT
Fluvial silt and sand, and till
UNCONFORMITY
PRECAMBRIAN
PROTEROZOIC
MESOPROTEROZOIC (0.9 to 1.6 Ga)
COLDWELL ALKALIC COMPLEX* (1.1 Ga)

- 16 Lamprophyre Dikes
 - 16a Pyroxene-phyric lamprophyre
 - 16b Amphibole-phyric lamprophyre
 - 16c Basaltic-phyric lamprophyre
 - 16d Lamprophyre dikes with mafic enclaves
 - 16e Lamprophyre with feldspar xenocrysts
 - 16f Lamprophyre with quartz xenocrysts
 - 16g Olivine-phyric lamprophyre
- 15 Amphibole Quartz Syenite
 - 15a Quartz syenite (amphibole < 10%)
 - 15b Amphibole quartz syenite
 - 15c Fine-grained amphibole quartz syenite
 - 15d Coarse-grained amphibole quartz syenite
 - 15e Fayalite-amphibole quartz syenite
 - 15f Felspar-phyric quartz syenite
 - 15g Dikes of amphibole quartz syenite
 - 15h Amphibole quartz syenite with pegmatitic patches and veins
 - 15i Layered amphibole quartz syenite
- 14 Amphibole Natriolite-Nepheline Syenite
 - 14a Amphibole natriolite-nepheline syenite
 - 14b Fine- to medium-grained amphibole natriolite-nepheline syenite
 - 14c Felspar-phyric amphibole natriolite-nepheline syenite
 - 14d Amphibole natriolite-nepheline syenite pegmatites
 - 14e Amphibole natriolite-nepheline syenite with biotite ovoids
 - 14f Dikes of amphibole natriolite-nepheline syenite
 - 14g Layered amphibole natriolite-nepheline syenite
 - 14h Natriolite-nepheline syenite with pegmatitic patches and veins
 - 14i Amphibole natriolite-nepheline syenite with near-equant amphibole
- 13 Nepheline Syenite
 - 13a Amphibole nepheline syenite
 - 13b Biotite amphibole nepheline syenite
 - 13c Biotite-amphibole nepheline syenite (< 10%)
 - 13d Fayalite amphibole nepheline syenite
 - 13e Layered amphibole nepheline syenite
 - 13f Nepheline syenite with pegmatitic patches and veins
 - 13g Amphibole nepheline syenite with near-equant amphibole
 - 13h Nepheline syenite (amphibole < 10%)
 - 13i Felspar-phyric nepheline syenite
- 12 Monzonite Dikes
 - 12a Amphibole syenite
 - 12b Fine-grained amphibole syenite
 - 12c Amphibole-quartz syenite pegmatites
 - 12d Felspar-phyric amphibole syenite
 - 12e Dikes of amphibole syenite
 - 12f Amphibole syenite with quartz
 - 12g Amphibole syenite with pegmatitic patches and veins
 - 12h Amphibole syenite with biotite
 - 12i Amphibole syenite with ovoids
- 10 Iron-Rich Augite Syenite
 - 10a Augite syenite
 - 10b Fayalite augite syenite
 - 10c Layered augite syenite
 - 10d Augite syenite with pegmatitic patches and veins
 - 10e Augite syenite with quartz
 - 10f Augite syenite pegmatites
 - 10g Felspar-phyric augite syenite
 - 10h Augite syenite with biotite
- 9 Recrystallized Amphibole Quartz Syenite
 - 9a Recrystallized amphibole quartz syenite
 - 9b Felspar-phyric recrystallized amphibole quartz syenite
 - 9c Fine-grained alkali feldspar granite
 - 9d Recrystallized amphibole quartz syenite pegmatitic patches and veins
- 8 Alkaline Gabbro
 - 8a Gabbro
 - 8b Biotite gabbro
 - 8c Olivine gabbro
 - 8d Biotite-olivine gabbro
 - 8e Enclave-rich biotite-olivine gabbro
 - 8f Fine-grained gabbro
 - 8g Olivine melagabbro
 - 8h Wehrite
 - 8i Olivine-phyric gabbroic rocks
 - 8j Layered gabbroic rocks
 - 8k Coarse-grained to pegmatitic gabbro
- 7 Gabbro*
 - 7a Fine-grained gabbro
 - 7b Medium-grained gabbro
 - 7c Coarse-grained gabbro
 - 7d Coarse-grained gabbro with pegmatitic patches
 - 7e Felspar-phyric gabbro
 - 7f Leucogabbro (Cl 10 to 35)
 - 7g Monzonitic quartz diorite-quartz monzonite
 - 7h Layered gabbroic rocks
 - 7i Anorthosite inclusions
 - 7j Gabbro with rock
- 6 Rheomorphic Breccia
 - 6a Breccia
- 5 Mafic Volcanic, Subvolcanic and Hypabyssal Intrusive Rocks
 - 5a Oceanic basalt
 - 5b Fine-grained to aphanitic basalt
 - 5c Fragmental basalt
 - 5d Dabasse
 - 5e Felspar-phyric mafic rocks
 - 5f Layered mafic rocks
 - 5g Pyroxene-phyric phenocrysts mafic rocks

ARCHEAN
FELSIC TO INTERMEDIATE PLUTONIC ROCKS

- 4 Massive to Foliated Granitoid Rocks
 - 4a Foliated tonalite, granodiorite
 - 4b Quartz-monzonite gneiss
 - 4c Granodiorite granite
- 3 Metasediments
 - 3a Argillite
 - 3b Biotite schist
 - 3c Wacke
 - 3d Conglomerate
- 2 Intermediate to Felsic Metavolcanic Rocks
 - 2a Flows
 - 2b Pyroclastics
- 1 Mafic Metavolcanic Rocks
 - 1a Flows
 - 1b Pyroclastics

*Plutonic rock classification based on the IUGS Subcommission on the Systematics of Igneous Rocks (Steinmetz, 1986).
Rocks in this category are generally coarse grained and may contain quartz, biotite and amphibole, but do not contain feldspar.
Olivine-rich gabbro is used here to refer to gabbro with quartz, biotite and pyroxene.
Gabbro is considered alkaline on the presence of minor Na-feldspar inclusions.
Compositions from this gabbro are similar to those of the Coldwell Complex.
*Felsic compositions in the Eastern Gabbro range from feldspathic to oligoclase, therefore the rocks range from gabbroic to anorthositic to dioritic.

ABBREVIATIONS

- | | | | |
|------|---------------|-----|-------------------------|
| am | amethyst | Pt | platinum group elements |
| carb | carbonate | PGE | platinum group elements |
| cp | chalcophylite | py | pyrite |
| Cu | copper | RE | rare earth elements |
| Fe | iron | Th | thorium |
| fl | fluorite | U | uranium |
| gn | gneiss | Ti | titanium |
| gr | granite | V | vanadium |
| mag | magnetite | Zn | zinc |
| Nb | nibidium | Zr | zirconium |
| ne | nepheline | | |

LIST OF MINERAL OCCURRENCES

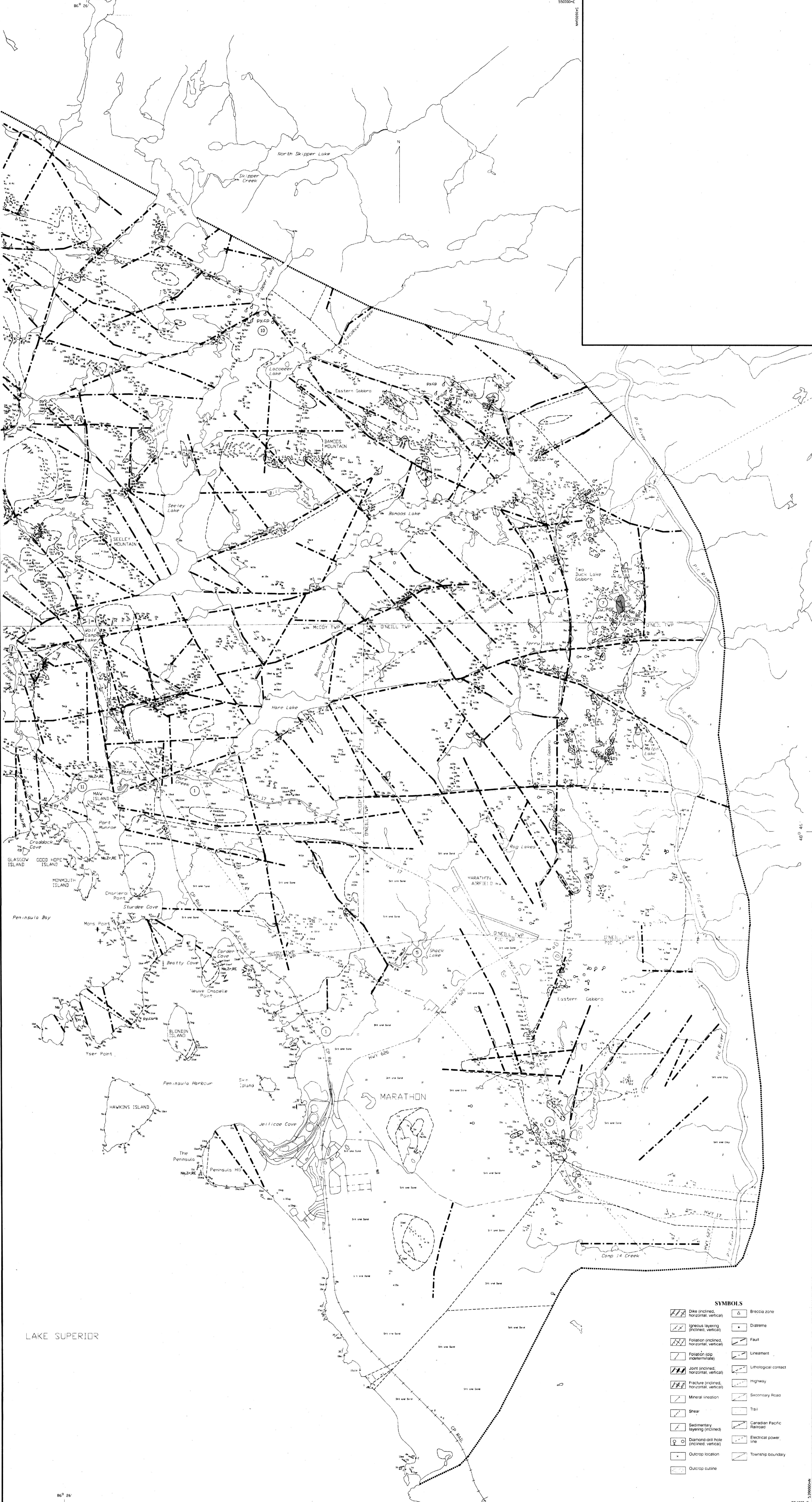
1. Cold Spring Granite Company (building stone)
2. Dead Horse Creek Damme
3. Danson Mines Limited
4. Dunlop W.B.
5. Ferguson, J.
6. MacRae Cu-PGE Occurrence
7. Marathon Cu-PGE Deposit
8. Marathon Niobium Occurrence
9. Middleton Cu Occurrence
10. Placer Development Limited
11. Port Morris Ni-Zn-PGE Occurrence
12. Renshaw-Tipp Fe-Ti Occurrence
13. Willie Lake Cu-PGE Occurrence

SOURCES OF INFORMATION

Base derived from Ministry of Natural Resources OBM maps 5200 5300, 5200 5400, 5200 5410, 5300 5300, 5300 5400, 5300 5410, 5400 5300, 5400 5400, 5400 5410, 5500 5300, 5500 5400, 5500 5410, 5500 5300, 5500 5400, 5500 5410, 5500 5300, and 5500 5400 were digitized by the authors.
Magnetic declination approximately 3' 08" west in 1991.
Geology is not surveyed lines.

CREDITS

Geology by E.C. Walker, R.H. Sutcliffe, C.S.J. Shaw, G.T. Shore and R.S. Penczak, 1991 and 1992.
To enable the rapid dissemination of information, this map is credited. Discrepancies may occur for which the Ontario Geological Survey does not assume liability. Users should verify critical information.
Issued 1993.
Information from this publication may be quoted if credit is given. It is recommended that reference to this map be made in the following form:
Walker, E.C., Sutcliffe, R.H., Shaw, C.S.J., Shore, G.T. and Penczak, R.S., 1993. Precambrian geology, Port Coldwell Complex, east half, Ontario Geological Survey, Preliminary Map P3233, scale 1:20 000.



- SYMBOLS**
- Dike (inclined, horizontal, vertical)
 - Igneous layering (inclined, vertical)
 - Foliation (inclined, horizontal, vertical)
 - Foliation (up, indeterminate)
 - Joint (inclined, horizontal, vertical)
 - Fracture (inclined, horizontal, vertical)
 - Mineral in-situ
 - Shear
 - Sedimentary layering (inclined)
 - Diamond drill hole (inclined, vertical)
 - Outcrop location
 - Outcrop outline
 - Breccia zone
 - Dateme
 - Fault
 - Lineament
 - Lithological contact
 - Highway
 - Secondary Road
 - Trail
 - Canadian Pacific Railroad
 - Electrical power, line
 - Township boundary