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Ontario

Ministry of
Northern Development
and Mines

Ontario Geological Survey
Open File Report 5859

Geology of Oliver Township, District of Thunder Bay

1993

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ONTARIO GEOLOGICAL SURVEY

Open File Report 5859

Geology of Oliver Township, District of Thunder Bay

By

G.H. Brown

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Foreword

The present investigation is part of a two-year detailed mapping project of Oliver and Ware townships. District of Thunder Bay. The objective of the mapping is to describe the geology of the two townships and to assess their mineral potential.

The project is part of a five-year Canada-Ontario 1991 Northern Ontario Development Agreement, a subsidiary agreement to the Economic and Regional Development Agreement (ERDA) signed and funded by the governments of Canada and Ontario.

Oliver Township is underlain by Archean supracrustal and felsic and minor mafic intrusive rocks and Proterozoic sedimentary rocks of the Animikie Group. Minor sulphide mineralization and quartz-carbonate veins occur in the township. The veins have been prospected for silver, copper, gold and amethyst.

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Critical reader: G.Johns, A/Subsection Manager. Approved for publication by B.Dressier, Section Chief, Precambrian Geoscience Section and A/Director, Geoscience Branch, Ontarion Geological Survey; May 11, 1993

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ABSTRACT

Archean rocks of the Superior Province underlie the northern half of Oliver Township; Proterozoic rocks of the Southern Province underlie the southern half of the township. A major unconformity separates the rocks of these two provinces.

Mafic to intermediate metavolcanic rocks, consisting predominantly of massive, pillowed and hornblende and/or feldspar-phyric flows with minor vesicular, amygdaloidal and tuffaceous components, dominate the Archean stratigraphy. Clastic and chemical metasedimentary rocks, consisting of magnetite-chert iron formation, wacke, siltstone, argillite and minor conglomerate occur as thin units interbedded with the mafic to intermediate metavolcanic rocks. Intermediate to felsic metavolcanic rocks, dominated by fragmental deposits, occur primarily in the northwest corner of the township and consist of heterolithic and monolithic tuff breccia, lapilli tuff and tuff. Minor massive and feldspar and/or quartz-phyric flows occur in the more felsic units. Felsic stocks intrude the Archean rocks in the northeastern, central and southwestern parts of the township. Rare mafic intrusions consist primarily of narrow lamprophyre dikes and small gabbro bodies. The steeply-dipping Archean stratigraphy generally strikes east-

northeast. Northeast, northwest and east-striking joint and fracture planes, and a weak to moderate, northeast-striking foliation are usually present within the Archean rocks. Narrow northeast and, less commonly, northwest-striking zones of moderate shearing are locally present.

Paleoproterozoic rocks of the Gunflint Formation, Animikie Group consist predominantly of complexly interbedded layers of chert, carbonate, shale, tuffaceous shale and taconite. A basal conglomerate occurs locally. Bedding in the Proterozoic rocks is flat-lying to subhorizontal and these rocks display little structure other than minor fracturing, jointing and locally, brecciation.

Sulphide mineralization was noted as: 1) minor disseminated to massive pyrite, pyrrhotite and magnetite as fine disseminations, fracture fillings, and within cavities in brecciated iron formation in the northwest part of the township; 2) finely disseminated pyrite (2-5%) along foliation planes within narrow, northeast-striking, weakly to moderately sheared zones in the Archean metavolcanic rocks in close proximity to felsic intrusions and near lithologic boundaries. Within the Proterozoic rocks, quartz-carbonate vein systems in east-northeast-striking breccia zones associated with late faults

have been prospected for silver, copper, gold and amethyst. In this setting, pyrite, chalcopyrite, and galena occur in fractures, in cavities between brecciated fragments, and in small pods and lenses within the host rock and the brecciated fragments.

Geology of Oliver Township, District of Thunder Bay

By G.H. Brown[1]

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INTRODUCTION

Location and Access

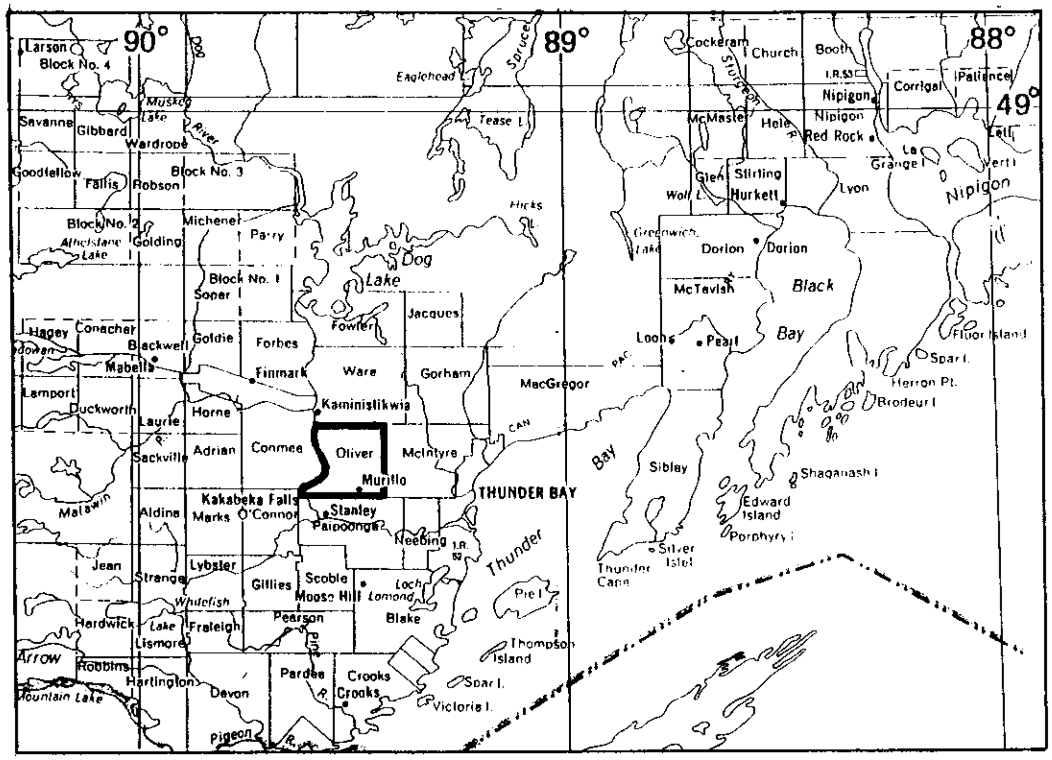
Oliver Township is situated approximately 36 km west of the city of Thunder Bay in northwestern Ontario and encompasses an area of roughly 175 km^2 (see Figure 1 for location) . It is bounded on the west by the Kaministiquia River, on the north and south by latitudes 48° 30' and 48° 23', respectively, and on the east by longitude 89° 25' . The community of Kakabeka Falls is located in the southwest corner of the township and the village of Murillo is situated in the south central portion.

Highway 11-17 crosses the southwest corner of the township; Highway 102 is situated in the northeast portion. A well-maintained network of paved and gravel regional roads provides excellent access to the interior. Canadian National and Canadian Pacific Railway lines cross the southern portion of the township, and hydroelectric power lines are situated in parts of the southern and northern sections.

Physiography and Drainage

Eight physiographic regions have been identified in Oliver Township (Mollard and Mollard 1981). They are summarized in Table 1.

The majority of the township is characterized by low to moderate relief, undulating to knobby topography, and variable amounts of drift cover. The area of highest relief is located in



Scale : 1 : 1 548 000 or 1 inch to 25 miles

Figure 1 - Location map of Oliver Township.

the northwest corner of the township where steep-sided bedrock knobs and deep valleys are common. From here, the land slopes to the south and southeast where the topography is typically low and rolling. Depth of overburden is generally greater in the southern half of the township than in the north.

Prominent glacial features identified in the township include a north-northeast trending end moraine in the southeast part of the township, and a small kame field in the north central part (Mollard and Mollard 1981) .

The Kaministiquia River constitutes the major waterway in the area. It flows generally southward along the western edge of Oliver Township. Drainage in the northwestern and central parts of the township is southeastward, into Corbett Creek, a fault-controlled stream which flows southwest and then southeast through the central and southern parts of the township and eventually drains into the Kaministiquia River a few kilometres south of the township boundary. Streams in the eastern portion of the township drain southeastward into the Neebing River.

History of Exploration

The first reported exploration activity in Oliver Township began around the mid to late 1800s following recognition of the silver potential of quartz-calcite and quartz-calcite-amethyst veins and vein systems within the Proterozoic rocks of the Thunder Bay area (Ingall 1887) . Although little documentation of this early exploration in Oliver Township exists, peak periods of activity likely coincided with significant discoveries in nearby townships such as the Walbridge Mine in Paipoonge Township in 1863 and Rabbit Mountain Mine in Gillies Township, southwest of Paipoonge Township, in 1882 (Ingall 1887). Because of the characteristic predominance of chalcopyrite, galena and other sulphide minerals over the silver minerals in the veins these early-discovered occurrences were often initially assessed for their copper and lead-zinc potential (Tanton 1931). By 1890, several potential silver-bearing veins in the southern half of Oliver Township were being investigated by trenches, pits and small shafts (Tanton 1931). A few silver and amethyst showings were uncovered and low copper values were reported from some of the properties (Tanton 1924, 1931). Following the drop in the price of silver in 1892, exploration declined and most of the properties in Oliver Township were idle by 1900 (Bowen 1911). Very little work was carried out on existing silver properties after 1903 (Bowen 1911).

The discovery of rich iron ore bodies in Proterozoic rocks of northern Minnesota around 1887 prompted an interest in the potential for similar deposits in the Thunder Bay area (Ingall 1887). Due to the similarities in age and composition with the rocks hosting the ore bodies in Minnesota the bulk of the exploration for this commodity was carried out on rocks of the Gunflint Formation (Gill 1924). Gunflint Formation rocks underlying the southern half of Oliver Township were included in regional investigations for iron ore carried out intermittently until the early 1950s (Moorhouse 1960).

The potential for economic deposits of iron within Archean iron formation in the region was recognized by the early 1900s as well. Although little record of exploration for deposits of this type in Oliver Township remains, at least one occurrence of pyritic Archean iron formation in the northwest part of the township is known to have been investigated prior to 1918 (Tanton 1924).

Following these periods of relatively active exploration, no further work was reported in Oliver Township until the early 1970s. At this time, reports of copper and gold mineralization uncovered during construction of a dam on the Kaministiquia River prompted the re-staking of a former silver showing in the southwest corner of the township (Property 1 in Economic Geology section of this report). This property was re-evaluated for its gold potential during the mid 1970s to early 1980s.

Felsic metavolcanic rocks underlying the northwest part of the township were the focus of reconnaissance geological mapping early in the 1970s as a result of the discovery of copper and zinc mineralization in similar rocks in Ware Township, immediately north of Oliver Township (John Scott, Geologist, Resident Geologist's Office, Ministry of Northern Development and Mines, Thunder Bay, personal communication, 1992).

More recent exploration was conducted in the west central part of Oliver Township. A block of claims was staked in Conmee and Oliver townships (Property 2 in Economic Geology section of this report) to cover a small gold showing reported in Conmee Township by Carter (1985). Conmee Township adjoins Oliver Township on the west.

Presently, interest in the amethyst potential of some of the former silver showings in Oliver Township has been renewed and the showing in the southwest part of the township (Property 1) was restaked at the end of the field season.

Previous Geological Work

Geological mapping along highway 102 (formerly Dawson Road) in the northeast section of the township was carried out in 1872 by R. Bell (Bell 1873). A.P. Coleman (1902) reported on the iron ranges of northwestern Ontario including a description of the Gunflint Formation rocks underlying the southern part of Oliver Township. T.L. Tanton (1924, 1931) synthesized existing geological maps of the Thunder Bay area including Oliver Township and augmented these with personal observations on the geology and mineral occurences of the area. W.W. Moorhouse (1960) completed a detailed report and accompanying series of maps outlining the characteristics and location of the Gunflint Iron Range including that portion which underlies the southern part of Oliver Township. The township is also included on regional geological compilation maps by Pye and Fenwick (1963, 1965). Conmee Township, which adjoins Oliver Township on the west, was mapped in detail by Carter (1985, 1990).

The geology and geochemistry of an anthraxolite occurrence at Kakabeka Falls is examined in a B.Sc. thesis by D. Kwiatkowski (1975), and J.R. Dubyk (1982) completed a B.Sc. thesis on the structure and stratigraphy of the metavolcanic and metasedimentary rocks along highway 102. Detailed descriptions of the Proterozoic rocks in Oliver Township and the Thunder Bay area are included in reports by Goodwin (1956), Moorhouse (I960), Franklin (1970) and Shegelski (1982).

Present Geological Work

Mapping of Oliver Township was carried out during the summer of 1992 by pace and compass traverses, spaced at 400 to 500m intervals, and by traverses along all primary and secondary roads. Control of traverses was facilitated by the use of 1 inch to 1/4 mile air photographs obtained from the Ministry of Natural Resources. Traverses were planned to maintain the required spacing and to ensure that all outcrops identified on the air photographs were examined.

Field data were recorded directly onto acetate overlays attached to the air photographs which were carried on traverse. The data were then transferred onto 1 inch to 1/4 mile cronaflex base maps compiled from, digitized maps obtained from the Surveys, Mapping and Remote Sensing Branch, Ministry of Natural Resources. Minor discrepancies in scale which were noted during transfer of the data were adjusted for, using topographical and cultural features wherever possible to ensure accuracy in the plotted location of the outcrops. As such, the geology can not be tied to the survey lines, but it is accurate within the limits of the mapping scale.

Depth of overburden in the area is variable. Portions of the township, particularly in the south, are covered by up to 50m of till. As a result, surface mapping of the southern third of the township was supplemented by information gathered from water well logs, on file with the Ministry of Environment in Thunder Bay.

Acknowledgements

Field work for this project was carried out with the assistance of R.I. Fogal (senior assistant), L.H. Wong, D. Cairns and C.L. Browne (junior assistants). Their continued enthusiasm in spite of a soggy field season was encouraging and greatly appreciated. Helpful discussions with J. Scott, M. Lavigne Jr. and M. Garland of the Resident Geologist's office. Ministry of Northern Development and Mines, Thunder Bay, and with Dr. P. Fralick of Lakehead University are acknowledged. The ready assistance of the staff at the Thunder Bay Core Library and Resident Geologist's office. Ministry of Northern Development and Mines, was also appreciated.

GEOLOGY

General Geology

Oliver Township straddles the boundary between the Superior and Southern tectonic provinces. The northern half of the township lies within the Wawa Subprovince of the Superior Province and is underlain by Archean metavolcanic and metasedimentary rocks of the Shebandowan greenstone belt (Williams et al 1991). The southern half of the township is underlain by the Paleoproterozoic Gunflint Formation of the Animikie Group, Southern Province (Sutcliffe 1991). An angular unconformity separates the strata of the two provinces.

The Shebandowan greenstone belt has been subdivided into three assemblages (Williams et al 1991) - the Burchell, Greenwater and Shebandowan assemblages. Within the Greenwater assemblage three subaqueous to locally subaerial, mafic to felsic metavolcanic cycles have been recognized (Williams et al 1991). As proposed by Williams et al (1991), the uppermost cycle of the Greenwater assemblage, composed primarily of tholeiitic, massive to pillowed flows, underlies the northern and central parts of Oliver Township and the northwest portion of the township is underlain by rocks of the Shebandowan assemblage, a younger, possibly fault-bounded sequence of calc-alkalic to alkalic flows and pyroclastic deposits with intercalated fine to coarse-grained clastic metasedimentary rocks (Williams et al 1991). Early to late mafic and felsic intrusions within the Shebandowan greenstone belt consist of various granitoid plutons, fine-grained and porphyritic felsic dikes and mafic to ultramafic dikes and intrusions.

The Proterozoic rocks underlying the southern half of the township consist of a homoclinal, south-facing sequence of complexly interbedded clastic and chemical metasedimentary rocks representing a period of pre- to syn-orogenic sedimentation in the

Precambrian (Sutcliffe 1991). Within the study area these rocks are characterized by weak deformation, abrupt mineralogical and stratigraphic changes and an abundance of iron-bearing minerals in many of the facies.

Metamorphism and Alteration

The Archean metavolcanic and metasedimentary sequences in the study area have been regionally metamorphosed to greenschist facies. Original mafic minerals in the metavolcanic rocks have been altered to tremolite-actinolite with variable chloritization. Feldspars are commonly saussuritized and incipient carbonate, epidote and sericite is present in the matrix of all rock types. Within the felsic intrusions, the mafic mineral component (hornblende ± biotite) shows slight to moderate chloritization, and the feldspars show similarly variable saussuritization.

On both a regional and local scale, the Proterozoic rocks are weakly metamorphosed. Thermal metamorphism in the immediate vicinity of diabase dikes and sills, commonly seen south of the study area, has mainly resulted in the formation of magnetite at the expense of hematite (Goodwin 1956). Regional metamorphism is most commonly manifest as the partial to complete recrystallization of the silicate greenalite to amphibole. In the shale facies, illite has often been formed by metamorhpism of lithic fragments (Goodwin 1956).

Common alteration within the study area consists of widespread veins, veinlets and irregular vugs of potassium feldspar ± epidote

± calcite, which rarely constitute more than 5% of the total volume of the rock. More significant alteration is present in localized, scattered patches throughout the township, as discussed below.

Within the mafic to intermediate metavolcanic unit in the north central part of the township, mafic minerals locally show variable biotite alteration. Two areas where this alteration is particularly abundant are in the northeast part of the township near the First Sideroad, and in the northwest part of the township, in the vicinity of the Seventh Concession. In the northeast corner of the township rocks displaying this alteration are situated in close proximity to a felsic pluton and the alteration in this vicinity is likely related to the emplacement of the pluton. In the area of biotite alteration in the northwest part of the township, nearby faults may represent the conduits for the alteration fluids.

The felsic and intermediate to felsic metavolcanic rocks in the northwest corner of the township locally contain patches of moderate carbonate alteration. In these areas, calcite is present in abundance as a product of the alteration of individual feldspar crystals and as a major component of the matrix. Less abundant iron carbonate is also commonly present.

Local minor to moderate sericitization also occurs within the more felsic metavolcanic rocks in the northwestern part of the township, primarily within outcrops showing a moderate to high degree of fracturing. These outcrops are situated close to local faults and it is likely that this alteration is directly related to the presence of the faults.

Scattered patches of intense hematization occur within the coarse-grained, pyroclastic, intermediate and mafic to intermediate metavolcanic sequences in the northwest and northern portions of the township. This alteration affects both the matrix and the fragments of the rocks and in some instances cuts across matrix and fragment boundaries.

Rock Descriptions

Archean

The stratigraphy of the western portion of the Shebandowan greenstone belt has been well documented (Williams et al 1991, and references therein) and the problem of identifying the diverse constituents of the Shebandowan assemblage has been recognized (G. Stott, Geoscientist, Ontario Geological Survey, Ministry of Northern Development and Mines, personal communication, 1993) . In light of current studies being carried out in the vicinity of the study area to address this problem (Berger 1992 ; Osmani et al 1992), no attempt will be made at present to classify the rocks of the study area into either of the proposed assemblages.

The metavolcanic rocks within Oliver Township can be separated into four distinct units. The central and northern parts of the township are underlain by mafic, predominantly pillowed flows and mafic to intermediate, predominantly hornblende and/or feldspar-phyric flows. Intermediate to felsic, predominantly coarse-grained pyroclastic deposits and felsic, predominantly massive to porphyritic flows primarily underlie the northwest corner of the township but are also found in small localized areas throughout the Archean sequences.

Interbedded clastic and chemical metasedimentary rocks occur locally within the metavolcanic rocks in the western part of the township. These units are narrow, discontinuous and comprise only a minor proportion of the Archean stratigraphy.

Felsic intrusions in the study area consist of scattered, narrow, commonly porphyritic dikes, and small plutons. The plutons occur in the northeast, east central and southwest parts of the township. In the eastern part of the township these intrusions are predominantly syenitic to monzonitic in composition whereas the plutons in the southwestern part of the township are comprised primarily of tonalite to granodiorite. Mafic intrusions within the study area are restricted to a small gabbro body in the northwest part of the township and scattered, narrow mafic dikes, primarily lamprophyre.

Mafic metavolcanic rocks

This unit is composed primarily of pillowed, massive, porphyritic, amygdaloidal and medium to coarse-grained flows with minor interbedded tuff, lapilli tuff, and rarely, pillow breccia and hyaloclastite. The rocks are generally a dull dark green to dark greyish green on the weathered surface and dark green or black on the fresh surface.

Pillowed flows are most abundant and although the degree of preservation of the pillows varies considerably, well-formed pillow shapes are locally visible, providing some of the few reliable top direction indicators within the Archean sequences. Where well-preserved, the pillows range in size from 10cm X 15cm to 30cm X 60cm, and average approximately 25cm X 30cm. Selvages are generally < 1cm thick, very chloritic and recessively weathered. Locally, particularly near faults and later intrusions, the selvages appear to be more resistant to weathering, possibly indicating slight silicification. Commonly, carbonate-filled amygdules, generally < 1mm in size, are present, locally radiating outward from the core of the pillows.

Porphyritic and fine-grained massive flows are also an abundant component of this unit. The porphyritic flows generally contain phenocrysts (< l-2mm X 2-3mm) of plagioclase and, less commonly, of amphibole, in a very fine-grained matrix.

Medium to coarse-grained flows are present to a lesser extent, primarily in the northeast and western parts of the township. Within the extensive outcrops along the Kaministiquia River in the western part of the township the coarser-grained flows are locally seen to grade into finer-grained and pillowed flow facies and are unmistakably extrusive. In most outcrops, however, contacts between coarser-grained units and the surrounding rocks are not visible, and may locally be intrusive.

Thin, discontinuous layers of interbedded tuff and lapilli tuff occur in a few outcrops near the central portion of the township. The lapilli tuff is composed of lenticular mafic volcanic fragments, up to 1cm X 4-5cm in size, within a fine-grained matrix of lithic fragments and broken feldspar crystals. This unit is generally fragment-supported and commonly interbedded with very fine-grained tuff and crystal tuff.

An outcrop of pillow breccia and hyaloclastite is present along Mud Lake Road, in the central part of the township. This unit consists of fine-grained, pale green, angular to subrounded, locally variolitic pillow fragments ranging in size from 1cm X 2cm to 15cm X 40cm within a darker green, tuffaceous to hyaloclastic matrix.

Mafic to intermediate metavolcanic rocks

This unit is composed predominantly of porphyritic, amygdaloidal, massive and pillowed flows, with less abundant pillow breccia, tuff, lapilli tuff and tuff breccia. The rocks vary from a dull medium to dark green to lighter chalky green on the weathered surface. The fresh surface is most often dark greyish green.

The most abundant constituents of this unit are the porphyritic and amygdaloidal flows which commonly contain plagioclase and mafic phenocrysts up to 5-6mm X 7-8mm, and less abundant quartz-filled amygdules. These amygdules generally average only a few millimetres in diameter but can locally be up to 2cm in diameter (see Plate 1) . The subhedral to euhedral feldspar phenocrysts generally comprise 10-20% of the total volume of the rock. Mafic phenocrysts are more often lenticular to rounded and are readily eroded resulting in a distinctive pitted weathered surface. In some instances the mafic minerals appear to occur as amygdules, forming rounded to subrounded aggregates rimmed by tiny quartz grains (see Plate 2).

Fragmental deposits comprise another important component of this unit. Coarse-grained heterolithic tuff breccia occurs locally, generally interbedded with the intermediate and felsic metavolcanics in the north and northwest parts of the township. Angular to subrounded fragments varying from 0.5cm X 0.5cm to 40cm X 60cm in size comprise 30-80% of the volume of this rock. The lithic fragments are mainly feldspar and/or amphibole-phyric mafic and intermediate volcanics, brick red to pale green in colour and are generally more felsic in composition than the fine to medium-grained chloritic matrix. Aphanitic to fine-grained mafic and intermediate volcanic fragments with similar colouration are also important components of this unit. Locally any of the various rock types can constitute the predominant fragment type. Often this unit displays weak to intense hematization which affects both the fragments and matrix.

Brecciated pillowed flows also occur in the northwest part of the township. Angular to subrounded fragments of dull pink to pale green flow material occur in a dark green, chloritic, tuffaceous matrix. Fragments within the pillow breccia are not as coarse as the fragments in the tuff breccia, and are consistently aphanitic to very fine-grained rather than porphyritic, as fragments in the tuff breccia.

Minor tuff and lapilli tuff are locally interbedded with the pillowed and porphyritic flows, particularly in the northwest part of the township. The lapilli tuff varies from clast to matrix-supported and contains lenticular amphibole and feldspar-phyric fragments up to 1cm X 4cm which are slightly more felsic in composition than the chloritic, tuffaceous matrix. Well-bedded lithic and crystal tuff are present at one locality in the northwest part of the township. The thicker-bedded (2-5cm) lithic tuff consists of lenticular to subangular mafic to intermediate fragments within a fine-grained mafic matrix. The crystal tuff is generally thinner-bedded (< 1cm) and consists of angular, plagioclase crystals and crystal fragments in a very fine-grained ash matrix.

Intermediate to felsic metavolcanic rocks

This unit occurs primarily in the northwest part of the township and is composed predominantly of tuff, lapilli tuff and tuff breccia with subordinate massive, porphyritic and amygdaloidal flows. A small lobe of these rocks underlies the west-central part of the township. Outcrops of this unit are generally light greyish green to bluish green on the weathered surface and light grey on the fresh surface.

Massive, porphyritic and amygdaloidal flows are texturally similar to those described for the mafic and mafic to intermediate sequences. As with the more mafic flows, plagioclase ± amphibole phenocrysts up to 1mm X 2mm in size are common, and thin section examination of rocks which appear uniformly fine-grained in outcrop commonly contain microphenocrysts of feldspar. In contrast to the more mafic flows, the intermediate to felsic flows contain subordinate quartz, mainly as crystal fragments.

Tuffaceous deposits within this unit consist of fragment to matrix-supported, crystal and crystal-lithic tuff. Fragments within the lithic tuff are mainly intermediate and felsic in composition, angular to subrounded, and commonly feldspar ± amphibole-phyric. The crystal tuff consists of broken plagioclase, and less commonly, quartz crystals < 2mm in size. In all instances, the matrix to these deposits is composed of fine-grained quartz, plagioclase and incipient carbonate, epidote and sericite. Bedding within these deposits is rare.

Intermediate to felsic lapilli tuff is most abundant in the northwest part of the study area. Commonly, the lapilli and matrix are very similar in composition and the fragments are diffcult to discern in outcrop. In general the lapilli range from 0.5cm X 1cm to 1.5cm X 2cm in size, are lenticular in shape, and mainly composed of fragments of plagioclase ± amphibole-phyric intermediate metavolcanic flows. As with the finer-grained deposits, this unit is predominantly matrix supported with a fine-grained matrix of ash and fragments of plagioclase and rare quartz crystals.

Heterolithic to monolithic tuff breccia occurs in the northeast part of the township, along highway 102, and in the northwest. Exposures of heterolithic tuff breccia in the northwest part of the township are composed of angular to subangular fragments of felsic to intermediate tuff, intermediate to mafic feldspar-phyric flows, fine-grained mafic and intermediate flows, and aphanitic mafic volcanic flows. Fragments are generally ^ 15cm X 30cm in size and are set in a more felsic matrix of fine-grained, dark greyish green ash particles which comprise 35-65% of the rock. In the northeast part of the township, outcrops of heterolithic tuff breccia more commonly contains fragments of only a few rock types, primarily feldspar ± amphibole phyric intermediate flows and aphanitic, felsic to intermediate flows. The fragments are commonly angular to subangular and range from 4cm X 5cm to approximately 15cm X 20cm in size. As with the tuff breccia in the northwest part of the township, these exposures vary from matrix to fragment-supported. The tuff breccia in the northeast, however, locally shows 15-40cm thick, weakly graded bedding (see Plate 3).

Less abundant monolithic tuff breccia occurs in the norttfeast and northern parts of the township. In these outcrops, the fragments are composed of a pale green feldspar-phyric intermediate to felsic volcanic flow material. They are subangular to subrounded and generally < 10cm X 15cm in size. The matrix is extremely fine-grained, slightly more mafic than the fragments and contains rare, well-rounded quartz eyes <1.5mm in size.

Felsic metavolcanic rocks

This unit constitutes a relatively minor proportion of the metavolcanic rocks in the study area, occurring primarily in the northwest corner of the township and in minor, scattered lenses within the more mafic metavolcanic sequences. Rocks within this unit consist predominantly of massive and porphyritic flows with less abundant tuff and lapilli tuff. Weathered surfaces are generally creamy white to mottled pale green. On the fresh surface they are medium to light grey or very pale green to light blue-green.

Porphyritic flows are most abundant and generally contain fine-grained (< 2mm) euhedral phenocrysts of plagioclase. Amphibole phenocrysts are less abundant, rarely comprising more than 3-4% of the total volume. Rare, rounded to subrounded quartz phenocrysts are locally present. Although the massive flows appear very fine-grained to aphanitic in both outcrop and hand sample, thin section examination shows that they commonly contain microphenocrysts of plagioclase.

Monolithic and, less commonly, heterolithic lapilli tuff are sporadically interlayered with the felsic flows. These units are generally matrix-supported with lenticular to subrounded and, rarely, angular fragments within a fine-grained, felsic matrix. Fragment size ranges from approximately 0.5cm X 1cm to 2cm X 4cm and, as with the more intermediate deposits, it is often difficult to distinguish the fragments from the matrix, particularly in the monolithic units. Fragments within the deposits of monolithic lapilli tuff consist of fine-grained felsic volcanic rock, whereas heterolithic exposures contain fragments of two predominant rock types - feldspar-phyric felsic volcanic rock and amphibole-phyric intermediate volcanic rock. Fine-grained crystal tuff is locally interlayered with the deposits of lapilli tuff and is composed of abundant broken plagioclase and quartz crystals within a very fine-grained matrix of felsic ash particles.

Metasedimentary rocks

Thin, discontinous deposits of clastic and chemical metasedimentary rocks occur locally interbedded with the metavolcanic rocks, particularly in the western part of the township. Chert, magnetite-chert iron formation and rare pyrite-chert iron formation comprise the chemical metasedimentary sequences. Clastic sequences consist of immature, commonly volcaniclastic, siltstone, mudstone and wacke with less abundant heterolithic conglomerate.

Finely banded magnetite-chert iron formation occurs both in the northwest part of the township where it is interlayered with chert, minor conglomerate and fine-grained mafic metavolcanic rocks, and in the west central part of the township where it is interlayered with thinly bedded wacke, siltstone, mudstone and arenite. Individual bands within the iron formation locally show evidence of minor deformation prior to lithification. Pyrite-chert iron formation occurs only in the northwest part of the township where pyrite replaces magnetite within a narrow gossan zone developed over a portion of magnetite-chert iron formation.

Heterolithic conglomerate occurs in subordinate scattered outcrops in the northwest part of the township. Well-rounded to subangular clasts of various rock types comprise up to 70% of this unit. The matrix consists predominantly of fine-grained volcaniclastic material with less abundant sand and silt-sized particles. Clast size ranges from 0.5cm X 1cm to an approximate maximum of 10cm X 16cm. Predominant rock types comprising the various clasts consist of feldspar ± amphibole-phyric volcanic rocks, fine-grained to aphanitic mafic volcanic rocks, chert and jasper indicating proximal deposition.

Early mafic intrusions

Mafic intrusive rocks represent a minor component of the Archean sequences within the study area. A single, small gabbro intrusion is located in the northwest part of the township. It is medium-grained, slightly to moderately magnetic and is composed of amphibole and feldspar crystals up to 1.5mm X 3mm in size, within a groundmass of finer-grained feldspar, amphibole, chlorite and epidote. The felsic constituents generally comprise less than 40% of the rock.

Other gabbro intrusions may be present in the northeast part of the township where several outcrops of medium to coarse-grained gabbroic-textured mafic rock occur. Poor exposure, a lack of obvious intrusive contacts and proximity to surrounding pillowed and fine-grained mafic flows have resulted in these outcrops being classified as coarse-grained centres of flows.

Early felsic intrusions

Early felsic intrusions in Oliver Township consist of narrow, commonly porphyritic dikes and granitoid plutons. Felsic dikes are composed of feldspar, quartz and, rarely, quartz-feldspar-biotite porphyry and/ less commonly, syenite. Fracturing and weak foliation are often present.

Four small felsic stocks occur within Oliver Township. These are located in the northeast corner, in the east central portion and in the southwest corner of the township. Near the margins of these plutons, narrow dikes, veins and veinlets of intrusive material are common within the surrounding country rock, and xenoliths of country rock are seen throughout the intrusive bodies.

The pluton in the northeastern corner of the township is part of a- larger syenitic to monzonitic body which extends into the township east of the study area (Pye and Fenwick 1963). It is medium to coarse grained (crystal size ranges from 5mm X 10mm to 3mm X 5mm) , equigranular, and weakly to moderately magnetic. From the margins of this pluton towards the core, the composition becomes more granitic. Amphibole and biotite comprise 15-20% of the rock. Amphibole is generally more abundant than biotite.

The pluton in the east central part of the township is non-magnetic and does not contain as much alkali feldspar as the pluton to the north. Both plutons in the eastern portion of the township have a weak to moderate foliation. Contacts with surrounding rocks vary from sharp, with narrow chill margins, to wide zones of brecciation indicating local stoping.

The two smaller tonalitic to granodioritic stocks which occur in the southwestern portion of the township are inequigranular, with crystals of plagioclase (<3mm X 5mm) and aggregates of amphibole and biotite crystals (<3mm X 10mm) in a finer-grained groundmass of plagioclase, minor quartz and alkali feldspar, and subordinate sphene and apatite. In contrast to the intrusions in the eastern portion of the township, these plutons show a wide variation in the relative proportions of amphibole to biotite. It is likely that these plutons represent separate lobes of a single, larger pluton located to the west (Pye and Fenwick 1963). As with the plutons in the east, a weak to moderate foliation is commonly present. In the immediate vicinity of the fault north of Kakabeka Falls a strong foliation and locally migmatitic to gneissic fabric is developed in both the intrusive rocks and nearby metavolcanic and metasedimentary rocks.

Archean felsic intrusions along the Proterozoic contact show an enrichment in their iron and manganese content (Kronberg and Fralick 1992). This is primarily manifest as slight to extensive alteration of the mafic constituents and, to a lesser degree, the feldspars, to chlorite (Kronberg and Fralick 1992). In outcrop this alteration produces a pale greenish tinge in the felsic minerals, and the mafic minerals take on a greasy to dull lustre and very dark colour (see Plate 4). This alteration is readily visible in only the upper 10 to 15cm of the rock but more subtle alteration is present to depths of approximately lm (Kronberg and Fralick 1992). It was previously thought that this alteration represented a paleo-weathering surface of the Archean rocks. However, recent work indicates that this alteration may be a result of interstitial fluids percolating down through the overlying Gunflint Formation and penetrating the Archean sequences directly beneath (Kronberg and Fralick 1992).

Late mafic intrusions

Late mafic intrusions within the township are resticted to narrow (<1.5m) , scattered dikes of lamprophyre and undifferentiated mafic rocks. The lamprophyre dikes vary from fine-grained to coarse-grained, with crystals up to 0.5cm X 1cm in size, and contain up to 20% medium to coarse-grained biotite. Olivine generally comprises up to 2% of the rock and plagioclase comprises the majority of the finer-grained groundmass. Locally minor muscovite is present. These dikes are weakly to moderately magnetic and are reddish brown on the weathered surface.

Less abundant, fine-grained, non-magnetic mafic dikes occur locally. These undifferentiated mafic dikes contain little to no biotite, are very dark grey on both the weathered and fresh surfaces and are generally narrower than the lamprophyre dikes.

Late felsic intrusions

This unit comprises aplite and feldspar porphyry dikes. These rocks are commonly light to medium pink on both the weathered and fresh surfaces, fine-grained to aphanitic and range from 8cm to 40cm in width. Contacts with surrounding rocks are sharp and thermal metamorphism associated with the emplacement of the dikes has often resulted in a slight coarsening of grain size of the host rocks closest to the contacts. Trends and widths of these dikes can vary considerably along strike.

Proterozoic

The Proterozoic rocks underlying Oliver Township are part of the Paleoproterozoic Gunflint Formation of the Animikie Group. These rocks are flat-lying to subhorizontal with a shallow (< 10°) southeast dip and show little in the way of metamorphism or deformation. The Gunflint Formation is subdivided into three sequences (Moorhouse 1960). The lower unit consists of a basal pebble conglomerate, ferruginous carbonate, chert, jasper and hematite and magnetite taconite. The middle unit is a well bedded sequence of argillite and argillite tuff with subordinate chert and carbonate. The Upper Gunflint consists of thinly interbanded chert and ferruginous carbonate, chert, jasper and silicate taconite. Outcrops of the Proterozoic rocks within the study area are scarce due to the abundant overburden in the southern part of the township. Good exposures are seen in the vicinity of Kakabeka Falls, and in the south central part of the township near the village of Murillo.

Basal conglomerate

The basal unit of the Gunflint Formation consists of an erratically distributed pebble conglomerate which was deposited in paleotopographic lows on the Archean basement. Thickness of this unit varies from a few centimetres to a maximum of 1.5m (Goodwin 1956). The matrix is locally derived and variable depending on the composition of the underlying Archean rocks (Goodwin 1956). Where underlain by felsic intrusive rocks the matrix is quartz-rich, and where the underlying rocks arervolcanic the matrix is chloritic. The pebbles within this unit represent material from a distal source, likely the Matawin Iron Range northwest of the study area (Goodwin 1956). Good exposures of this unit can be seen in the riverbed above and below Kakabeka Falls, and in the central portion of the township near 2nd and 3rd Sideroads, north of John Street Road. At these latter locations, the conglomerate is in unconformable contact with altered Archean felsic intrusions (as described previously), and itself appears to be similarly altered. In the vicinity of Kakabeka Falls, the basal conglomerate is medium-grained and variable from matrix to clast-supported. Clasts consist of well-rounded to subrounded pebbles, up to 4 cm in size, of milky quartz and less abundant felsic to mafic intrusive and extrusive rocks, jasper, chert and rare finely banded sedimentary rocks within a quartz sand-rich matrix (see Plates 5 and 6).

Lower Gunflint Formation

The lower sequence of the Gunflint Formation in Oliver Township forms a narrow band extending northeast from the exposure at Kakabeka Falls to the east central boundary of the township. The best exposures of this sequence are found along the

Kaministiquia River at Kakabeka Falls. In these areas, finely laminated black shale and tuffaceous shale are complexly interlayered with medium to thick bedded limestone, carbonate, chert-carbonate and mudstone. Northeast of Kakabeka Falls the exposures of the lower Gunflint Formation consist predominantly of thinly interbedded chert and chert-carbonate.

Middle Gunflint Formation

Other than the extensive exposures which constitute the face of Kakabeka Falls, this unit is poorly represented within the study area. It is composed of interbedded tuffaceous shale, shale and minor chert and carbonate. The tuffaceous shale represents an important marker horizon within the Gunflint Formation (Moorhouse 1960) as it is one of the few units which show any degree of lateral continuity. To the east of Kakabeka Falls, only a few scattered outcrops of this unit occur and these consist entirely of shale.

Upper Gunflint Formation

The Upper Gunflint comprises the major portion of the Proterozoic rocks within the study area and occurs above and south of the lower sequences. This unit shows the most compositional diversity in the area south of Kakabeka Falls where discontinuous layers of chert, chert-carbonate, shale, taconite and minor limestone are intricately interbedded. To the east of Kakabeka Falls, the upper Gunflint Formation consists predominantly of taconite and interbedded chert and chert-carbonate.

Shale members of this unit often contain large, nodular concretions, some up to lm in size. Good examples are present in the riverbed downstream from Kakabeka Falls. Carbonate layers are predominantly ferruginous and where interbedded with the chert, they show up as distictively rusty weathering, friable layers. Often the chert in this unit forms lenticular nodules rather than discrete layers.

Taconite is defined as granular iron formation, and within the study area outcrops of this rock show a highly variable mineralogy. Granules within the silica-rich matrix are well-rounded to oblong or irregularly-shaped (see Plate 7) and commonly consist of chert, jasper, greenalite, ferruginous carbonate, hematite and magnetite in varying proportions (Goodwin 1956). Taconite beds in the southern-most portion of the township have an abundance of iron silicate granules, whereas outcrops of taconite further to the north contain a higher proportion of ferruginous carbonate granules. In iron-rich beds, hematite and magnetite commonly rim the granules of greenalite and can occur as separate grains (Goodwin 1956).

GEOCHEMISTRY

A total of forty (40) samples of the metavolcanic rocks within Oliver Township were submitted for whole rock geochemical analysis. Fourteen samples were of the mafic metavolcanic unit; sixteen samples were of the mafic to intermediate metavolcanic unit; six samples were of the intermediate to felsic unit; and four samples were of the felsic metavolcanic unit. Major oxide and selected trace element determinations were carried out by Technical Service Laboratories (TSL) of Rouyn-Noranda, Quebec. Results of the analyses are summarized in Table 2. Samples of accepted international standards supplied by the Geoscience Laboratory of the Ontario Geological Survey were submitted with the samples from the study area as a check on the quality of the determinations. There is good correlation for the major oxides in comparisons of results of TSL determinations with the accepted values for the standards, but the trace element determinations are not always within acceptable limits of accuracy. The trace element results have not been used to any great extent to aid in characterizing the geochemistry of the study area.

The major element discrimination diagram proposed by Irvine and Baragar (1971) (Figure 2) shows that all but two of the samples of metavolcanic rocks from the study area plot within the subalkaline field. The two samples which plot in the alkalic field are samples of mafic metavolcanic rocks from outcrops which show slight to moderate brecciation and abundant potassium feldspar veins, veinlets and lenses. Their position on this diagram is therefore likely a reflection of localized potassic alteration rather than original chemistry.

Further characterization of the metavolcanic rocks shows that the majority of the samples of mafic metavolcanic rocks plot within the tholeiitic field in Irvine and Baragar's AFM major oxides discrimination diagram (Irvine and Baragar 1971) (Figure 3). The two samples which plot within the calc-alkalic field are the same samples that appear in the alkalic field in Figure 2. The position of these samples on Figure 3 is also attributed to moderate potassic alteration.

The remainder of the samples, representing the mafic to intermediate metavolcanic rocks, the intermediate to felsic metavolcanic rocks and the felsic metavolcanic rocks, plot within the calc-alkalic field with the exception of a single sample of the mafic to intermediate metavolcanic unit. As discussed further below, this sample contains a high percentage of mafic phenocrysts (>20%) and its position on this diagram is likely a reflection of alteration rather than original chemistry.

On Jensen's cation classification diagram (Jensen 1976) (Figure 4), all but one of the samples of mafic metavolcanic rocks plot within the tholeiitic field, the majority in the high iron tholeiite field and the remainder in the high magnesium tholeiite field. The one exception plots within the basaltic komatiite field. The samples of mafic to intermediate metavolcanic rocks plot in the basaltic komatiite field (2 samples), the high magnesium tholeiite field (8 samples), the calc-alkalic basalt field (5 samples) and the calc-alkalic andesite field (1 sample). The samples which plot within the basaltic komatiite and the high magnesium tholeiite fields represent samples of amygdaloidal and porphyritic flows which contain a higher than average proportion

(>20%) of mafic phenocrysts. As discussed in the section on metamorphism and alteration, the mafic phenocrysts within the metavolcanic rocks are often slightly to moderately altered to chlorite and, in a few localities, to chlorite and biotite. On a plot of Mg Number vs Ni (Figure 5), the samples of mafic to intermediate metavolcanic rocks which plot within the basaltic komatiite field on Figure 4 appear to have high Ni contents and Mg Number values. The samples of mafic to intermediate metavolcanic rocks which plot in the high magnesium tholeiite field have normal values for both their Ni content and Mg# value. The position of the samples within the basaltic komatiite field on Figure 4 does not appear to be a function of alteration. It is likely that these samples represent specimens of a more primitive magma than the other samples. The samples which plot in the high magnesium tholeiite field in Figure 4 do not show Ni values compatible with their slightly elevated Mg Number (see Figure 5), and their position on Jensen's cation classification diagram is likely a reflection of alteration rather than representative of the true chemistry.

The intermediate to felsic and felsic metavolcanic samples fall within the calc-alkalic field in Jensen's (1976) classification scheme (Figure 4), ranging between calc-alkalic dacites (6 samples) and calc-alkalic rhyolites (4 samples).

On all three of the major element classification diagrams (Figures 2, 3 and 4) the distribution of samples shows a slight gap between the more mafic fields and the felsic and intermediate fields. This is seen best in Figure 2, where there is a distinct lack of samples plotting between Si02 values of approximately 58% and 63%. In Figure 4, this is seen as a lack of samples within the andesitic field. The location of the samples collected for geochemical analysis was carefully selected to represent both a geological and a geographical cross-section of the study area therefore the lack of rocks of andesitic chemistry can not be attributed to sampling bias. Although not a large number of samples were collected, it would appear that there is a weak bimodal geochemical distribution of the metavolcanic rocks in the study area.

An average value of the various trace elements was calculated for samples from each of the four metavolcanic units. These averages were plotted on a normal discrimination diagram (spider plot), shown in Figure 6. All four metavolcanic units show a similar negative slope and a relatively high content of lighter trace elements. This pattern is indicative of a degree of fractionation from an original parent magma (Arth 1976) . The close correlation between the slopes for all the metavolcanic units indicates a possible single original magma for all the samples. Not enough data is available at present, however, for any final conclusions to be reached. In future field seasons, sampling will be carried out to try to address both this question and the possible bimodal distribution of metavolcanic rocks within the study area.

STRUCTURAL GEOLOGY

Introduction

The Proterozoic and Archean rocks underlying Oliver Township are representative of two highly contrasting tectonic provinces. Bedding attitudes, deformation and structures within the two tectonic provinces are markedly different. As noted in "General Geology", the Southern Province is characteristically very weakly deformed. Primary sedimentary features and bedding attitudes commonly show only slight evidence of post-depositional disturbance. In contrast, the Superior Province has experienced a longer and more diverse deformation history with a resultant highly complex structural character.

Proterozoic Rocks

The Proterozoic rocks underlying Oliver Township are flat-lying to very gently dipping (< 10°) to the southeast and display few structural features other than jointing and narrow zones of fracturing and brecciation. These latter structures are associated with late-stage faults which generally trend northeast and northwest. The zones of fracturing and brecciation are most often associated with the northeast trending faults and are the locus for quartz-calcite vein systems in the southern part of the township which locally host silver, amethyst and, less commonly, copper mineralization.

The late stage jointing and quartz veining which is common to both the Archean and the Proterozoic rocks in the township display several trends. These are discussed below.

Archean Rocks

The Archean rocks in the study area are generally steeply dipping and have a pervasive, weakly to moderately developed, predominantly northeast-trending foliation (see Figure 7). Where primary layering or primary bedding indicators are preserved, the stratigraphy shows a general east-northeast strike. The degree of deformation within the Archean rocks is variable from very weak to strong. Two areas of very weak deformation have been identified in the township; in the predominantly pyroclastic felsic to intermediate and interbedded mafic to intermediate metavolcanic rocks in the northwest corner, and in pillowed to coarse-grained mafic metavolcanics in the north central portion of the township (see Figure 8). In both areas, primary features and textures are very well-preserved and there is little in the way of measurable structures in the rocks other than joints, fractures and quartz veins.

Areas of more intense deformation are associated with late-stage, northeast and northwest-trending faults, and with the contact strain aureoles of felsic intrusions. Proximity to faults is manifest as an increase in the amount of fracturing and veining in the country rock, and formation of a well-developed foliation. Rocks within the contact strain aureoles of the felsic intrusions commonly display a well-developed foliation, cross-cutting fracture cleavage, minor S and Z folds in late, cross-cutting quartz veins, and locally, narrow zones of shearing. Trends of foliation within the strain aureoles generally reflect the trends of the contacts of the intrusions rather than the regional foliation trends. Rarely, the plutonic bodies show evidence of stoping and in these instances their emplacement appears to have deformed the country rock relatively little.

In addition to the zones of shearing present within the contact strain aureoles, narrow zones of shearing occur throughout the Archean rocks in the township, often in close proximity to lithologic boundaries. These structures are narrow, moderately well-developed and can not be traced over any appreciable distance. They generally trend northeast and, less commonly, northwest. Where pyrite is present, usually as fine disseminations along foliation planes within the shear zones, anomalous gold values are also often reported.

Jointing and fracturing is common in all the Archean and the Proterozoic rocks in the township. These structures are late-stage features and cross-cut all other structures. Although joint planes are one of the most common structural features in the township, they show no distinct trends, as shown by Figure 9, nor any distinct correlation with other measured structural features (see Figures 7, 10 and 11). As such, they hold little significance in interpretations of the overall structure of the study area. Fracture planes, however, appear to display a few prominent trends, mainly northeasterly, northwesterly and northerly (see Figure 10).

These reflect the predominant trends of faults within the study-area and it is likely that fracturing in the study area is closely related to the late-stage faulting. The trends of the late-stage quartz and/or feldspar veins show very good correlation with the trends of fracture planes (see Figure 11) and are likely closely related to faulting as well.

Although studies conducted in adjoining townships indicate that the Archean sequences in the immediate area are likely isoclinally folded about northeast-trending axes (Carter 1985), evidence of regional folding in the study area is absent. Top direction indicators within the township are scarce and, where present, show a consistent younging direction to the north. Folds present in the rocks are minor features, related to the emplacement of the plutonic bodies and not to the regional deformation. A small, east-closing fold within a narrow band of iron formation has been proposed in the southwest portion of the township, however, this is based on interpretation of the pattern of airborne magnetic response in the immediate area and is subject to possible revision.

ECONOMIC GEOLOGY

Introduction

Several commodities have been noted within the Archean and Proterozoic rocks of Oliver Township. The characteristic settings and styles of mineralization for each commodity are described below. At present, no economic deposits are known to exist in

Oliver Township.

Two claim blocks are currently held in the township. Mineralization and exploration work carried out at these locations is described below in "Property Descriptions". Also included in the section are descriptions of mineral showings and areas of old workings that are not currently staked and which were examined this summer.

Table 3 shows the assay results from sampling carried out during the field season.

Silver

Tanton (1931) identified the typical setting for silver mineralization in the Thunder Bay area as fractured and brecciated zones associated with late faults'within Proterozoic sedimentary rocks. The zones are generally less than 6m wide but can be up to 30m wide. Quartz, calcite, amethyst and, to a lesser extent, barite and fluorite occur within these zones as individual veins, as networks of tiny veins and veinlets, and as cement around brecciated fragments of wall rock. Local concentrations of galena, sphalerite, chalcopyrite and pyrite occur within the veins as small blebs and as fine fracture fillings in breccia zones. Silver minerals and native silver are less abundant and more erraticallly distributed than the sulphide minerals and occur in vugs and in fine fractures within the vein minerals and in the wall rock (Tanton 1931).

Several such silver-bearing zones have been located in Oliver

Township, situated along northeast-trending faults in the southwest and south central parts of the township. Quartz, calcite and amethyst infill the fractured and brecciated zones and minor amounts of pyrite, chalcopyrite, galena, malachite, argentite and native silver have been reported from the showings located to date.

Amethyst

Iron-rich Proterozoic rocks, particularly near the Archean unconformity, have been identified as having high potential for amethyst mineralization (Garland 1991). Radioactive minerals, essential to the formation of amethyst, appear to be concentrated along the unconformity. Nearby zones of fracturing and brecciation provide the open spaces in which well-formed crystals can develop.

Two brecciated and fractured zones have been identified within the Proterozoic rocks in Oliver Township, in close proximity to the Archean unconformity. Both are associated with northeast-trending faults. Several areas along these zones were examined for their silver potential prior to 1903 (see section on History of Exploration) and at many locations well-formed quartz crystals showing variable degrees of amethyst coloration had been noted. Individual crystals range in size from a few millimetres to almost lcm across. The amethyst represents one of the vein minerals infilling these zones and occurs within fractures and cementing brecciated fragments of wall rock.

Copper

As noted in the description of silver mineralization, the vein systems associated with fractured and brecciated zones within the Proterozoic rocks of the area contain local concentrations of chalcopyrite, pyrite, galena and sphalerite. The sulphide minerals are typically "more widely distributed and more evenly disseminated through individual veins than silver minerals" (Tanton 1931, p.89). Often, early exploration of these veins focussed on their copper and lead-zinc potential.

Within Oliver Township small amounts of pyrite, chalcopyrite and galena have been noted in many of the vein systems investigated. At one location (Location E, described below) grab samples collected by the field crew of vein material hosting < 1% pyrite and malachite, and < 2% chalcopyrite in small blebs and filling fine fractures, returned values of up to 872 ppm Cu.

Gold

Gold showings within Oliver Township are primarily located within narrow shear zones either associated with the contact strain aureoles of Archean felsic intrusions, or in close proximity to lithologic boundaries between Archean metavolcanic units. These shear zones generally show two predominant trends - northeast and approximately north - and are locally mineralized with up to 3% pyrite finely disseminated along the foliation planes within and adjacent to the shear zones.

In addition, samples collected this summer from an occurrence of pyritic, brecciated magnetite-chert iron formation in the northwest part of the township (Location A) returned values of up to 153 ppb Au. The pyrite occurred as fine-grained rims around brecciated fragments and in concentrations of up to 80% within a gossan zone developed over a portion of the iron formation.

Iron

Both the Proterozoic and the Archean iron-rich rocks of the township have been assessed in the past for their iron ore potential.

Several studies have been conducted on the iron-bearing rocks of the Gunflint Formation throughout the Thunder Bay area in order to assess the potential for economic iron ore bodies similar to those hosted by rocks of the Biwabik Formation in Minnesota (Moorhouse 1960) . Although the Gunflint Formation represents the northeast continuation of the Biwabik Formation (Goodwin 1956) only limited areas of sub-economic iron concentration have been identified in the Thunder Bay area, none within Oliver Township (Moorhouse 1960). It has been noted, however (Moorhouse 1960), that in areas of thick overburden cover, such as in the southern half of Oliver Township, a complete evaluation is often hindered by insufficient outcrop.

Abundant Archean iron formation is present in townships to the west and north of Oliver Township and these have been assessed in the past for their iron potential (Parsons 1922). Occurrences of Archean iron formation in Oliver Township are limited and the potential for economic iron ore bodies within these rocks is minimal.

Sand and Gravel

The presence of numerous operational and non-operational gravel pits in all of the townships bordering Oliver Township, as well as the generally thick (< 22m) overburden cover present in the southern half of the township indicates there is potential for economic deposits of sand and gravel within the township.

A few small gravel pits, none currently in operation, have been worked in the past in the southwest and north central parts of the township.

Property Descriptions

Information presented below was compiled from data in the assessment files of the Resident Geologist's office. Ministry of Northern Development and Mines, Thunder Bay, from historical reports and files of old newspaper and other clippings also located in the Thunder Bay Resident Geologist's office, and from observations made during the present field season.

"Properties" refers to those locations which are currently staked; "Locations" refers to areas of old workings and mineral showings which are not currently held. Where significant assay results were obtained from the summer's sampling, they are included in the description of the property.

Properties

1 - Moore-Grayson Claims

Prior to 1928, veins "of the silver-bearing type" (Tanton 1931, p. 141) had been noted at this location. The property was staked as Mining Location D and a small amount of stripping was carried out which uncovered a 1.2m (4') wide quartz vein within locally brecciated amphibolite schist. The vein trended 192°, dipping vertically, and contained small amounts of galena and chalcopyrite. A network of smaller, similarly mineralized, composite veins branched out from the main vein in a southwest direction. Well-formed quartz and amethyst crystals were noted within the smaller, composite veins. No assay values or other results were reported from this work.

No further work was reported until the present claim group was staked in 1970 by L. Grayson. Interest at this time resulted from reports of copper and gold mineralization uncovered nearby during construction on the north hydroelectric dam on the Kaministiquia River. A partnership venture was formed with P. Moore shortly afterward and stripping and trenching were carried out early in the 1970s. The work concentrated on outcrops a few hundred metres east of the showing investigated prior to 1928. Two composite quartz veins, trending generally north and locally showing minor amethyst coloration, were uncovered within schistose mafic volcanic rock. Scattered zones of fracturing and brecciation were noted in the outcrops. A 4.6m (15') deep shaft was put down where one brecciated zone was intersected by a narrow felsic dike trending approximately north. A zone of shearing 2m wide), trending generally northeast and cross-cutting the felsic dike, was uncovered in the vicinity of the shaft (see property sketch. Figure 12). Up to 3% pyrite finely disseminated along foliation planes, as well as in thin, cross-cutting quartz veinlets, occurs in the vicinity of the shear zone.

Metal values reported from the property in 1972 were as high as 0.24 ounce Au per ton, 0.22 ounce Ag per ton, 0.24% Cu and 2.9% Fe. The best assay results were reportedly obtained from samples collected within, and adjacent to, the sheared zone (Assessment files. Resident Geologist's office. Ministry of Northern Development and Mines, Thunder Bay).

No further work was recorded on this property until 1985 when a minor amount of stripping was carried out. In 1989, P. Moore bought out his partner and completed two diamond drill holes, totalling 90m (296'), to test the mineralized zone in the vicinity of the shaft. The highest value reported from this work was 23 ppb Au. The claims were allowed to lapse. The property was re-staked at the end of the current field season as a result of interest in the amethyst potential of the property.

2 - Calvert-Wing Claims

A block of six claims was staked in Oliver and Conmee townships by D. Calvert and A. Wing shortly after published reports by Carter (1985) indicated that values of up to 0.24 ounce Au per ton and 0.78 ounce Ag per ton, were obtained from a zone of shearing within chloritized, silicified, pyritized dacite located in east central Conmee Township. The property was optioned to Inco Gold Company Limited in 1987. Linecutting, soil geochemistry and geological mapping were carried out by the company that same year. Two areas of significant gold mineralization (>500 ppb) were located as a result of the soil survey, and hand samples of sulphide-bearing, silicified, sheared, felsic and intermediate metavolcanic rocks from the west shore of the Kaministiquia River returned assay values of up to 24.8 ppm Au. Follow-up magnetometer, VLF, and IP surveys, and 738.8m of diamond drilling were carried out by Inco Gold Company Limited in 1988. No significant results were reported on the portion of the property underlying Oliver Township, and drilling results in Conmee Township were considered discouraging. The option was dropped. In 1989, two diamond drill holes, totalling 151.2m (496'), were completed by Calvert and Wing. The best assay value reported from this work was 537 ppb Au over 1.2m (4'). No further work has been recorded.

Locations

Location A

At this location, approximately 800 metres west of the west end of Saari Road, in the northwest portion of the township, two old trenches and a pit were found in the vicinity of a high airborne magnetometer response (see property sketch. Figure 13). This location corresponds to a pyrite occurrence noted on ODM map P.177 (Pye and Fenwick 1963). Magnetite-chert iron formation occurs interbedded with metaconglomerate, massive mafic metavolcanic rocks and fragmental intermediate to felsic metavolcanic rocks. The iron formation is locally brecciated and contains 5 to 20% pyrite as 1 to 2mm wide rims around the breccia fragments, as well as concentrations of up to 80% pyrite within a 0.6m wide gossan zone developed over a portion of the iron formation. Assay values from chip samples collected this summer over several sections within the trenches and from nearby outcrops gave values of up to 153 ppb Au and 1.6 ppm Ag. The highest values were obtained from samples collected within the trenches.

Location B

An area of old blasting was located at the western edge of a large outcrop of tuffaceous' to massive mafic metavolcanic rocks located in the northwest part of the township a few hundred metres east of the midpoint of Saari Road. A syenitic dike, trending approximately north-northwest, intrudes the volcanic rocks in the area of the blasting. Up to 1% pyrite is finely disseminated throughout the dike and within narrow, cross-cutting quartz veinlets. Minor potassic alteration was noted within fine fractures trending roughly parallel to the felsic dike. Assay values from grab samples collected this summer were only marginally anomalous (7 to 9 ppb Au).

Location C

An old shaft is present on the property of Hill's Greenhouse, located on the north side of Oliver Road, immediately west of 2nd Sideroad, in the southern part of the township. The shaft is presently being used as a water well. Historical files indicate that the 135 foot (41.1m) deep shaft, with levels at 60 feet (18.3m) and 123 feet (37.5m) had been put down prior to 1891 on a composite quartz vein within brecciated Proterozoic sedimentary rocks. A 75 foot (22.9m) drift had been constucted on the first level and a 25 foot (7.6m) drift had been constructed on the second level. Four test pits had also been dug: three to the west-northwest of the shaft, following the trend of the vein; and a fourth to the southeast of the shaft, in unmineralized rock. The quartz vein is locally brecciated and mineralized with amethyst, argentiferous galena, argentite and native silver. The vein was reported to be three feet (0.9m) in width at surface but widens to six feet (1.8m) at a depth of 50 feet (15.2m) (historical files. Resident Geologist's office. Ministry of Northern Development and Mines, Thunder Bay). Assay values reported from 1890 range from 73 ounces Ag per ton to 125 ounces Ag per ton. Present surface exposures show only a narrow (<lm) vein with very minor (<1%) galena. Little can be seen on the walls of the shaft above the current water level. Grab samples collected at this location during the summer gave no anomalous silver values.

Location D

This location is situated near the elementary school in the community of Murillo, approximately one kilometre west of Location

C. Very little information is available concerning this showing. According to Tanton (1931), two shafts were put down on this property prior to 1890. The deeper of the two former shafts (80 feet (24.4m)) is currently being used as a water well for the school and could not be investigated this summer. The shallower shaft (30 feet (9.1m)) was reportedly 45.7m (150') west of the deeper one. No evidence remains of this second shaft. The shafts were reportedly put down on a composite quartz vein, made up of a network of tiny veinlets in a zone at least 6.1m (20') wide. The general strike of the vein is east, with a dip of 45° north (Tanton 1931). Host rock and mineralization are similar to that at Location C. Hand samples collected this summer from a waste rock pile situated approximately 100m west of the current water well show brecciated quartz-calcite vein material with local amethyst coloration and rare specks of galena. No anomalous values were obtained from sampling this summer.

Location E

Work at this location, situated along the north side of Pole Line Road, roughly 300m east of Mining Road, at the south boundary of the township, was carried out prior to 1928. None of the work is recorded in government assessment files. According to Tanton (1931), at least one test pit was sunk on this occurrence. A zone of veining was uncovered, reportedly up to 35 feet (10.7m) wide, composed of a network of veinlets, generally less than 2 inches (50.8mm) wide, trending 065° dipping vertically and 090° dipping vertically. The network of veins reportedly occurred in a brecciated fault zone within interbedded shale and chert units of the Gunflint Formation (Tanton 1931). Abundant chalcopyrite was reported in some of the tiny veinlets (Tanton 1931). Assay values in 1925 were reportedly as high as 16 ounces Ag per ton. Examination of this area during the field season located one poorly preserved test pit and a few small outcrops. Brecciated fragments of chert, siltstone and mudstone occur cemented by calcite and crystalline quartz, locally showing varying degrees of amethyst coloration. Malachite and pyrite, both generally <1% by volume, and up to 2% chalcopyrite are present as fine fracture fillings and as small blebs within the brecciated zone. Grab samples collected this summer returned values of 872 ppm Cu, but no other metals.

Location F

This location is situated on the south side of Pole Line Road, at the intersection with Mining Road, a few metres south of the township boundary. Tanton (1931) reported the presence of pits and trenches, put down prior to 1923, at this showing. The work was believed (Tanton 1931) to represent an attempt to investigate the extension of the faulted and quartz-veined zone found at Location E. Host rock and mineralization were reportedly very similar to that at Location E (Tanton 1931). The workings at this location are very poorly preserved and the property could not be sufficiently investigated this summer.

Location G

Evidence of old diamond drill holes were found along the east side of the Kaministiquia River, approximately 500m northwest of the west end of John Street Road, in the west central part of the township. Narrow zones of moderate shearing trending approximately northeast and east are scattered throughout ther fine- to coarse-grained massive and pillowed mafic volcanic rocks in this area. Finely disseminated pyrite, generally less than 2% by volume, occurs along the foliation planes within and adjacent to the zones of shearing. Several grab samples were collected in this area and assay results returned values of up to 0.003 ounce Au per ton.

RECOMMENDATIONS TO PROSPECTORS

Although several commodities have been reported from the showings located within Oliver Township to date, the settings of mineralization can be grouped into three main categories: narrow zones of shearing within the Archean metavolcanic rocks, associated with either the contact strain aureoles of felsic intrusions, or with lithologic boundaries between metavolcanic sequences; brecciated zones within Archean iron formation; and brecciated quartz and calcite veined zones associated- with late faults in the Proterozoic rocks.

Several zones of weak to moderate shearing have been noted within the Archean sequences underlying the study area. Anomalous gold values were obtained from sampling this field season in pyritized, narrow, sheared zones within the extensive outcrops of pillowed, massive and coarse-grained mafic metavolcanic rocks along the east shore of the Kaministiquia River in the west central part of the township. Similar zones of shearing are present within the intermediate to felsic metavolcanic rocks located a few kilometres north of these outcrops. Minor to moderate sericitization is commonly present in the sheared zones within these intermediate to felsic sequences, and low gold values have been reported from exploration work carried out in this area (Property 2). In addition, copper and zinc mineralization has been noted within a sericitized, sulphide-bearing zone of shearing in intermediate to felsic metavolcanic rocks located in Ware Township. This showing is situated approximately 1km north of the boundary of Oliver Township, in the vicinity of Mud Lake Road. The metavolcanic rocks hosting the mineralization in Ware Township are a continuation of the belt of intermediate to felsic metavolcanic rocks underlying the northwest part of Oliver Township.

Magnetite-chert iron formation interbedded with massive mafic metavolcanic flows and intermediate fragmental volcanics outcrops in the northwest part of the township. Pyrite mineralization at this location occurs within a zone of brecciation cutting the iron formation. Anomalous gold values were obtained from sampling during the current field season at this location (Location A).

Several silver and copper occurrences were investigated in the late 1800s and early 1900s within the Proterozoic rocks in the southern part of the township. Many had pits and shafts constructed by the early workers. These showings are associated with zones of brecciation resulting from late faulting. In the vicinity of the Archean unconformity, these zones are also a prime locus for amethyst mineralization.

In summary, shear zones hosting finely disseminated pyrite within the Archean metavolcanic sequences should be closely investigated for potential gold mineralization, particularly where they occur near late felsic intrusions or are associated with lithologic boundaries. The presence of late faults in these areas may increase the potential for mineralization. Zones of shearing within the intermediate to felsic metavolcanic rocks in the northwest part of the township have further potential to host copper and zinc mineralization.

Exposures of Archean iron formation should be closely investigated for potential gold mineralization, particularly where late brecciation has produced sites for the precipitation of economic concentrations of minerals.

The amethyst potential of many of the old silver and copper occurrences in the Proterozoic rocks in the southern part of the township has never been fully assessed. In light of current marketing and promotional projects, these showings deserve more attention.

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Landform Type	Characteristics	Location Within Township	Density of Outcrop
Ground moraine, bedrock knobs subordinate	Low relief; variable undulating, ridged and planar topography; surface conditions dry to mixed wet and dry; material composed of silty till	Most of central and southern portions	Moderate in central portions to scarce in south
Ground moraine with bedrock knobs beneath thin veneer of drift	Moderate relief; knobby, hummocky topography; surface conditions dry; material composed of silty, clayey till	Northeast corner, portions of northwest corner	Moderate
Organic terrain locally overlying glaciolacustrine plain	Low relief; planar topography; surface conditions wet; material composed of peat, muck, clay	Scattered patches. Most abundant in north central and central portions	Scarce
Ground moraine with bedrock knobs, and bedrock beneath thin veneer of drift	High relief; knobby, hummocky topography; surface conditions dry; material composed of silty till and bedrock	Northwest corner	Abundant
Glaciolacustrine plain	Low relief; planar topography; surface conditions dry; material composed of sand and silt	Adjacent to Kaministiquia River in west and southwest	Absent
Alluvial plain, local bedrock plain, bedrock plateau	Low to moderate relief; planar to rugged and cliffed topography; surface conditions dry to mixed wet and dry; material composed of sand, gravel, bedrock	Along Kaministiquia River	Absent to abundant
Glaciofluvial kames with bedrock beneath a thin veneer of drift	Moderate relief; variable knobby, hummocky and ridged topography; surface conditions dry; material composed of sand and gravel	North central portion	Scarce
End moraine	Low relief; ridged topography; surface conditions dry; material composed of sandy, bouldery till	Southeast corner	Absent

Table 1. Physiographic regions identified in Oliver Township. (Summarized from Mollard and Mollard 1981)

Table 2 - Results of geochemical analyses of the metavolcanic rocks in Oliver Township.

Sample Name	Easting	Northing	Rock Type	Mg Numbe	SiO2	TiO2	Al2O3	Fe2O3	MnO	MgO	CaO	Na2O	K2O	P2O5	LOI
GHB-92-0003	309330	5376025	int volc	54.42	63.18	0.53	14.55	4.08	0.09	2.46	3.63	4.12	2.74	0.38	2.38
GHB-92-0006	309350	5375780	felsic volc	41.90	71.07	0.27	12.30	1.84	0.04	0.67	3.27	2.86	2.24	0.14	4.14
GHB-92-0027	310565	5375590	felsic volc	42.31	71.01	0.28	13.28	1.35	0.06	0.50	3.40	3.91	2.40	0.12	4.21
GHB-92-0029	310535	5375570	mafic to int volc	47.76	52.51	1.10	13.24	7.69	0.14	3.55	7.51	2.95	1.54	0.36	7.98
GHB-92-0038	311270	5374430	mafic volc	56.34	48.01	0.73	13.93	9.87	0.24	6.43	8.01	2.31	2.78	0.46	5.37
GHB-92-0039	311270	5374430	mafic volc	28.18	56.20	0.41	12.77	16.76	0.47	3.32	4.05	2.33	1.44	0.12	2.43
GHB-92-0040	311200	5375420	mafic to int volc	55.27	52.29	1.08	13.92	9.68	0.10	6.04	3.51	4.08	0.90	0.32	6.60
GHB-92-0060	314860	5375040	mafic to int pillowed	65.84	54.38	0.56	14.78	7.89	0.11	7.68	7.05	3.16	0.56	0.12	2.07
GHB-92-0061	314860	5375040	mafic to int volc	63.33	56.01	0.58	15.94	7.50	0.12	6.54	7.31	4.08	1.00	0.14	1.11
GHB-92-0065	315480	5373160	mafic volc	46.17	49.88	1.21	14.24	14.11	0.25	6.11	9.87	3.25	0.20	0.12	0.50
GHB-92-0068	316770	5372350	mafic volc	48.98	49.92	1.14	14.12	14.03	0.24	6.80	10.06	2.79	0.30	0.10	0.83
GHB-92-0075	316155	5373080	mafic to int volc	42.55	48.23	1.42	13.52	16.39	0.22	6.13	7.93	3.38	0.16	0.16	0.76
GHB-92-0131	309350	5368250	c-g mafic volc	52.46	50.00	1.10	15.00	14.00	0.21	7.80	9.90	1.80	0.32	0.12	0.85
GHB-92-0220	312555	5373105	mafic to int;porph	82.50	54.00	0.41	13.00	6.30	0.11	15.00	4.00	2.70	0.88	0.10	4.00
GHB-92-0221	312625	5371670	mafic,pillowed	48.66	51.00	1.20	14.00	14.00	0.24	6.70	9.50	3.10	0.08	0.12	0.72
GHB-92-0222	314405	5372690	mafic,pillowed	44.20	48.00	1.20	15.00	13.00	0.19	5.20	14.00	1.50	0.28	0.10	1.60
GHB-92-0223	314600	5377000	felsic tuff	39.07	75.00	0.31	13.00	2.10	0.03	0.68	1.70	2.50	2.20	0.10	2.20
GHB-92-0224	312550	5377800	mafic to int;hem'zd	54.81	55.00	0.72	16.00	8.00	0.13	4.90	6.90	4.10	1.10	0.30	2.00
GHB-92-0225	319380	5374075	porp maf to int	70.63	65.00	0.38	13.00	5.60	0.07	6.80	3.90	2.60	1.00	0.08	1.90
GHB-92-0226	319030	5373485	c-g mafic volc	45.41	50.00	1.40	14.00	15.00	0.23	6.30	8.30	3.10	0.26	0.12	1.40
GHB-92-0227	309160	5375060	massive felsic	36.14	70.00	0.29	14.00	3.50	0.13	1.00	2.70	3.40	2.50	0.10	4.00
GHB-92-0228	317510	5371010	mafic,pillowed	50.14	49.00	1.10	16.00	13.00	0.27	6.60	11.00	2.00	0.50	0.08	0.89
RIF-92-0001	309180	5373310	int to felsic volc	51.26	71.45	0.36	13.03	3.22	0.03	1.71	1.42	3.91	2.60	0.14	1.63
RIF-92-0009	309190	5373240	mafic to int volc	50.20	57.62	0.65	15.87	7.27	0.09	3.70	7.65	3.56	0.50	0.26	1.87
RIF-92-0033	311550	5373725	mafic to int volc	75.94	54.85	0.49	13.18	8.09	0.13	12.89	2.85	1.93	0.46	0.10	4.82
RIF-92-0049	311850	5374030	mafic to int volc	71.60	55.07	0.42	12.69	5.49	0.12	6.99	6.89	3.09	0.86	0.10	8.00
RIF-92-0052	314220	5374045	mafic to int volc	63.80	54.57	0.69	16.43	6.82	0.10	6.07	5.22	4.75	1.08	0.16	2.03
RIF-92-0056	308580	5374080	mafic volc	67.21	48.31	0.63	12.49	7.75	0.22	8.02	6.68	2.66	3.60	0.52	6.73
RIF-92-0075	310855	5373120	mafic volc	74.88	50.00	0.42	12.00	9.30	0.20	14.00	9.30	1.80	0.36	0.08	3.10
RIF-92-0080	310525	5372820	mafic to int volc	75.16	55.00	0.50	14.00	7.20	0.14	11.00	4.90	2.60	1.10	0.10	3.10
RIF-92-0086	309175	5371820	int to felsic volc	59.34	66.00	0.36	15.00	3.60	0.08	2.80	2.20	0.85	3.40	0.16	3.60
RIF-92-0096	310705	5372550	int to felsic volc	54.52	67.00	0.39	15.00	3.80	0.07	2.30	4.20	2.80	1.90	0.16	2.50
RIF-92-0108	317825	5374635	int to felsic tuff	44.65	68.00	0.30	15.00	2.70	0.04	1.10	1.60	6.50	1.00	0.10	1.00
RIF-92-0112	316615	5374215	mafic to int volc	67.82	57.55	0.57	14.22	7.48	0.13	7.96	5.47	3.06	1.68	0.14	1.92
RIF-92-0116	316300	5374150	mafic to int volc	72.03	55.81	0.49	14.26	6.53	0.11	8.49	5.03	4.77	1.02	0.12	1.49
RIF-92-0118	315420	5374185	mafic to int volc	68.57	57.38	0.58	14.62	7.09	0.13	7.81	6.15	4.09	0.44	0.12	1.79
RIF-92-0150	320575	5373370	mafic to int volc	61.10	54.00	0.63	18.00	8.70	0.12	6.90	6.00	3.00	1.50	0.12	2.40
RIF-92-0154	320310	5371305	mafic volc	54.62	48.00	1.00	16.00	13.00	0.20	7.90	11.00	2.10	0.36	0.10	0.75
RIF-92-0215	320855	5376475	int to felsic volc	50.50	69.00	0.34	16.00	3.30	0.04	1.70	2.60	4.00	2.60	0.14	1.00
RIF-92-0216	309390	5369210	f-g mafic volc	45.80	50.00	1.40	15.00	15.00	0.12	6.40	9.40	1.50	0.46	0.12	1.20

Sample Name	Cr	Ni	Co	Sc	V	Cu	Zn	Mo	K	Ba	Sr	Zr	Ti	Y	Be
GHB-92-0003	70	25	15	9	75	40	185	0.00	22746	730	760	170	3177	14	2.00
GHB-92-0006	50	15	0	5	30	15	70	0.00	18595	510	160	100	1619	8	1.00
GHB-92-0027	65	5	0	2	35	10	35	0.00	19923	260	100	120	1679	10	1.00
GHB-92-0029	185	110	30	16	125	30	115	0.00	12784	220	250	130	6595	16	2.00
GHB-92-0038	245	55	30	24	190	0	95	0.00	23078	890	660	110	4376	16	3.00
GHB-92-0039	65	40	10	9	80	15	65	0.00	11954	230	180	90	2458	4	2.00
GHB-92-0040	195	85	20	22	140	55	95	0.00	7471	580	290	110	6475	16	2.00
GHB-92-0060	485	265	35	22	125	35	80	0.00	4649	160	290	90	3357	6	2.00
GHB-92-0061	465	195	30	22	145	60	70	0.00	8301	220	180	90	3477	6	2.00
GHB-92-0065	195	90	40	45	325	75	120	0.00	1660	50	160	70	7254	24	2.00
GHB-92-0068	200	105	45	45	325	140	125	0.00	2490	50	120	60	6834	24	2.00
GHB-92-0075	140	50	45	50	370	175	85	0.00	1328	30	90	90	8513	36	2.00
GHB-92-0131	205	100	55	41	280	60	25	1.00	2656	100	120	72	6595	22	0.00
GHB-92-0220	889	570	40	13	75	0	0	1.00	7305	230	170	88	2458	8	0.00
GHB-92-0221	205	80	50	45	300	75	25	1.00	664	63	150	72	7194	22	0.00
GHB-92-0222	274	70	45	42	290	65	25	2.00	2324	110	220	70	7194	20	0.00
GHB-92-0223	205	20	0	4	39	0	20	1.00	18263	410	160	110	1858	10	0.00
GHB-92-0224	342	50	30	20	170	40	20	18.00	9131	280	990	120	4316	16	0.00
GHB-92-0225	616	210	30	15	88	35	15	3.00	8301	250	220	92	2278	10	0.00
GHB-92-0226	205	70	50	46	330	85	45	2.00	2158	120	120	80	8393	24	0.00
GHB-92-0227	274	40	5	5	46	25	20	0.00	20753	400	140	140	1739	10	0.00
GHB-92-0228	274	160	60	40	270	140	10	1.00	4151	150	170	58	6595	18	0.00
RIF-92-0001	75	25	0	5	45	20	25	0.00	21583	450	180	110	2158	6	1.00
RIF-92-0009	210	60	15	18	120	50	85	0.00	4151	180	930	140	3897	12	2.00
RIF-92-0033	865	420	40	19	115	15	105	0.00	3819	150	100	80	2938	8	1.00
RIF-92-0049	360	160	15	16	95	0	35	0.00	7139	180	170	70	2518	8	2.00
RIF-92-0052	305	180	30	20	130	60	100	0.00	8965	250	380	130	4137	14	2.00
RIF-92-0056	385	200	30	18	135	25	105	0.00	29885	940	870	160	3777	20	3.00
RIF-92-0075	958	380	45	24	130	15	0	1.00	2988	200	210	68	2518	10	0.00
RIF-92-0080	1026	480	40	21	120	160	15	1.00	9131	300	340	84	2998	12	0.00
RIF-92-0086	205	30	5	7	54	35	45	1.00	28224	400	180	120	2158	8	0.00
RIF-92-0096	753	110	15	6	72	90	40	2.00	15772	400	350	120	2338	8	0.00
RIF-92-0108	479	10	10	4	49	10	30	1.00	8301	250	200	120	1799	4	0.00
RIF-92-0112	380	210	25	18	135	40	100	0.00	13946	420	260	90	3417	12	2.00
RIF-92-0116	500	260	30	17	130	45	75	0.00	8467	220	190	90	2938	10	2.00
RIF-92-0118	475	260	30	18	105	55	75	0.00	3653	130	230	110	3477	10	2.00
RIF-92-0150	342	100	35	25	140	85	45	0.00	12452	460	290	92	3777	16	0.00
RIF-92-0154	274	290	50	40	260	120	15	0.00	2988	110	130	56	5995	18	0.00
RIF-92-0215	410	20	5	4	57	45	50	1.00	21583	660	280	130	2038	4	0.00
RIF-92-0216	205	50	40	45	330	0	25	1.00	3819	160	110	84	8393	28	0.00

TABLE 3: ASSAY RESULTS, WITH DESCRIPTIONS AND LOCATIONS OF SAMPLES						
SAMPLE NUMBER	**Au ppb**	**Ag ppm**	**Cu ppm**	**Pb ppm**	**Zn ppm**	**COMMENTS**
GHB-92-002	10	<0.2	32			1% disseminated py in carbonatized intermediate to felsic tuff. Northwest part of township. 309330E, 5376025N.
GHB-92-005	9	0.4	44			≤1% disseminated py in weakly magnetic, carbonatized, hematized, mafic to intermediate tuff. Northwest part of township. 309375E, 5375940N.
GHB-92-007	<5	<0.2	11			≤1% py disseminated and along fractures in sericitic, carbonatized, fine-grained felsic volcanic. Northwest part of township. 309370E, 5375590N.
GHB-92-008	6	<0.2	14			2-3% py disseminated in feldspar and quartz-phyric, carbonatized, sericitic felsic volcanic. Northwest part of township. 309420E, 5375465N.
GHB-92-012	<5	0.4	40			≤1% py disseminated in carbonatized, fine-grained intermediate to felsic volcanic. Northwest part of township. 309000E, 5374725N.
GHB-92-013	<5	<0.2	12			≤1% py disseminated in fractured, carbonatized, feldspar and quartz-phyric felsic volcanic. Same location as above.
GHB-92-014	7	<0.2	14			≤1% py along fractures in carbonatized felsic tuff. Northwest part of township. 308930E, 5374710N.
GHB-92-015	7	0.4	14			≤1% py disseminated in fractured, carbonatized felsic tuff. Northwest part of township. 308635E, 5374750N.
GHB-92-016	7	0.4	15			≤1% py disseminated in hematized, feldspar and quartz-phyric felsic volcanic. Northwest part of township. 308830E, 5374780N.
GHB-92-017	<5	0.4	8			≤1% py disseminated in fractured, carbonatized felsic lapilli tuff. Northwest part of township. 309655E, 5375345N.
GHB-92-019	<5	<0.2	10			≤1% py disseminated in carbonatized intermediate to felsic tuff. Northwest part of township. 309800E, 5376060N.
GHB-92-020	7	<0.2	19			≤1% py disseminated in amphibole, feldspar and quartz-phyric intermediate to felsic volcanic. Northwest part of township. 309820E, 5376085N.
GHB-92-021	12	<0.2	31			≤1% py disseminated in mafic volcaniclastic sediment. Northwest part of township. 309865E, 5376395N.
GHB-92-022	7	<0.2	29			≤1% py in veinlets and rimming clasts in Archean metaconglomerate. Northwest part of township. 310525E, 5376100N.
GHB-92-026	10	0.4	7			≤1% py disseminated in rusty, carbonatized felsic tuff cut by minor quartz veinlets. Northwest part of township. 310565E, 5375590N.

TABLE 3: ASSAY RESULTS, WITH DESCRIPTIONS AND LOCATIONS OF SAMPLES						
SAMPLE NUMBER	Au ppb	Ag ppm	Cu ppm	Pb ppm	Zn ppm	COMMENTS
GHB-92-028	6	0.4	18			≤1% py disseminated in feldspar and quartz-phyric felsic volcanic. Northwest part of township. 310500E, 5375625N.
GHB-92-030	7	<0.2	44			Minor py disseminated in carbonatized intermediate to felsic lapilli tuff. Northwest part of township. 310270E, 5375000N.
GHB-92-032	<5	<0.2	66			≤1% py disseminated and within quartz veins cutting syenite dike. Northwest part of township. Location B. 310565E, 5374070N.
GHB-92-033	9	<0.2	56			Same location, mineralization and rock type as above.
GHB-92-034	7	<0.2	34			Minor py disseminated in fine-grained mafic volcanic near contact with syenite dike. Same location as above.
GHB-92-035	7	<0.2	56			≤1% py disseminated in mafic to intermediate tuff cut by numerous quartz ± epidote veinlets. Northwest part of township. 310620E, 5374100N.
GHB-92-037	6	<0.2	26			≤1% py disseminated in weakly magnetic, amphibole-phyric mafic to intermediate volcanic. Northwest part of township. 311270E, 5374430N.
GHB-92-041	7	<0.2	6			Minor py disseminated in rusty, carbonatized, fine-grained felsic volcanic. Northwest part of township. 311200E, 5375600N.
GHB-92-042	7	<0.2	20			≤1% py along fractures in carbonatized felsic lapilli tuff. Northwest part of township. 311705E, 5376020N.
GHB-92-043	6	<0.2	18			2-3% py disseminated in fractured, carbonatized felsic lapilli tuff. Northwest part of township. 311760E, 5376010N.
GHB-92-049	6	<0.2	44			≤1% py disseminated in carbonatized, fine-grained to amphibole-phyric mafic to intermediate volcanic. Northwest part of township. 312660E, 5374810N.
GHB-92-056	7	<0.2	49			≤1% py disseminated in carbonatized, amygdaloidal mafic to intermediate volcanic. Northwest part of township. 312780E, 5375840N.
GHB-92-058	6	<0.2	3			≤1% py along foliation planes in schistose, carbonatized felsic lapilli tuff. North central part of township. 313690E, 5376170N.
GHB-92-059	6	<0.2	29			≤1% py disseminated and along fractures in hematized, weakly magnetic, amphibole-phyric mafic to intermediate volcanic. North central part of township. 313900E, 5375770N.

TABLE 3: ASSAY RESULTS, WITH DESCRIPTIONS AND LOCATIONS OF SAMPLES						
SAMPLE NUMBER	**Au ppb**	**Ag ppm**	**Cu ppm**	**Pb ppm**	**Zn ppm**	**COMMENTS**
GHB-92-066	<5	<0.2	52			1-2% fine to coarse-grained py disseminated in very fine-grained mafic volcanic. North central part of township. 314135E, 5371750N.
GHB-92-072	<5	<0.2	100			≤1% py disseminated in fractured, schistose, coarse-grained mafic volcanic cut by quartz veinlets. North central part of township. 316710E, 5372605N.
GHB-92-076	<5	<0.2	135			≤1% py disseminated in fractured, coarse-grained mafic volcanic cut by numerous epidote ± iron carbonate veinlets. North central part of township. 316155E, 5373080N.
GHB-92-079	9	<0.2	46			≤1% py disseminated in fractured, amphibole-phyric mafic to intermediate volcanic cut by numerous quartz ± epidote veinlets. North central part of township. 317160E, 5374535N.
GHB-92-084	6	<0.2	120			≤1% py disseminated and in rare lenses in fractured, fine-grained mafic volcanic. North central part of township. 317085E, 5372930N.
GHB-92-108	30	<0.2	39			≤1% py in quartz veins and veinlets cutting fractured, carbonatized, amphibole and feldspar-phyric mafic to intermediate volcanic. Northwest part of township. 309530E, 5374610N.
GHB-92-112	64	<0.2	129			1% py disseminated in fine-grained mafic to intermediate volcanic. Northwest part of township. 310715E, 5374050N.
GHB-92-134	<25	<0.2	111			Minor py in quartz veinlets cutting schistose, fine to coarse-grained mafic volcanic. Kaministiquia River, west central part of township. In vicinity of Location G. 309350E, 5368350N.
GHB-92-135	<25	<0.2	64			≤1% py disseminated in schistose, biotite-quartz-feldspar porphyry dike cutting fine-grained mafic volcanic. Same general area as above. 309315E, 5368525N.
GHB-92-136	<25	<0.2	121			≤1% py disseminated in schistose, fine-grained mafic volcanic. Same location as above.
GHB-92-137	<25	<0.2	125			≤1% py disseminated in schistose, carbonatized, rusty, pillowed mafic volcanic. Same general area as above. 309200E, 5368900N.
GHB-92-138	96	<0.2	119	<10	25	≤1% py disseminated and in quartz veinlets in schistose, carbonatized, rusty, pillowed mafic volcanic. Same location as above.
GHB-92-139	<25	<0.2	121			1-2% py disseminated and in quartz veinlets in schistose, carbonatized, rusty, pillowed mafic volcanic. Same location as above.
GHB-92-149	<25	<0.2	36			≤1% galena and minor py in quartz-calcite vein (4cm wide) cutting brecciated taconite and chert-carbonate. Southeast part of township. Location C. 316950E, 5365425N.

TABLE 3: ASSAY RESULTS, WITH DESCRIPTIONS AND LOCATIONS OF SAMPLES						
SAMPLE NUMBER	Au ppb	Ag ppm	Cu ppm	Pb ppm	Zn ppm	COMMENTS
GHB-92-152	<25	<0.2	45	<10	5	Minor py disseminated in jaspilitic chert. Along Corbett Creek at Pole Line Road, south central boundary of township. 313550E, 5363500N.
GHB-92-179	<25	<0.2	52			2-3% py in stringers and disseminated in schistose, amphibole, feldspar, and quartz-phyric mafic to intermediate volcanic. Northeast corner of township. 317900E, 5375550N.
GHB-92-187	<25	<0.2	30	<10	45	≤1% py in quartz-calcite vein cutting schistose intermediate to felsic tuff breccia. North central part of township. 315400E, 5376200N.
RIF-92-002	6	0.4	38			≤1% py disseminated in amphibole-phyric, amygdaloidal, mafic to intermediate volcanic. Northwest part of township. 308650E, 5372080N.
RIF-92-043	9	<0.2	31			Minor py disseminated in quartz veinlets cutting amygdaloidal mafic to intermediate volcanic. North central part of township. 313645E, 5373420N.
RIF-92-047	6	<0.2	99			1-2% py filling fractures and in small lenses in magnetic, fine-grained mafic to intermediate volcanic. Northwest part of township. 310700E, 5373600N.
RIF-92-064	12	<0.2	53			1-2% py disseminated in matrix, and rimming fragments in intermediate to felsic lapilli tuff. Northwest part of township. 308120E, 5373700N.
RIF-92-066	6	<0.2	48			1-2% py disseminated, in small lenses, and filling fractures in hematized, carbonatized intermediate to felsic volcanic. Northwest part of township. 309215E, 5373950N.
RIF-92-087	6	<0.2	10			1-2% py in gossan zone within schistose, carbonatized intermediate to felsic volcanic. Northwest part of township. 309175E, 5371820N.
RIF-92-097	43	<0.2	8			≤1% py disseminated in felsic tuff. Northwest part of township. 311345E, 5372890N.
RIF-92-107	<5	<0.2	38			≤1% py disseminated in feldspar porphyry dike cutting amphibole-phyric mafic to intermediate volcanic. Northeast part of township. 317825E, 5374635N.
RIF-92-125	<25	<0.2	18	<10	39	≤10% py along fractures and in lenses (≤3cm long) within felsic volcanic. Northwest part of township. 309160E, 5371760N.
RIF-92-127	<25	<0.2	21	<10	33	≤1% py disseminated in schistose quartz porphyry. Northwest part of township. 308970E, 5370615N.
RIF-92-129	<25	<0.2	13	<10	4	Rusty quartz veinlets and pods in felsic tuff. West central part of township. In vicinity of Property 2. 309160E, 5370080N.

TABLE 3: ASSAY RESULTS, WITH DESCRIPTIONS AND LOCATIONS OF SAMPLES						
SAMPLE NUMBER	Au ppb	Ag ppm	Cu ppm	Pb ppm	Zn ppm	COMMENTS
RIF-92-131	64	<0.2	93	<10	40	≤5% py in coarse-grained cubes and in crystal aggregates in rusty shear zone within quartz porphyry intruding hematized, amphibolitized intermediate to felsic volcanic. Same general area as above. 309220E, 5369680N.
RIF-92-132	<25	<0.2	109	<10	38	≤8% py filling fractures and in small lenses (≤3cm long) in sheared, rusty, intermediate to felsic volcanic. Same location as above.
RIF-92-136	<25	<0.2	41	<10	108	≤5% py along foliation planes in schistose, amphibolitized, rusty, intermediate to felsic volcanic. West central part of township. 309335E, 5369195N.
RIF-92-138	<25	<0.2	46	<10	136	≤3% disseminated py and ≤5% magnetite clots within intermediate to felsic lapilli tuff. Northwest part of township. 307525E, 5373335N.
RIF-92-143	<25	<0.2	11	<10	27	3% py as small clots in sheared felsic tuff. West central part of township. In vicinity of Property 2. 309210E, 5370175N.
RIF-92-152	30	<0.2	98	<10	83	≤10% py in small clots, along fractures and within quartz veinlets in schistose mafic volcanic. Northeast part of township. 320295E, 5371575N.
RIF-92-157	<25	<0.2	7			Rusty, fractured, hematized felsic dike intruding schistose pillowed mafic volcanic. Northeast part of township. 318900E, 5370800N.
RIF-92-162	<25	<0.2	872			2-3% cp, py and malachite filling fractures and in clots in brecciated, quartz/calcite veined zone in chert. Minor amethyst. South central part of township. Location E. 311555E, 5364575N.
RIF-92-163	<25	<0.2	97			Same location, mineralization and rock type as above.
RIF-92-169	<25	<0.2	7			≤15% py and minor malachite filling fractures in brecciated quartz vein in schistose, rusty tonalite. Southwest part of township, along Kaministiquia River, approximately 1.3 km north of falls. 305675E, 5365450N.
RIF-92-171	30	<0.2	8			≤30% py in rusty, schistose zone in felsic dike intruding amphibolite schist. Same location as above.
RIF-92-175	<25	<0.2	164			≤1% py disseminated in weakly magnetic amphibolite schist. Southwest part of township. Property 1. 307485E, 5366205N.
RIF-92-176	<25	0.3	110			≤5% py disseminated in rusty amphibolite schist. Same location as above.
RIF-92-178	30	0.3	154			Minor disseminated py in brecciated, rusty amphibolite schist. Same location as above.
RIF-92-179	30	<0.2	26			Same mineralization, rock type and location as above. Minor amethyst.

TABLE 3: ASSAY RESULTS, WITH DESCRIPTIONS AND LOCATIONS OF SAMPLES						
SAMPLE NUMBER	Au ppb	Ag ppm	Cu ppm	Pb ppm	Zn ppm	COMMENTS
RIF-92-180	<25	<0.2	40			≤1% disseminated py in brecciated amphibolite schist with quartz and calcite infilling fractures. Same location as above.
RIF-92-181	30	<0.2	28			≤20% py within fragments of brecciated chert. Same location as above.
RIF-92-182	30	<0.2	83			Minor py in rusty amphibolite schist. Same location as above.
RIF-92-183	<25	<0.2	358			Minor py in quartz, calcite and amethyst-infilled brecciated zone in amphibolite schist. Same location as above.
RIF-92-186	<25	<0.2	38			2-5% py in lenses within fractured, rusty chert. Southwest part of township, along Kaministiquia River, 500-600m upstream from falls. 305300E, 5365005N.
RIF-92-190	<25	<0.2	46	79	32	5-10% py in nodules (≤10cm in size) in matrix of Kakabeka conglomerate. Southwest part of township, along Kaministiquia River, 800m below falls. 306205E, 5363645N.
RIF-92-196	<25	<0.2	23	<10	41	≤5% py filling fractures in schistose, carbonatized felsic lapilli tuff. Northeast part of township. 310150E, 5375885N.
RIF-92-551	153	1.6	16			75-80% py and magnetite in lenses and rimming fragments in gossan zone over brecciated iron formation. Northwest part of township. Location A. 308540E, 5374145N.
RIF-92-552	12	<0.2	7			5-10% py and magnetite disseminated in weathered iron formation at edge of gossan zone. Same location as above.
RIF-92-555	16	<0.2	4			≤2% py disseminated and in stringers in chert layers of iron formation, near edge of gossan zone. Same location as above.
RIF-92-556	112	0.4	15			≤5% disseminated py and magnetite in brecciated, weakly carbonatized iron formation. Same location as above.
RIF-92-557	6	<0.2	9			10% py and minor po rimming magnetite layers within gossan zone in iron formation. Same location as above.
RIF-92-558	<5	0.4	40			≤5% py disseminated in chert layers of iron formation. Same location as above.
RIF-92-559	<5	0.2	20			10% py disseminated in chert layers of iron formation. Same location as above.
RIF-92-560	7	<0.2	5			≤5% py disseminated in gossan zone over brecciated iron formation. Chip sample over 2m. Same location as above.
RIF-92-561	76	1.2	18			≤10% py and minor po in gossan zone over iron formation. Same location as above.

TABLE 3: ASSAY RESULTS, WITH DESCRIPTIONS AND LOCATIONS OP SAMPLES						
SAMPLE NUMBER	Au ppb	Ag ppm	Cu ppm	Pb ppm	Zn ppm	COMMENTS
RIF-92-562	50	0.8	13			Minor py disseminated in chert layers of iron formation. Composite sample from three separate layers. Same location as above.

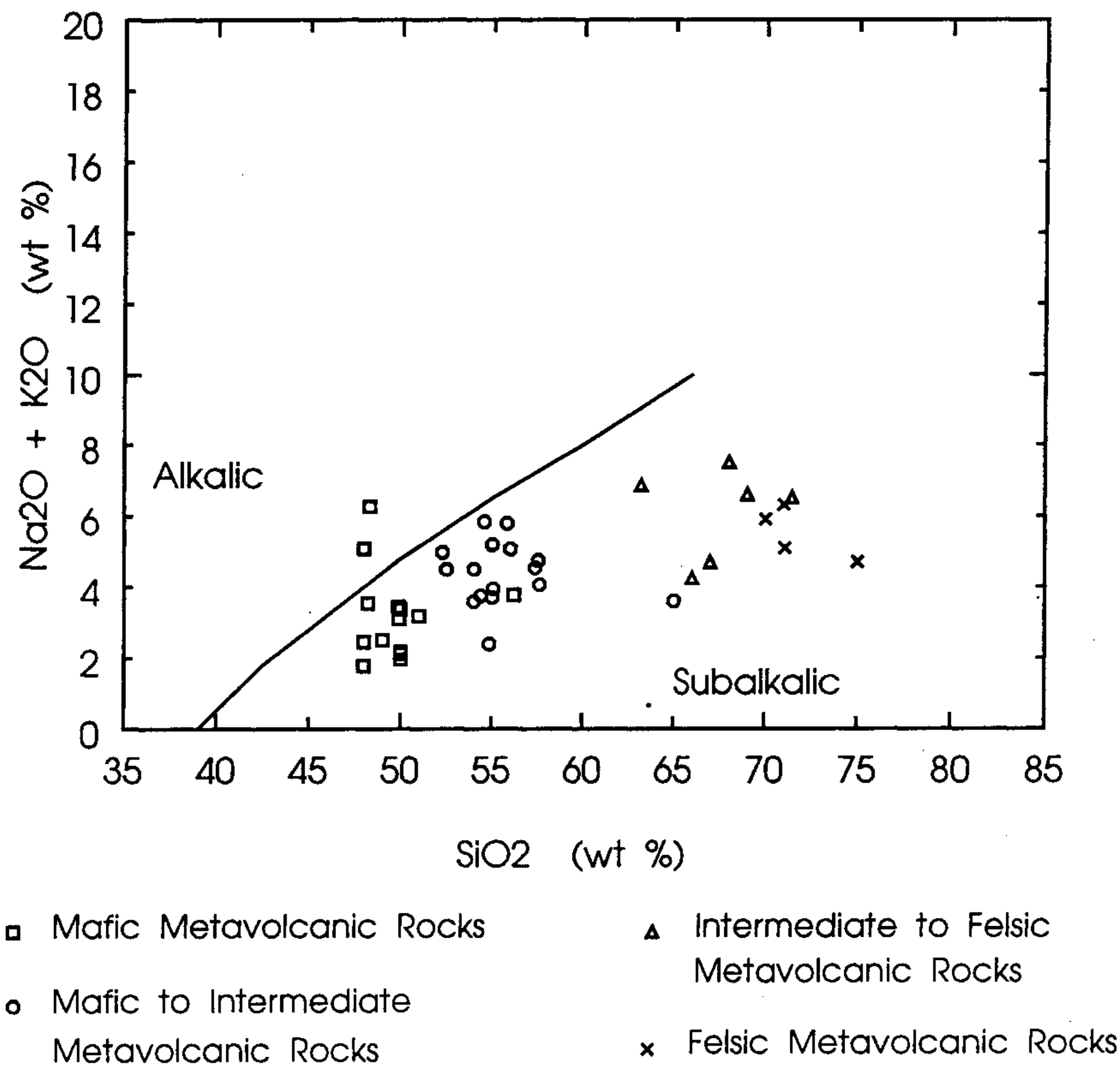

Figure 2 - Irvine and Baragar's (1971) alkalic vs subalkalic classification diagram of metavolcanic rocks in Oliver Township.

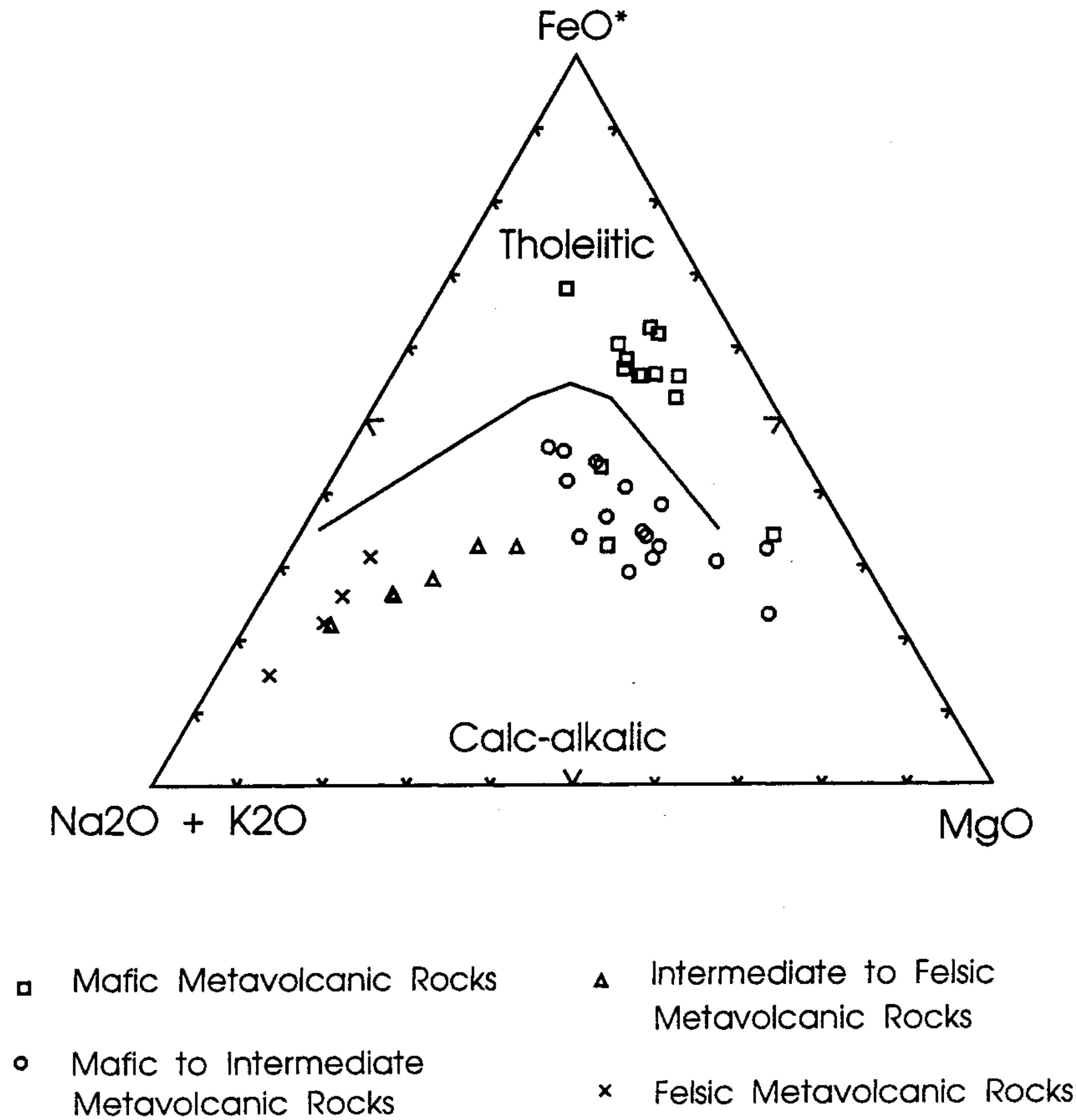

Figure 3 - Irvine and Baragar's (1971) AFM major oxide discrimination diagram of metavolcanic rocks in Oliver Township.

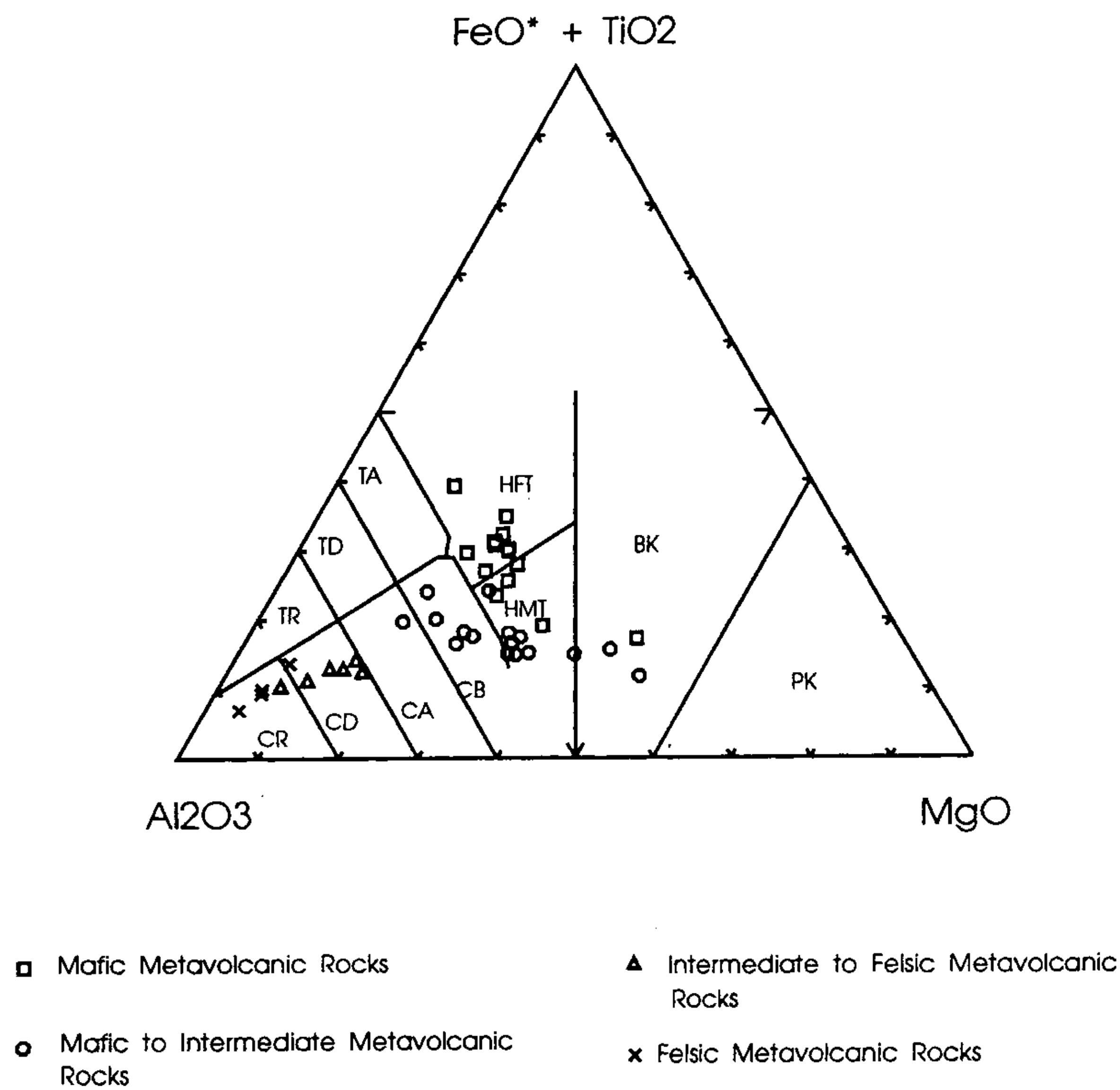

Figure 4 - Jensen's (1976) cation discrimination diagram of metavolcanic rocks in Oliver Township. PK= peridotitic (ultramafic) komatiite; BK= basaltic komatiite; HFT= high iron tholeiite; HMT= high magnesium tholeiite; CB= calc-alkalic basalt; CA= calc-alkalic andesite; CD= calc-alkalic dacite; CR= calc-alkalic rhyolite; TA= tholeiitic andesite; TD= tholeiitic dacite; TR= tholeiitic rhyolite.

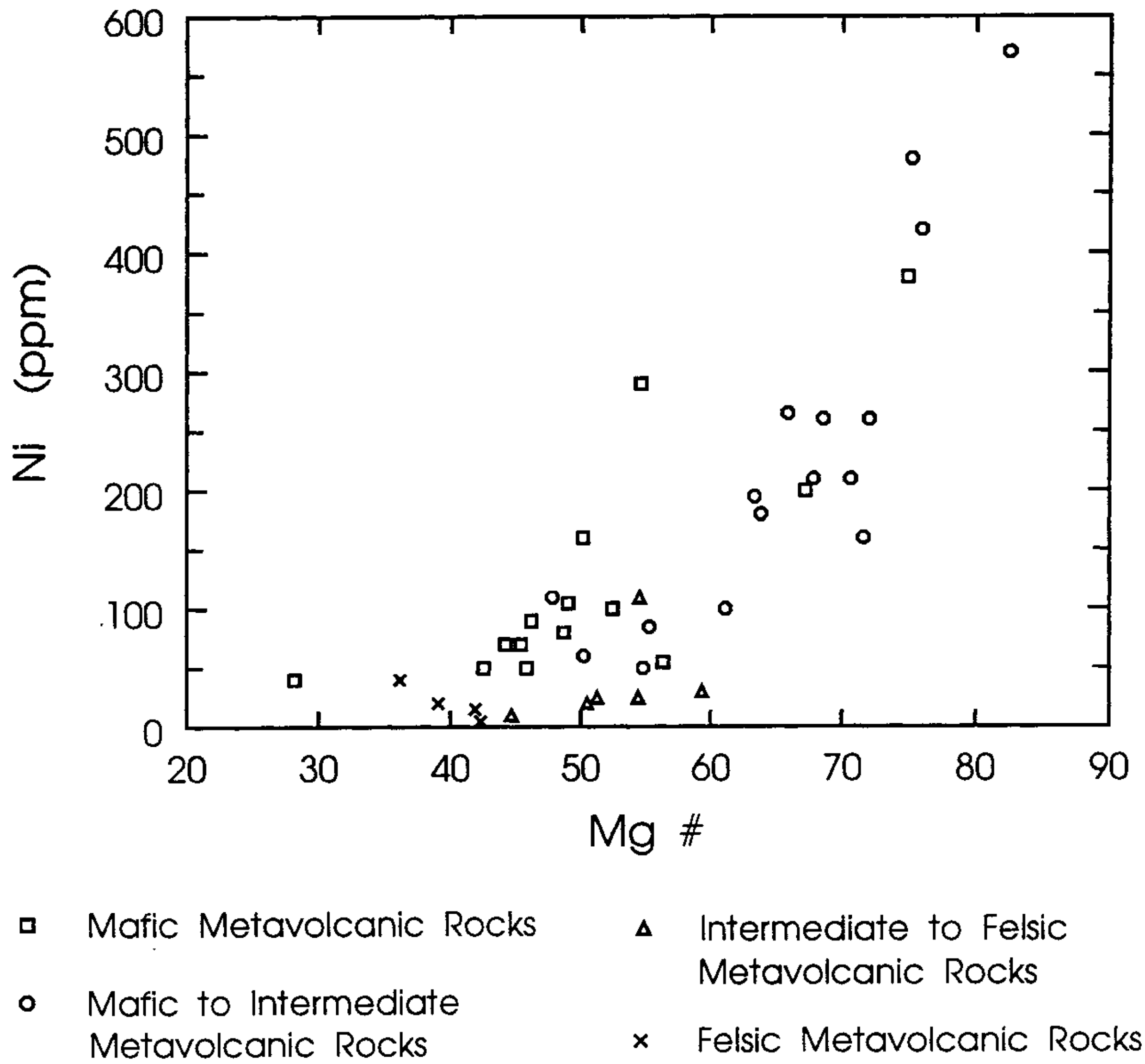

Figure 5 - Mg # vs Ni content for typical metavolcanic rocks. The four samples in the top right hand corner of the diagram plot in the basaltic komatiite field in Figure 4; the samples near the right hand side of the diagram, with Mg # values greater than 60, plot in the high magnesium tholeiite field in Figure 4.

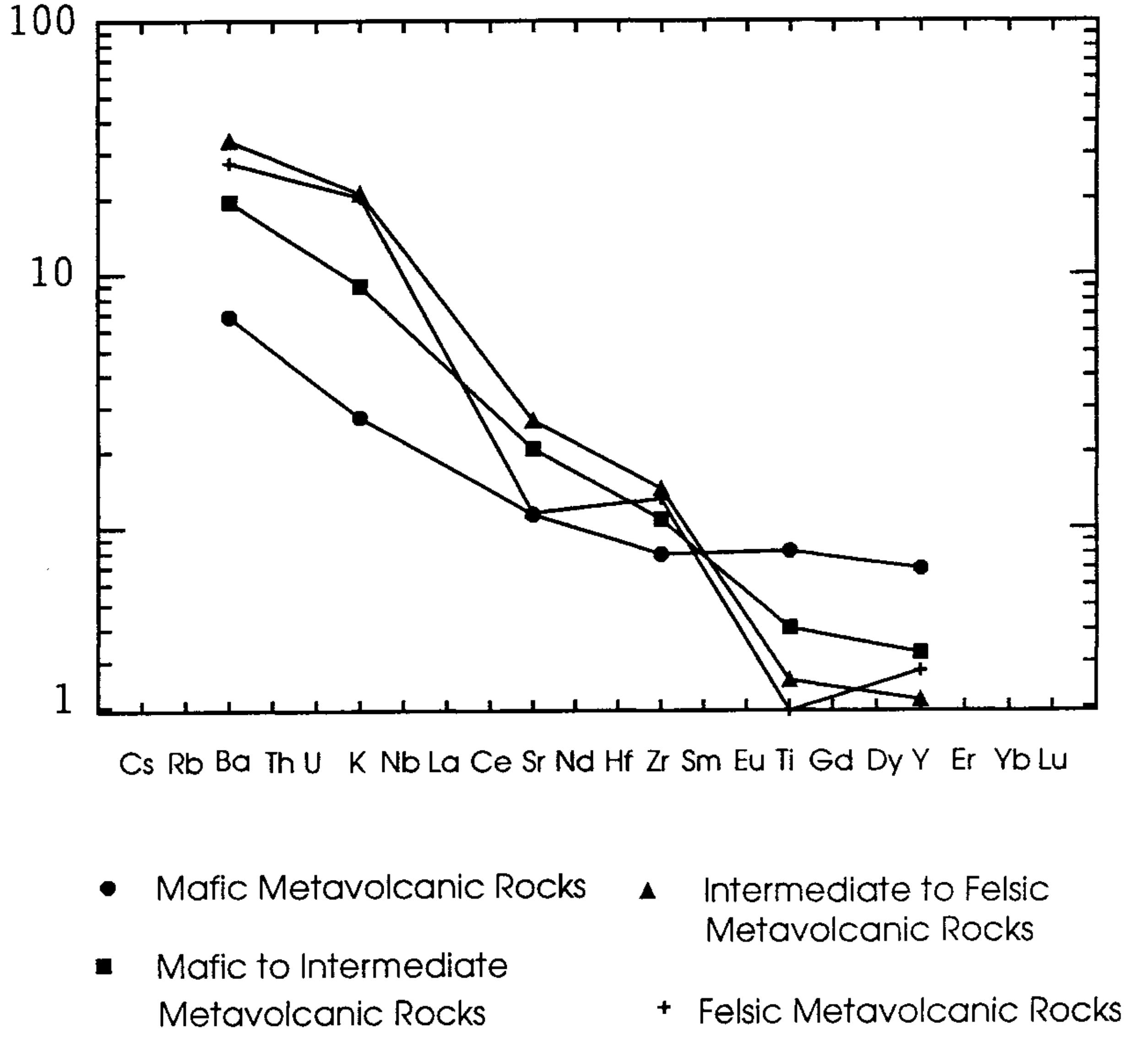

Figure 6 - Average trace element abundances for the metavolcanic units in Oliver Township.

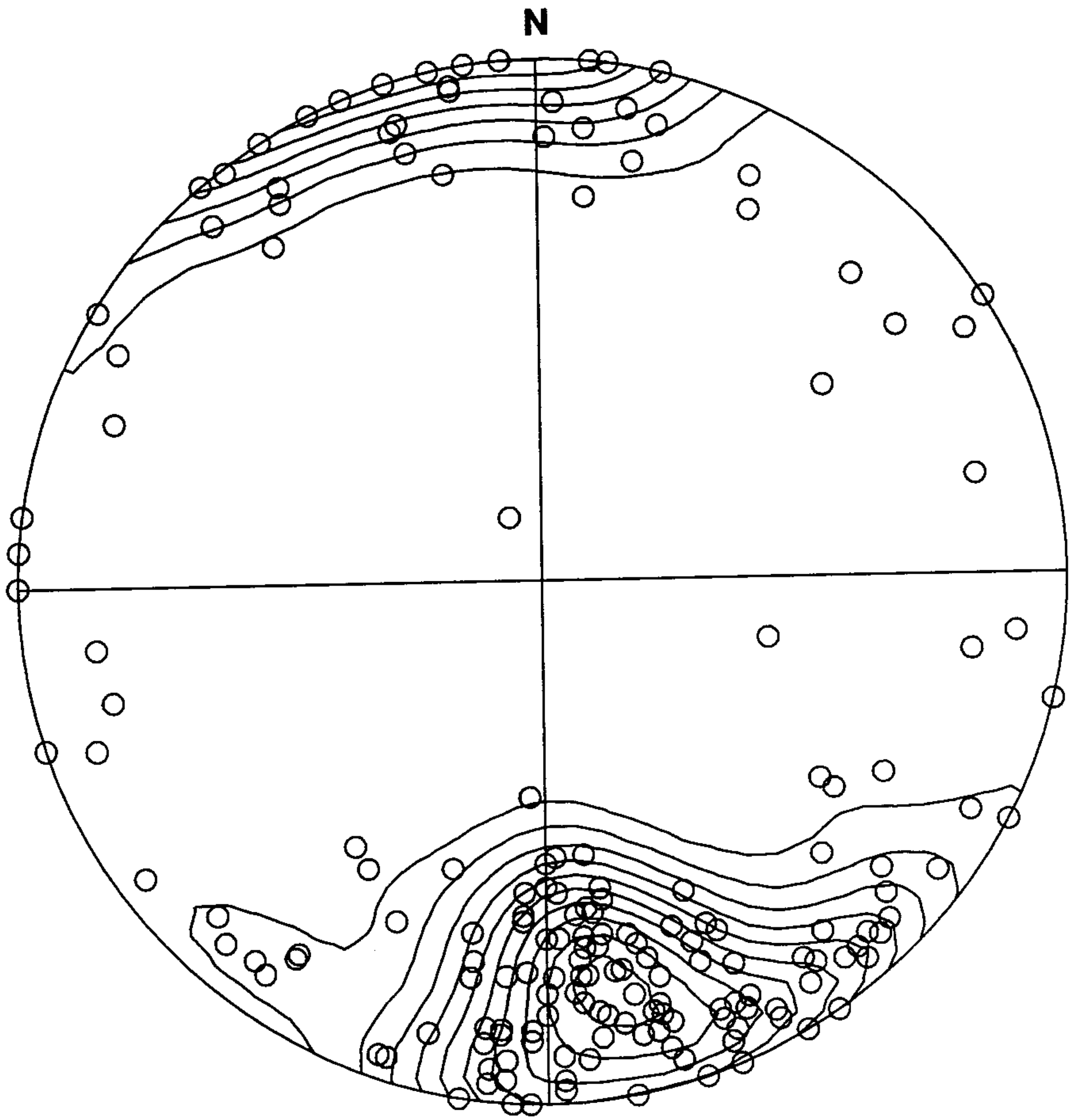

Figure 7 - Equal area stereonet plot of poles to foliation, contoured. (184 data points represented.) A predominant northeast trend is apparent.

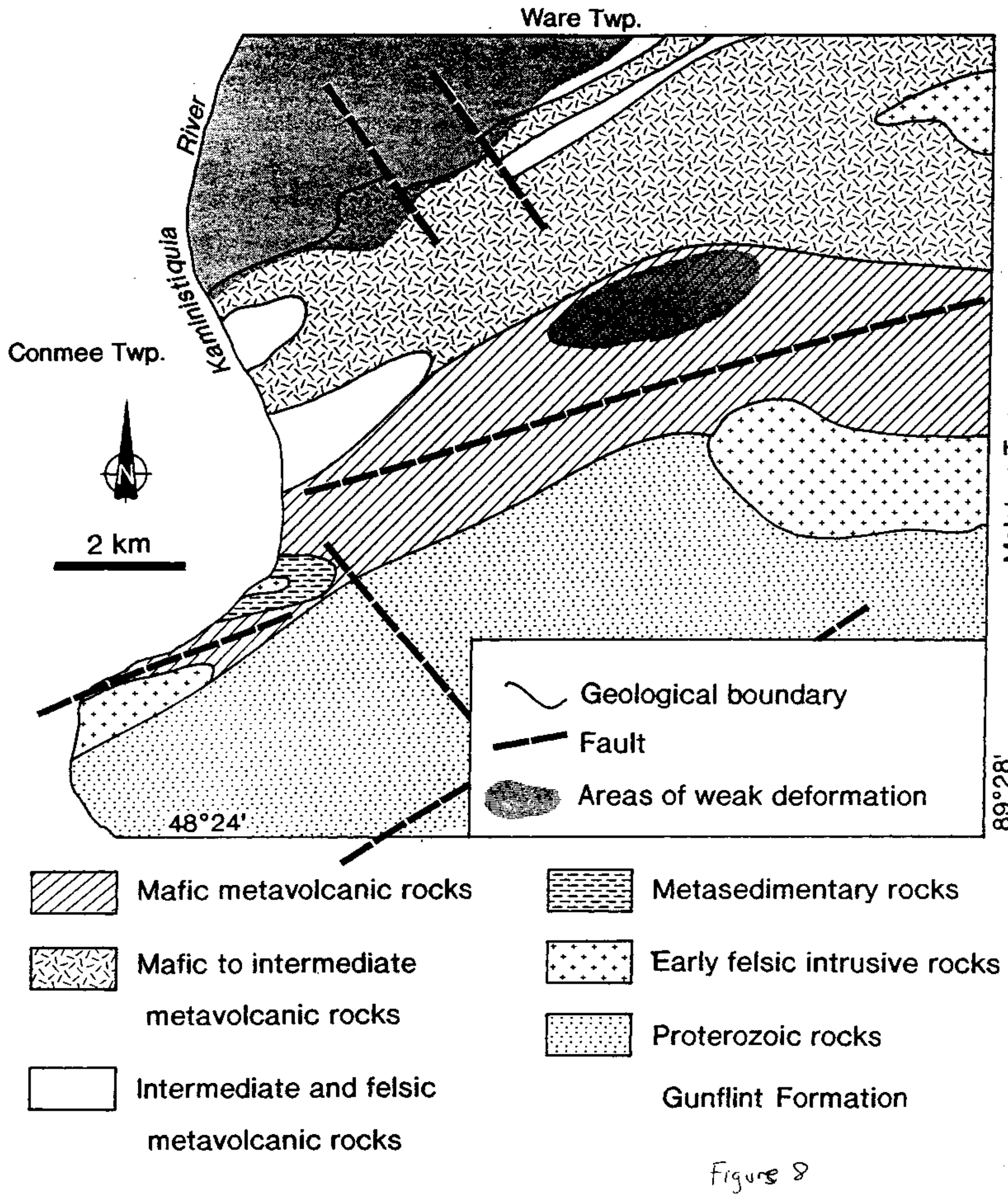

Figure 8 - Simplified geology of Oliver Township showing areas of very weak deformation.

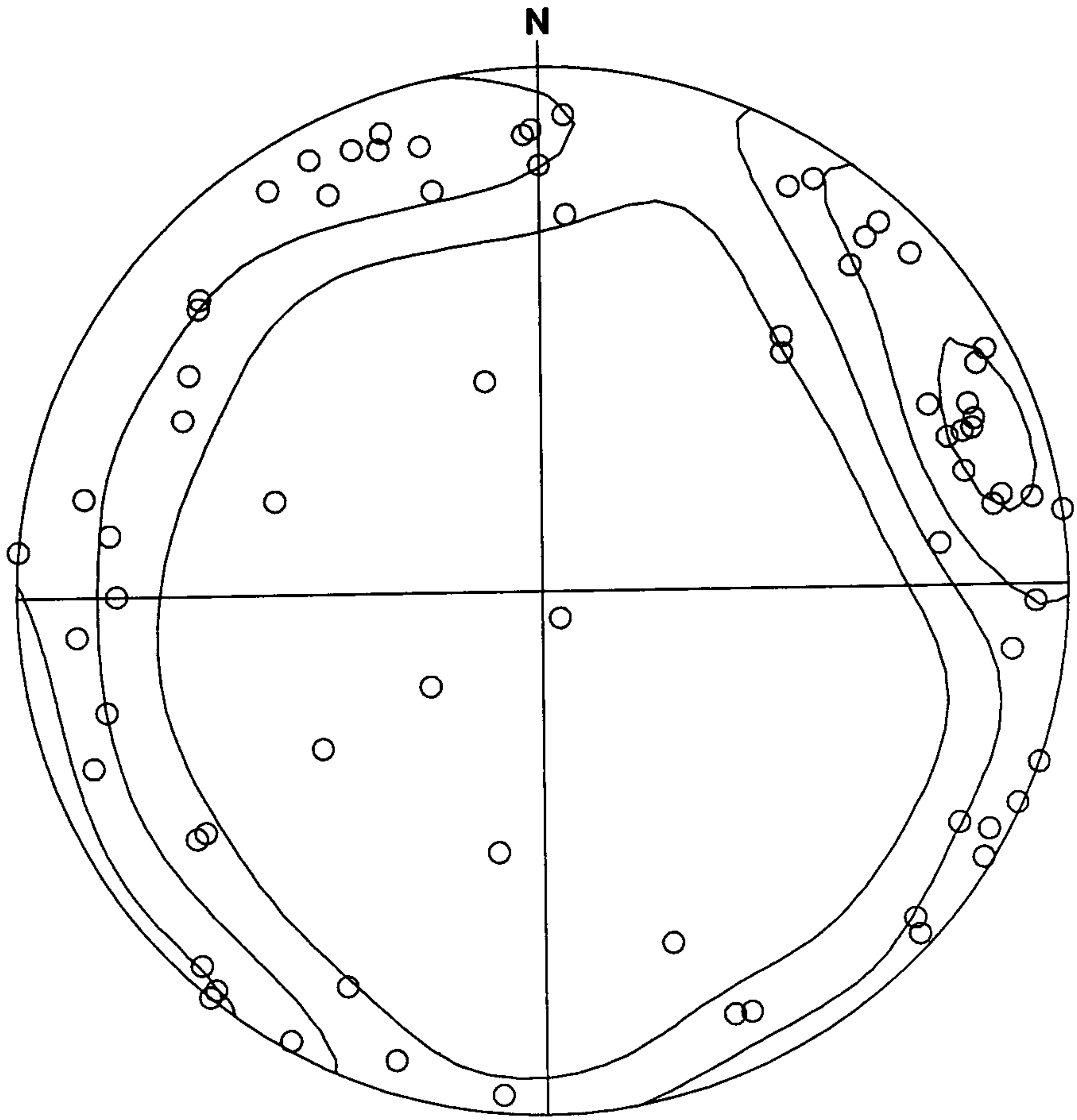

Figure 9 - Equal area stereonet plot of poles to joint planes, contoured. (73 data points represented.) Note random distribution of data points.

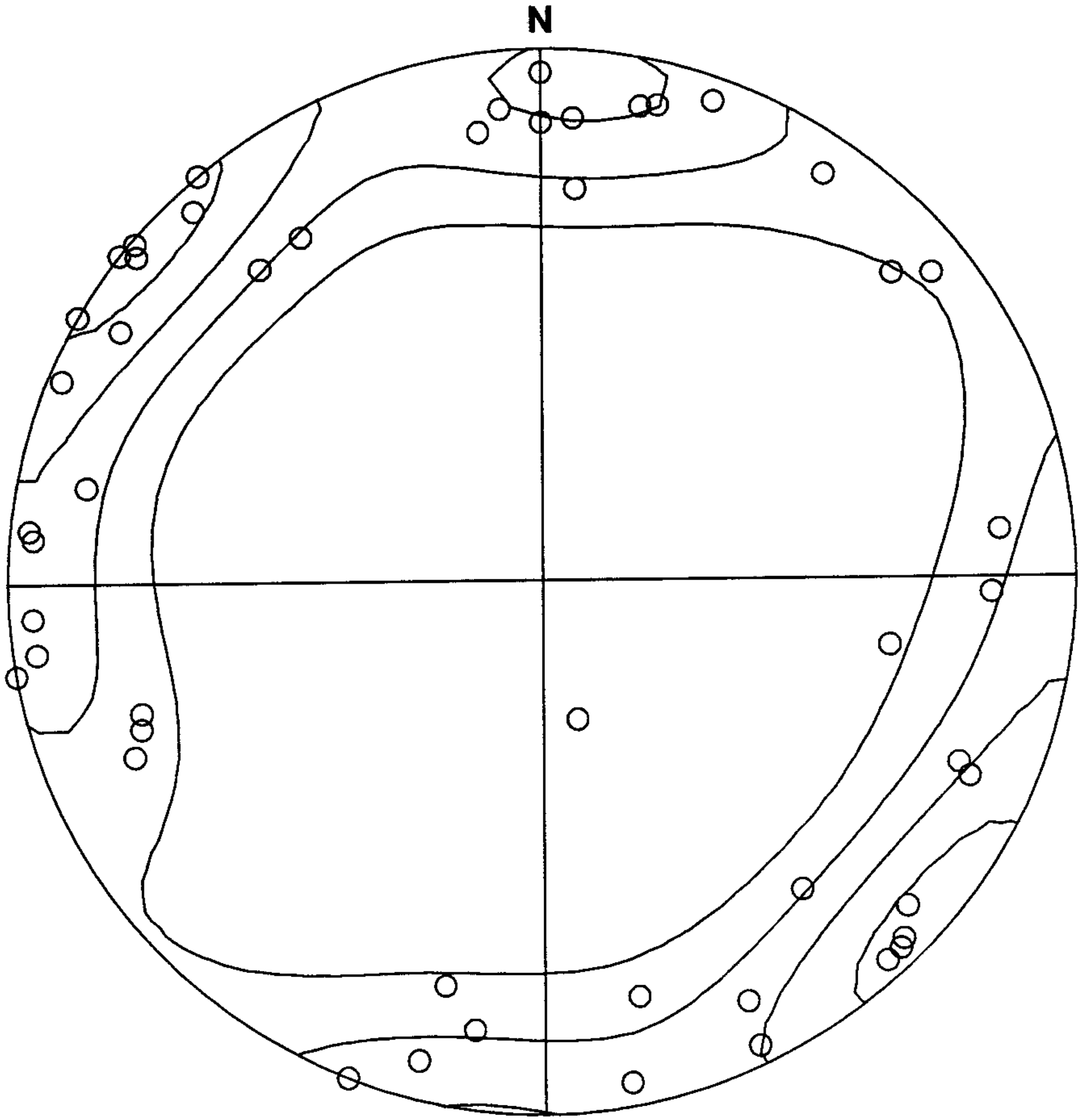

Figure 10 - Equal area stereonet plot of poles to fracture planes, contoured. (50 data points represented.) Three predominant trends are discernible, 1) east-west, with steep northerly dip, 2) northeast, with steep southeast and northwest dip and 3) north-northwest, with steep southwest and northwest dip.

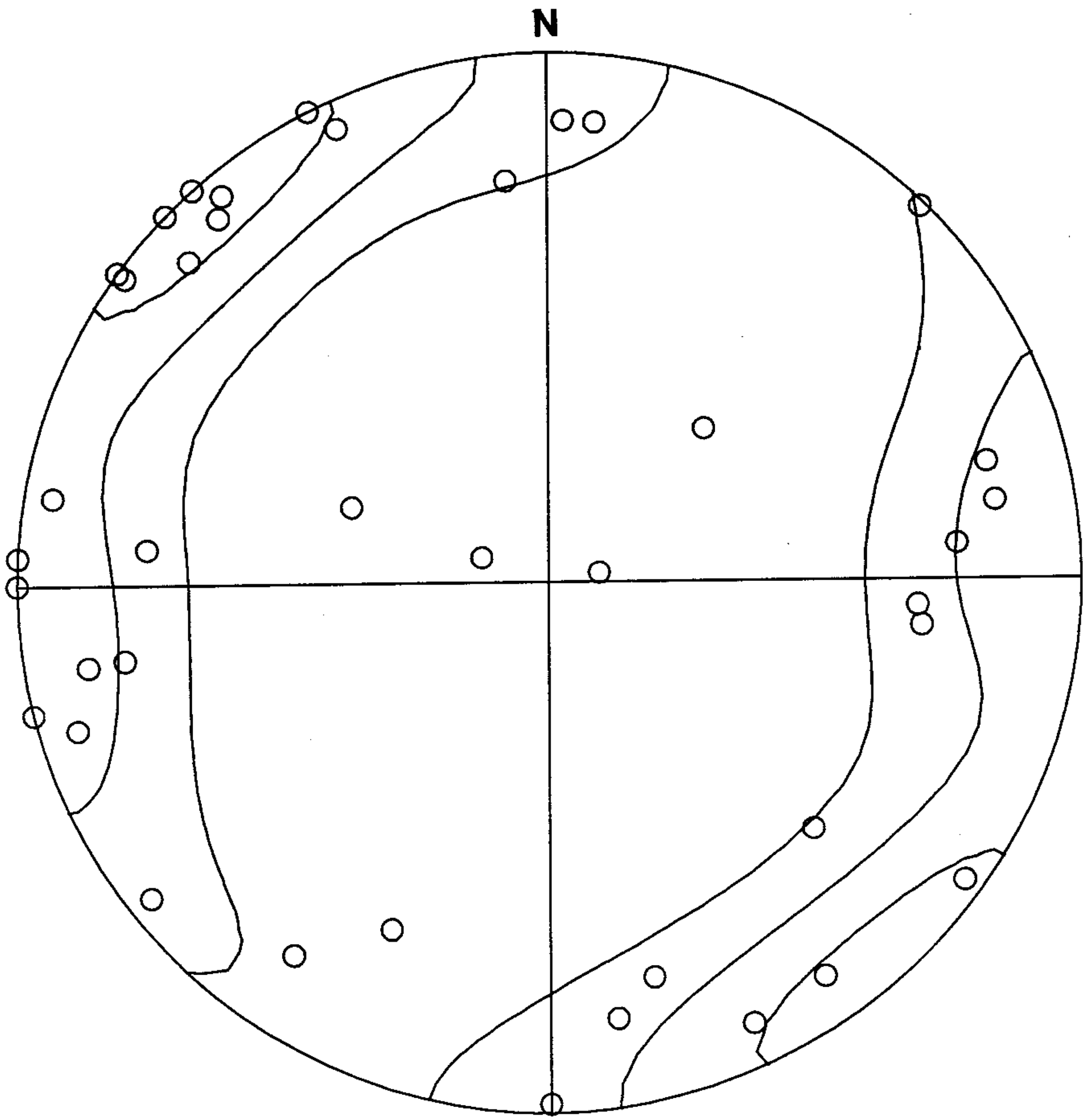

Figure 11 - Equal area stereonet plot of poles to late quartz veins, contoured. (40 data points represented.) Distribution of data points correlates well with that of poles to fracture planes shown in Figure 10.

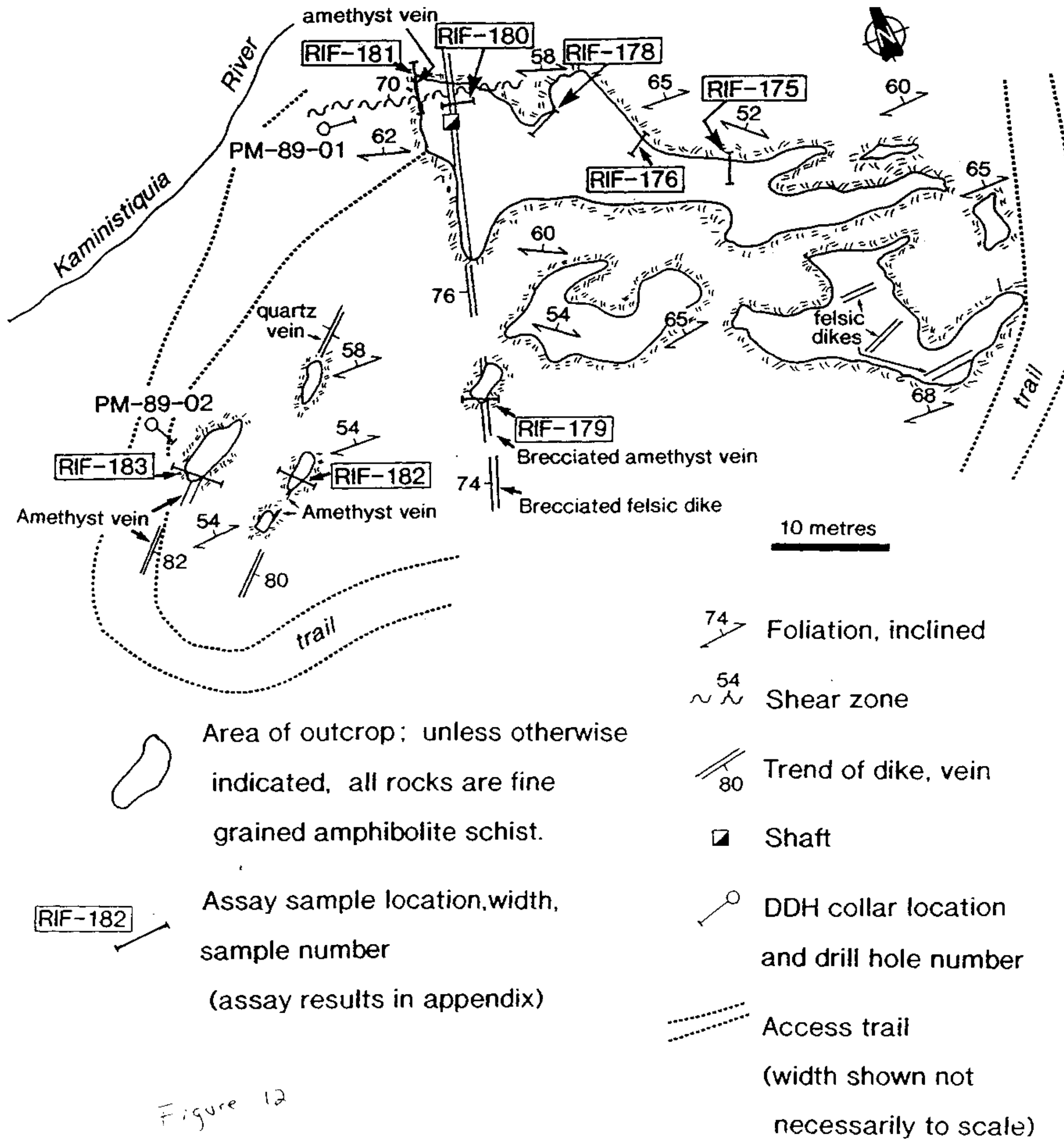

Figure 12 - Sketch map of Moore-Grayson occurrence, Property 1.

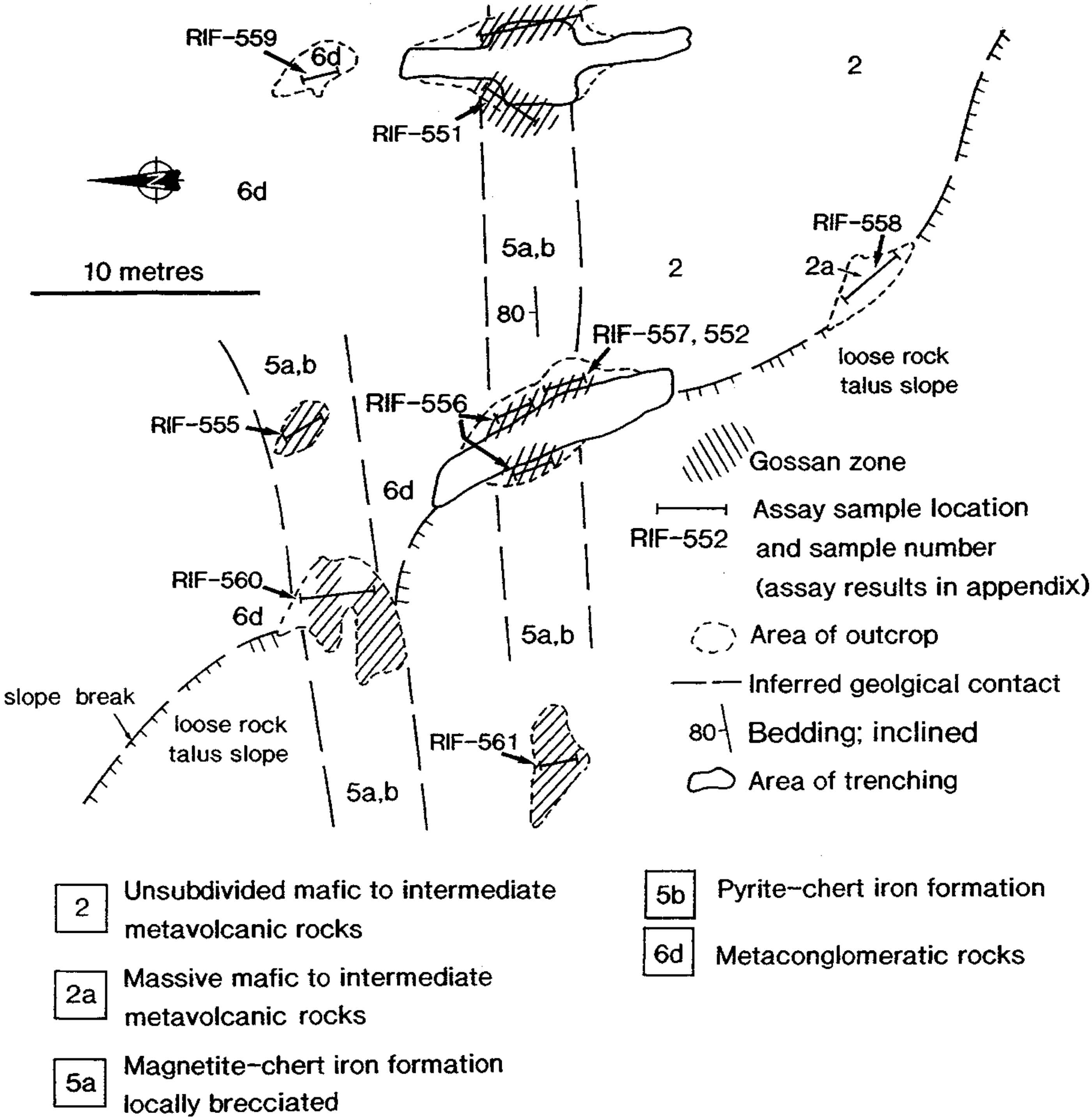

Figure 13 - Sketch map of Saari occurrence, Location A.

Photo 1 Hand sample of amphibole and feldspar-phyric amygdaloidal mafic to intermediate metavolcanic rock from the north central portion of Oliver Township. Note large (2 cm in diameter) quartz-filled amygdule in the centre of the hand sample. (Total length of hand sample is 10.4 cm)

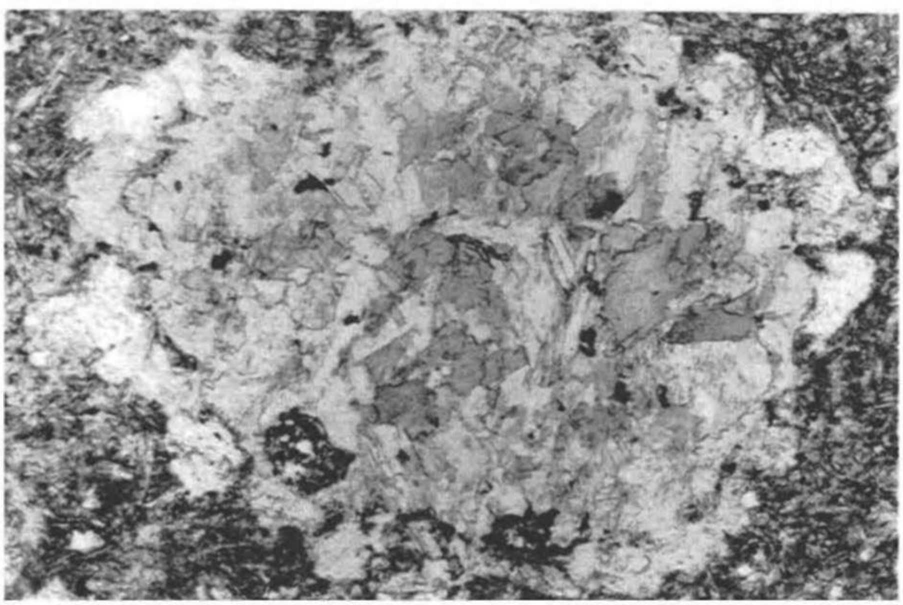

Photo 2 Photomicrograph of amphibole-phyric mafic to intermediate metavolcanic rock showing amphibole possibly occurring in an amygdule. Note subrounded shape of amphibole (centre of photo) and tiny quartz grains (white) rimming the borders. Amphibole is partially altered to chlorite. (Photo taken in plane polarized light, field of view is 13.2 mm)

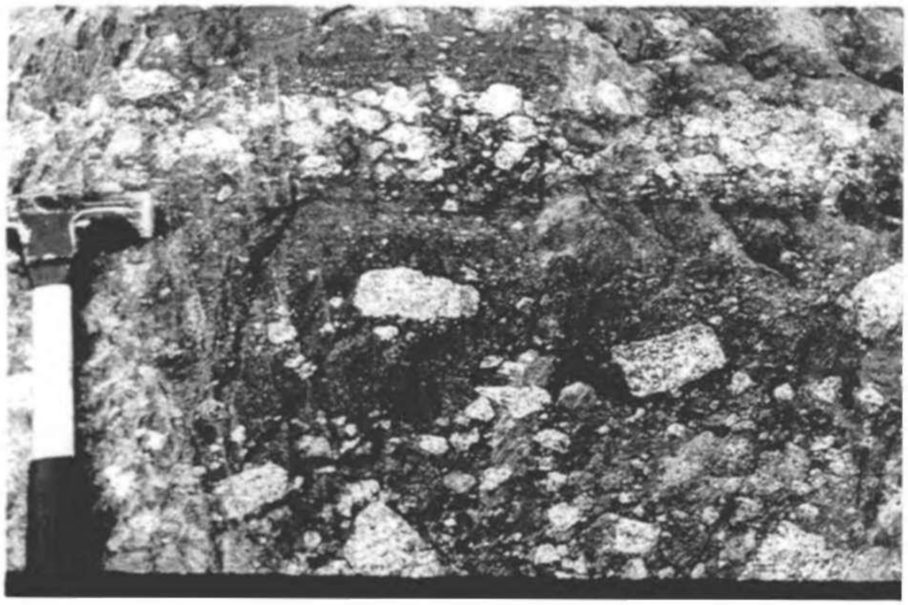

Photo 3 Weakly graded layering in heterolithic intermediate to felsic tuff breccia along Highway 102 in northern portion of Oliver Township. Hammer head oriented north.

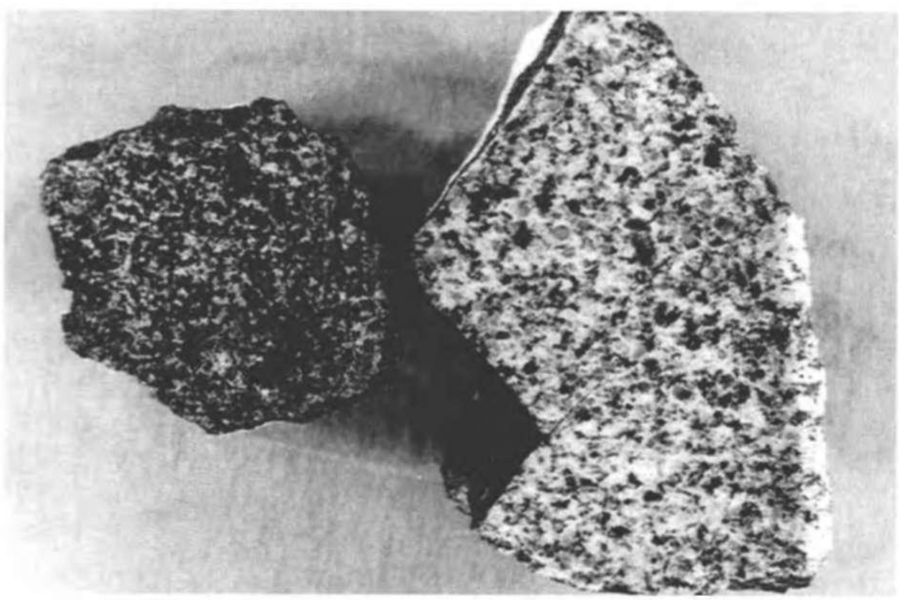

Photo 4 Fresh (lighter-coloured, right hand side of photo) and altered examples of the tonalitic pluton in east-central Oliver Township. The altered sample was collected from an outcrop located at the Archean/Proterozoic unconformity and shows the effects of iron and manganese enrichment caused by fluids percolating down through the overlying Proterozoic Gunflint Formation into the Archean basement. (Longest axis of larger hand sample is 12 cm long)

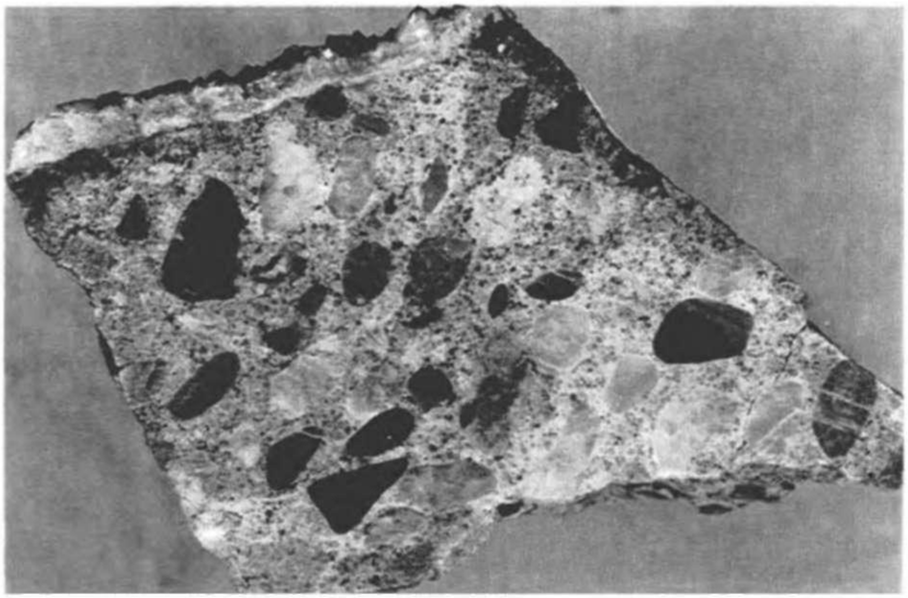

Photo 5 Hand sample of Kakabeka conglomerate from an outcrop located near Kakabeka Falls. Note fine sand matrix. (Longest axis of sample is 15.5 cm long)

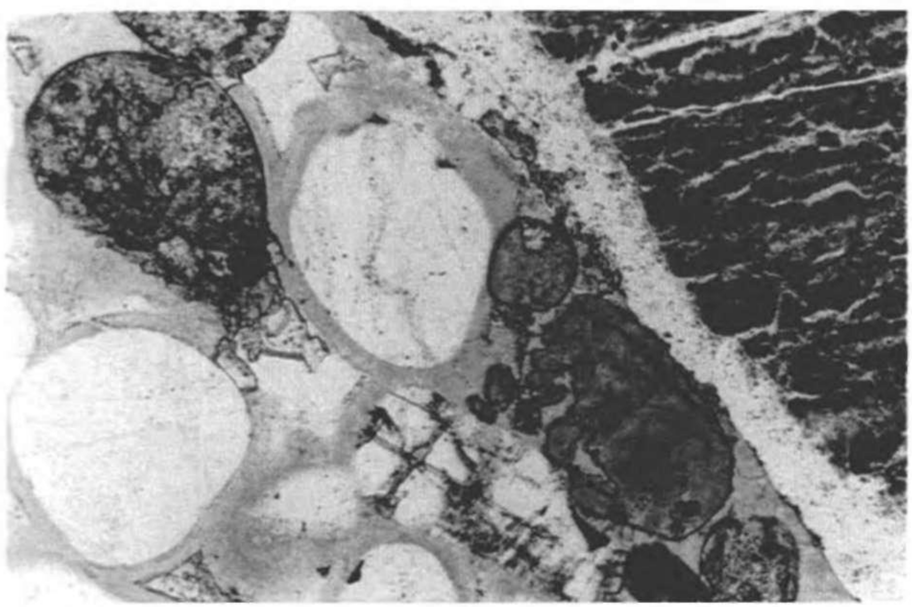

Photo 6 Photomicrograph of Kakabeka conglomerate; taken from same sample as shown in Photo 5. Large, dark clast on right hand side of photo is a banded, jaspilitic fragment. Note well-rounded quartz grains in matrix to left of large clast. (Photo taken in plane polarized light, field of view is 13.2 mm)

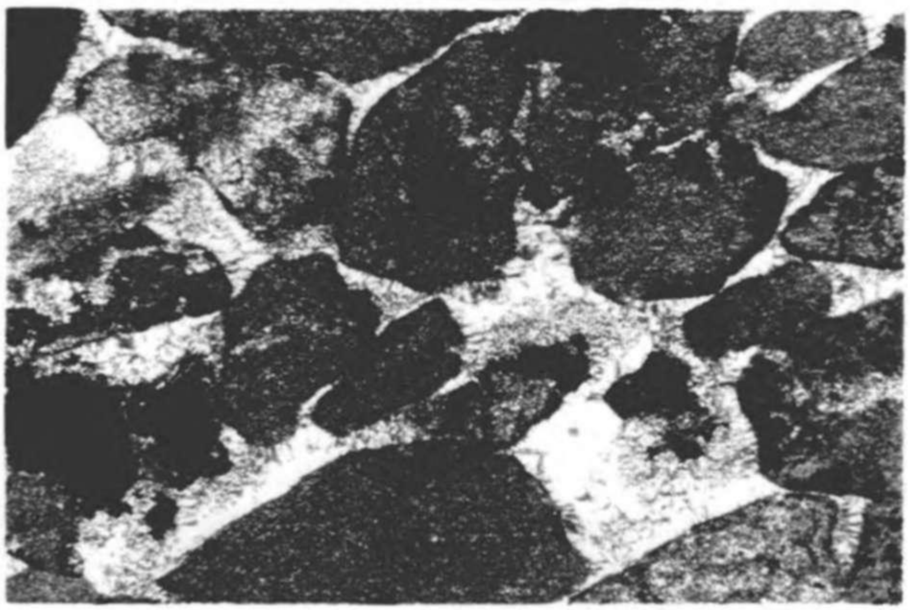

Photo 7 Photomicrograph of taconite from sample collected in southern part of Oliver Township. Note irregular shape of silicate grains (greenalite) rimmed by hematite (black borders). Matrix is fine-grained silica. (Photo taken in crossed polarized light, field of view is 13.2 cm)

CONVERSION FACTORS FOR MEASUREMENTS IN ONTARIO GEOLOGICAL SURVEY PUBLICATIONS

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

OTHER USEFUL CONVERSION FACTORS

	Multiplied by	
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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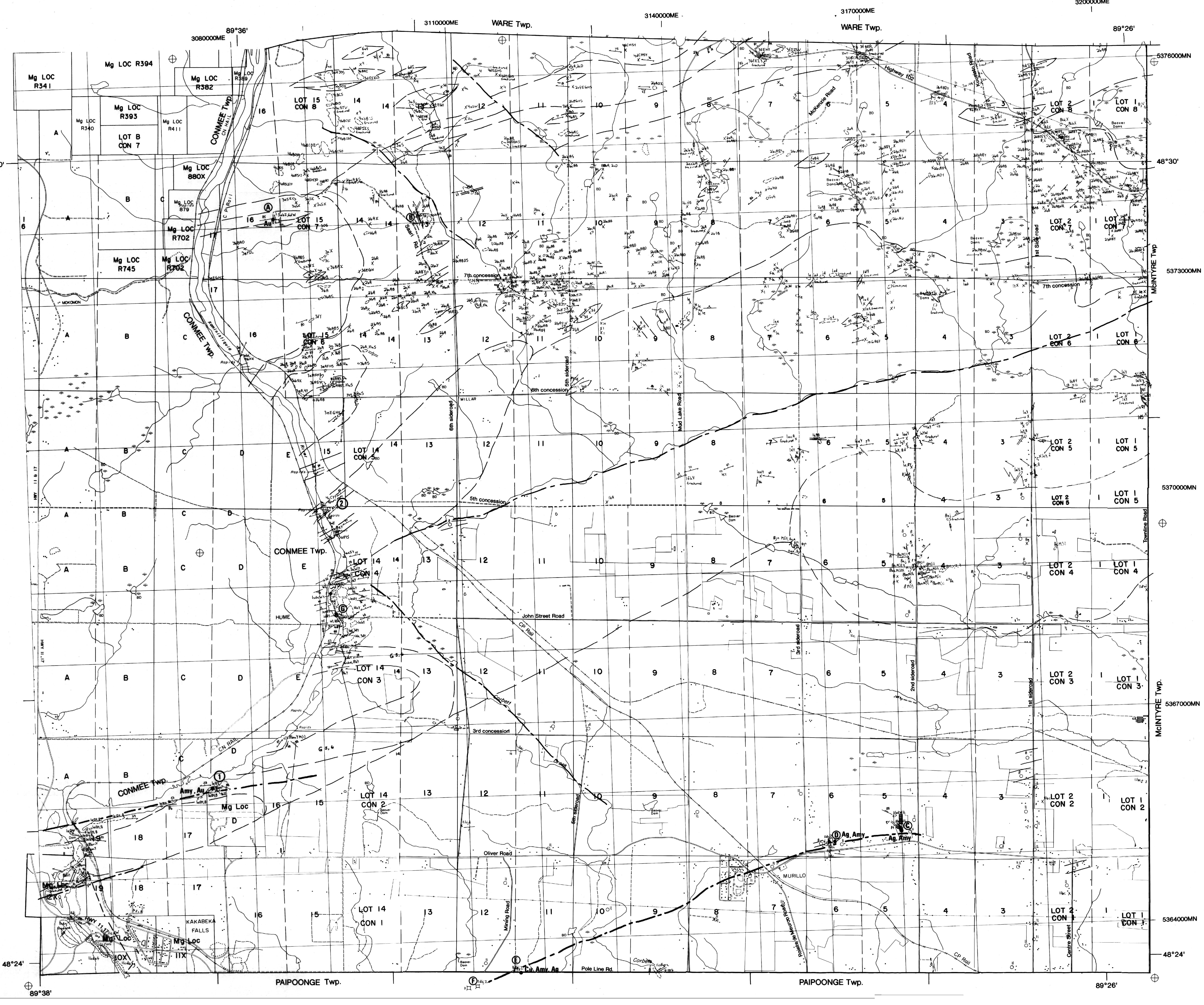

LEGEND[a,b,e,f]

PHANEROZOIC

CENOZOIC

QUATERNARY

PLEISTOCENE AND RECENT

Glacial, glaciofluvial, peat, lake and stream deposits

UNCONFORMITY

PRECAMBRIAN

PALEOPROTEROZOIC

11 **Sedimentary Rocks:** Animikie Group, Gunflint Formation
- 11a Limestone
- 11b Taconite
- 11c Shale, argillite
- 11d Chert, chert-carbonate
- 11e Arkose
- 11f Tuffaceous shale
- 11g Conglomerate
- 11h Siltstone
- 11j Mudstone

UNCONFORMITY

NEOARCHEAN

10 **Mafic Intrusive Rocks**
- 10a Lamprophyre

INTRUSIVE CONTACT

9 **Late Tectonic Felsic Intrusive Rocks**
- 9a Feldspar porphyry
- 9b Aplite

INTRUSIVE CONTACT

8 **Syntectonic to Late Tectonic Felsic Intrusive Rocks**
- 8a Granodiorite
- 8b Tonalite
- 8c Syenite
- 8d Feldspar porphyry
- 8e Quartz porphyry
- 8f Biotite-quartz-feldspar porphyry
- 8g Granite
- 8h Diorite
- 8j Monzonite
- 8k Amphibole > Biotite
- 8m Biotite > Amphibole
- 8n Regolith

INTRUSIVE CONTACT

7 **Metamorphosed Mafic Intrusive Rocks**
- 7a Gabbro[c]

INTRUSIVE CONTACT

Metavolcanic and Metasedimentary Rocks

6 **Clastic Metasedimentary Rocks**
- 6a Siltstone
- 6b Mudstone
- 6c Wacke
- 6d Conglomerate
- 6e Arenite
- 6f Volcaniclastic rocks

5 **Chemical Metasedimentary Rocks**
- 5a Magnetite-chert iron formation
- 5b Pyrite-chert iron formation
- 5c Chert

4 Felsic Metavolcanic Rocks
- 4a Massive flow
- 4b Porphyritic flow
- 4c Tuff
- 4d Lapilli tuff

3 **Intermediate to Felsic Metavolcanic Rocks**
- 3a Massive flow
- 3b Porphyritic flow
- 3c Amygdaloidal flow
- 3d Tuff
- 3e Lapilli tuff
- 3f Tuff breccia

2 **Mafic to Intermediate Metavolcanic Rocks**
- 2a Massive flow
- 2b Porphyritic flow
- 2c Amygdaloidal flow
- 2d Medium- to coarse-grained flow[d]
- 2e Pillowed flow
- 2f Pillow breccia
- 2g Tuff
- 2h Lapilli tuff
- 2j Tuff breccia

1 **Mafic Metavolcanic Rocks**
- 1a Massive flow
- 1b Porphyritic flow
- 1c Amygdaloidal flow
- 1d Medium- to coarse-grained flow[d]
- 1e Pillowed flow
- 1f Pillow breccia
- 1g Lapilli tuff
- 1h Hyaloclastite

[a] *Subdivision of major rock units does not imply age relationships.*

[b] *Descriptive terms applying to all rock units denoted by upper case letters; see legend below.*

[c] *May in part be extrusive.*

[d] *May in part be intrusive.*

[e] *Field legend; subject to change.*

[f] *The letter "G" preceeding a map unit number indicates lithologic information interpreted from geophysical data.*

LEGEND OF DESCRIPTIVE TERMS

- A Mafic phenocrysts/amygdules/crystal fragments
- B Feldspar phenocrysts/crystal fragments
- C Quartz phenocrysts/amygdules/crystal fragments
- D Large, quartz-filled vesicles
- E Angular to subangular fragments
- F Rounded to subrounded fragments
- G Fragments more felsic than matrix
- H Monolithic
- I Heterolithic
- J Essential fragments
- K Accessory fragments
- L Accidental fragments
- M Xenoliths; rock type in brackets
- N Potassic alteration
- O Hematization
- P Chloritization
- Q Amphibolitization
- R Biotitization
- S Carbonatization
- T Sericitization
- U Silicification
- V Epidote layers and lenses
- W Rusty weathering
- X Magnetic
- Y Schistose
- Z Brecciated

Ministry of Northern Development and Mines

Ontario

Mines and Minerals Division
Ontario Geological Survey

MAP P.3190

PRECAMBRIAN GEOLOGY

OLIVER TOWNSHIP

DISTRICT OF THUNDER BAY

Scale 1:15 840

500 m 0 0.5 1 km

Mile 1/4 0 1/2 Mile

NTS References: 52 A 5/NE, 52 A 6/NW, 52 A 11/SW, 52 A 12/SE

CANADA ONTARIO NODA-EDNO

This publication was funded under the Minerals program of the Canada-Ontario Northern Ontario Development Agreement (NODA), a four year joint initiative signed November 4, 1991.

SYMBOLS

Geological contact; actual, approximate	Fracture cleavage; inclined
Fault; interpreted	Joint, fracture; inclined, vertical
Schistosity; inclined, vertical, no dip obtained	Minor fold with plunge direction
Vein, dike; inclined, vertical, no dip obtained	Zone of shearing; no direction of movement obtained, direction of movement indicated
Bedding; inclined, vertical, graded-top direction indicated	Lineation with plunge direction
Top direction obtained from pillowed flow	Drill hole location; attitude assumed
Trench	Trail
Pit	Railway tracks; existing, abandoned
Shaft	Hydroelectric or phone line
Information obtained from water well log; rock unit indicated by legend code	Bridge
Area of outcrop; large, small	Swamp
Main road	Mineral occurrence
Secondary road	Property

ABBREVIATIONS

- Ag .... silver
- Amy .... amethyst
- Au .... gold
- Cu .... copper
- qv .... quartz vein
- q-carb vein .... quartz-carbonate vein

PROPERTIES

1. Moore-Grayson claims
2. Calvert-Wing claims

SOURCES OF INFORMATION

Base map derived from digital base maps of the Ministry of Natural Resources, Surveys and Mapping Branch.

Assessment files, Resident Geologist's Office, Ministry of Northern Development and Mines, Thunder Bay.

OGS Geophysical/Geochemical Series Maps 81580, 81581, 81592, 81593, scale 1:20 000.

ODM-GSC Aeromagnetic Maps: 2096G, 2106G

OGS Geological Compilation Map: 2065

OGS Map 2542, 1991, scale 1:1 000 000.

ODM Geological Map P.177, scale 1:126 720.

ODM Map 1960k, scale 1:31 680.

ODM Map 1960m, scale 1:31 680.

GSC Map 198A, scale 1:63 360.

GSC Map 213A, scale 1:63 360.

ODM, Mineral Resources Circular No. 10.

Geology not tied to survey lines.

Magnetic declination 2° 20'W in 1992.

Metric conversion factor: 1 foot = 0.3048m.

CREDITS

Geology by G.H. Brown, R.I. Fogal and assistants, 1992.

To enable the rapid dissemination of information, this map is **unedited**. Discrepancies may occur for which the Ontario Geological Survey does not assume liability. Users should verify critical information.

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Issued 1993.

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

Brown, G.H. and Fogal, R.I. 1993. Precambrian geology, Oliver Township; Ontario Geological Survey, Preliminary Map P.3190, scale 1:15 840.