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Ontario Geological Survey
Open File Report 5862

Geology of Adrian and Marks Townships

1993

Ministry of
Northern Development
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ONTARIO GEOLOGICAL SURVEY

Open File Report 5862

Geology of Adrian and Marks Townships

By

B.R. Berger

1993

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FOREWORD

This report presents the results of detailed mapping undertaken in the Adrian and Marks townships area to improve the geological data base for mineral exploration and land use planning and to stimulate mineral exploration by describing geological environments favourable for mineralization.

The study discovered new amethyst showings hosted in granitic rocks, identified structures hosting anomalous gold mineralization and identified felsic pyroclastic rocks which hold potential for base metal mineralization.

J. Wood
Director
Ontario Geological Survey

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MAPS IN BACK POCKET

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2. P.3195 Precambrian Geology,Marks Township

ABSTRACT

Adrian and Marks townships are located between latitudes 48°18'41" and 48°59'55" N and between longitudes 89°46' and 89°53'50" W. The map area is centered approximately 45 km west of Thunder Bay and is easily reached via Highway 590 from Kakabeka Falls.

The northern and central parts of the map area are underlain by Neoarchean rocks composed of ultramafic, mafic, intermediate and felsic metavolcanic rocks, related intrusive rocks, clastic and chemical metasedimentary rocks which have been intruded by Neoarchean plutons and batholiths composed of diorite, tonalite, granodiorite and granite. Paleoproterozoic metasedimentary rocks composed of tactonite, conglomerate, stromatolitic and algae mat chert belonging to the Gunflint Formation of the Animikie Group unconformably overlie the Neoarchean granitic rocks in the southern part of the map area.

Komatiitic, mafic and intermediate to felsic metavolcanic rocks capped by deep water, clastic and chemical metasedimentary rocks and intruded by peridotitic and gabbroic sills comprise an older rock sequence which underlies the eastern and central parts of the map area. A distinctive suite of plagioclase and hornblende-phyric, intermediate metavolcanic rocks overlies the older rock sequence in the northwestern part of the map area. This suite morphologically resembles metavolcanic rocks of the Timiskaming-like Shebandowan assemblage south of Shebandowan Lake.

Two periods of deformation have affected the Neoarchean rocks. The first deformation is characterized by northwest trending isoclinal folds and foliations. Northeast trending faults, folds and foliations were imposed on the first deformation. Most of the Neoarchean metavolcanic and metasedimentary rocks attained lower to middle greenschist grade metamorphism. An upper greenschist to lower amphibolite grade metamorphic aureole extends for up to 2 km from the contact of the granitic rocks into the supracrustal rocks in the central part of the map area. The Paleoproterozic rocks are relatively undeformed and only low grade metamorphosed.

There is potential for gold mineralization along a pronounced northwest trending fault in the northern part of the map area. There is potential for base metal mineralization hosted in felsic metavolcanic rocks in the central and northern parts of the area. Amythest was discovered in northeast trending veins hosted by granodiorite in the southwestern part of Marks Township.

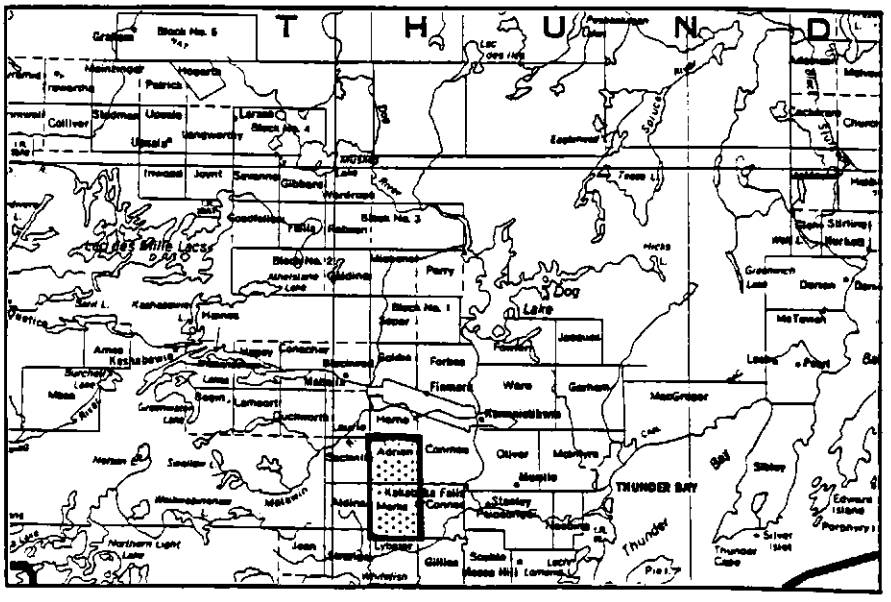

Figure 1. Location map of Marks and Adrian townships, scale 1:1 584 000.

Geology of Adrian and Marks Township

District of Thunder Bay

by

Ben Berger

Critical Reader: Glen Johns, a/Supervising Geologist.
Manuscript approved for publication by B.Dressler, Section Chief Precambrian Geoscience Section, May 31, 1993. This report is published with the permission of John Wood, Director, Ontario Geological Survey.

Precambrian Geology

Adrian and Marks Townships,

District of Thunder Bay

B.R. Berger1

Introduction

Marks and Adrian townships are located between latitudes 48°18'41" and 48°59'55" N and between longitudes 89°46' and 89°53'50" W (Figure 1). The area, approximately 184 km^2, was mapped at 1:15 840 scale to improve the geological data base and to provide an incentive for mineral exploration. The map area is centered approximately 45 km west of Thunder Bay and is easily reached via Highway 590 from Kakabeka Falls, approximately 13 km to the east. Major logging roads referred to locally as "the Boreal road" and "the Adrian Lake road" provide access to the northern part of Marks Township and Adrian Township respectively. Numerous minor logging roads, concession roads and side roads provide access to most of the map area. The northeastern part of Adrian Township was accessed by helicopter.

This project was part of the five-year Canada-Ontario 1991 Northern Ontario Development Agreement (NODA), a subsidary agreement to the Economic and Regional Development Agreement (ERDA) signed by the government of Canada and Ontario.

History of Exploration

There are no known economic mineral deposits within the map area. Tanton (1931) reported that amethyst and quartz crystals occurred in granite in lot 4, Concession VI, Marks

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Township and that an amethyst vein was reported to occur in Lot 12, Concession I of Marks Township. There was no report that either of these occurrences were subsequently explored. In 1962, the Hanna Mining Company carried out exploration for iron on two properties in northern Marks Township and on one property in Adrian Township. Magnetite-chert ironstone hosted in wacke and mafic amphibolite were explored; however, no economic ore bodies were discovered.

In the late 1960s and 1970s exploration for base metals was carried out by Noranda Exploration Company Limited and the Canadian Nickel Company Limited mainly in Adrian Township. Selected airborne magnetic anomalies and electromagnetic conductors were tested by ground exploration and diamond drilling. No significant mineralization was discovered.

A number of mining claims were in good standing at the time of writing. These claims covered areas underlain by airborne electromagnetic conductors detected by the recently released Ontario Geological Survey total intensity magnetic and electromagnetic surveys (OGS, 1991 a-d).

Previous Geological Work

Tanton's (1931) mapping covered Adrian and Marks townships at reconnaissance scale (1:63 360) showing the greenstone and granite boundary. Moorhouse (1960a, b) mapped parts of southern Marks Township showing the distribution of the Animikie Group and its contact with the Archean rocks. Carter (1985,1986) mapped the areas north and east of Adrian Township at 1:15 840 scale.

In 1961, an aeromagnetic survey was flown over the map area and the final map was published at a scale of 1:63 360 (ODM-GSC, 1962). An airborne electromagnetic and total intensity magnetometer survey was flown by the Ontario Geological Survey over the

Shebandowan greenstone belt in 1991 and the northern two thirds of the map area were covered (OGS, 1991a-d).

Present Survey

Adrian and Marks townships were mapped at a scale of 1:15 840 during the 1992 field season. The mapping crew comprised the author, 1 senior assistant and 3 junior assistants. Standard pace and compass traverses, using 1:15 840 scale black and white, vertical aerial photographs for control, were carried out in conjunction with roadside traverses. Traverses were spaced to provide coverage of the supracrustal rocks at no more than 500 m intervals. In areas of complex geology traverses were spaced closer together. Areas underlain by granitic rocks in the southwestern part of Marks Township were investigated in less detail than areas underlain by supracrustal rocks.

The field data were plotted on acetate overlays that were taped to the aerial photographs. The data were transferred to base maps derived from the Forest Resource Inventory, Ontario Ministry of Natural Resources. Additionally, data were entered onto a computer data base (Fieldlog version 2.83) and stored on floppy discs.

Physiography

All waters in the map area eventually flow east into Lake Superior which is part of the Atlantic watershed. Drainage patterns are poorly developed in the northern part of the map area and are locally controlled by bedrock structures and glacial features. Drainage patterns in the southern part of the area are better developed due , largely to the influence of the flat lying Proterozoic metasedimentary rocks.

Topographic relief commonly exceeds 30 m in the northern part of Adrian Township and rugged cliffs up to 25 m high occur in the northeastern part of the Township. Relief is fairly gentle in Marks Township especially in the area underlain by the Proterozic rocks.

Outcrop density is erratic throughout the map area ranging from less than 1% in the southeastern part of the area to approximately 25% in the north central part of the area.

Acknowledgements

J.P. Edwards capably served as senior assistant on this project and carried out independent mapping over approximately 40% of the area. V.L. Bannister did independent mapping over selected areas in Marks Township. A. Arnott and E. Squair provided competent assistance. This project benefitted from discussions with H. Brown and I. Osmani, both geologists with the Ontario Geological Survey and who mapped other portions of the Shebandowan greenstone belt during the 1992 field season.

Logistical support and geological discussions with Maurice Lavigne, Resident Geologist, and John Scott, staff geologist for the Thunder Bay District are gratefully acknowledged.

General Geology

Marks and Adrian townships are underlain by Neoarchean rocks of the Superior Province and by Paleo- and Mesoproterozoic rocks of the Southern Province; both provinces are part of the Canadian shield. The Neoarchean rocks are part of the Wawa Subprovince and underlie approximately 85% of the map area. They comprise supracrustal rocks which are part of the Shebandowan greenstone belt and granitic rocks external to the greenstone belt (Williams et al 1991). The supracrustal rocks are composed of ultramafic, mafic, intermediate and felsic metavolcanic rocks; related intrusive rocks composed of peridotite, gabbro, feldspar and quartz-

feldspar porphyries; clastic and chemical metasedimentary rocks (Table 1). The granitic rocks are composed predominantly of quartz diorite, granodiorite, quartz monzonite and granite (Table 1).

The supracrustal rocks of the Shebandowan greenstone belt were divided into two assemblages based on morphology, composition, structure and metamorphism. These assemblages were correlated with the Greenwater assemblage and the Shebandowan assemblage based on previous work by Carter (1985, 1986) and by Williams et al (1991). The Greenwater assemblage is inferred to be older than the Shebandowan assemblage although precise ages have not been determined (Williams et al, 1991). The Greenwater assemblage contains 3 cycles of volcanism. The lowermost cycle contains mafic and komatiitic flows capped by thin intermediate and felsic tuff and extensive magnetite-chert and jasper ironstone. Cycle 2 mafic flows are capped by thick intermediate and felsic metavolcanic rocks and Cycle 3 is composed of mafic flows and tuff (Williams et al 1991). It appears that only Cycle 1 is present in the map area.

The Shebandowan assemblage is approximately 2689 Ma and is composed of calc-alkalic to alkalic metavolcanic rocks and clastic and chemical metasedimentary rocks (Williams et al 1991). Primary structures and geochemistry indicate that these rocks were deposited in alluvial-fluvial, shallow subaqueous to subaerial environments elsewhere in the greenstone belt (Williams et al 1991). Rocks correlated with the Shebandowan assemblage in the map area display abundant features indicative of shallow water to subaerial deposition; however, the geochemistry is less definitive. Figure 2 shows the location of each of these assemblages within the map area.

The Paleoproterozoic rocks underlie the southeastern part of the map area and comprise members of the Gunflint Formation of the Animikie Group. These rocks are composed predominantly of taconite, chert and algal mat chert. Conglomerate is rare and argillite is reported

in one area. These metasedimentary rocks are relatively flat lying and rest unconformably of the Archean rocks.

Mesoproterozoic, Keweenawan diabase occurs as small outliers in two separate areas in the northern part of Adrian Township. These rocks are relatively unaltered and flat lying.

Much of the description in this section on the general geology is in table form; emphasis is placed on describing the similarities of, and differences between the supracrustal groups and on interpreting depositional environments. Nomenclature and terminology in this report follows that proposed by Thurston (1991).

Neoarchean

Ultramafic and Mafic Metavolcanic Rocks

Ultramafic and mafic metavolcanic rocks characterized by spinifex, polysutured and flow breccia textures are restricted to the Greenwater assemblage north and northeast of Stephens Lake (Table 2a). These rocks form narrow units, commonly less than 50 m thick and less than 1 km along strike. One well exposed outcrop in northern Adrian Township is composed of a series of stacked flows 1-2 m thick; each flow with a massive base, a spinifex textured central portion and a brecciated flow top. In most outcrops, however, only spinifex or polysutured textures were observed. For the most part these flows are non-magnetic and are inferred by the author to be basaltic komatiites. Carter (1985, 1986) inferred that most of the ultramafic and mafic rocks in adjacent Horne and Conmee townships were cumulate textured komatiitic flows. This interpretation may be valid for some of these rocks in northeastern Adrian Township but the author has included these rocks under ultramafic and mafic intrusive rocks for reasons outlined below.

Table 2a shows the estimated modal mineralogy of the inferred komatiitic flows. The pyroxene is primary and commonly displays feathery textures (Photo 1) and skeletal crystal habits (Photo 2) indicative of rapid cooling similar to those described by Arndt et al (1977). The presence of plagioclase and the absence of olivine in these rocks supports the interpretation that most of the komatiites are basaltic (Arndt et al 1977).

Mafic Metavolcanic Rocks

Mafic metavolcanic rocks underlie approximately 10% of the map area. They are most abundant in the Greenwater assemblage where they occur along the contact with the granitic rocks in northern Marks Township and along the northwestern boundary of the map area. Mafic metavolcanic rocks comprise only a minor proportion of the Shebandowan assemblage.

Greenwater assemblage

Mafic metavolcanic rocks of the Greenwater assemblage are predominantly massive flows with minor pillowed flows and rare pyroclastic rocks. The general macroscopic and microscopic features of these rocks is presented in Table 2b. Mafic amphibolite is most common adjacent to the granitic rocks in northern Marks Township. These rocks are composed mainly of dark green, bladed hornblende and actinolite that are commonly aligned along the foliation planes. These rocks are non-magnetic, extensively recrystallized and commonly contain epidote and silica stringers. The recrystallization is attributed to thermal metamorphism caused by intrusion of the granitic rocks to the south. The mafic rocks are almost always massive flows although rare pillowed flows and lapilli tuff were observed in northeastern Marks Township. Magnetite and chert ironstone is interlayered with the amphibolite and was the target of early exploration efforts (see Economic Geology). Most of the prominent airborne magnetic high anomalies (OGS 1991c, d) in this area are caused by ironstone.

Mafic metavolcanic rocks of the Greenwater assemblage also occur in northwestern Adrian Township where they form a northwest trending unit. These rocks are composed of approximately equal proportions of massive and pillowed flows with minor flow top breccia and tuff. Massive flows contain either small amygdules (< 5 mm in size) that comprise less than 10% of the rock or no amygdules and they are more abundant in the southeast part of the unit. Pillowed flows are more common than massive flows in the northwest part of the unit. Pillows are commonly well formed and vary in size from 50 to 100 cm long by 30 to 70 cm wide. Selvedges are from 1 to 2 cm thick and there is very little interpillow material. Pillow shapes indicate that stratigraphy youngs to the northwest or southwest.

The size and abundance of amygdules combined with the lack of pyroclastic material indicates that the mafic metavolcanic rocks in Adrian Township were most likely deposited in deep water (Easton and Johns 1986). The greater proportion of massive flows to pillowed flows in the southeastern part of the unit is interpreted by the author to indicate that this area was closer to the vent than the northwestern part of the unit (Easton and Johns 1986).

There are a number of small gabbroic textured dikes with well defined chilled margins crosscutting the mafic metavolcanic rocks. However, the largest of these coarse-grained bodies is semi-concordant to stratigraphy and it may represent a thick, ponded mafic flow or several flows. For consistency, the author has mapped all such rocks as gabbro.

Magnetite-jasper ironstone, wacke and graphitic metasedimentary schist are interlayered with the mafic rocks. These rock types are generally too narrow to form mappable units; however, one northwest striking unit is over 100 m thick.

Mafic metavolcanic rocks also occur within the Greenwater assemblage in the northwestern part of Adrian Township. These rocks are composed of massive flows with minor

tuff. They are dark green to black weathering and are commonly very fine- to medium-grained. The mafic metavolcanic units in this area are discontinuous and are in close spatial association with ultramafic flows and mafic intrusive rocks.

Shebandowan assemblage

Mafic metavolcanic rocks form only a small portion of the Shebandowan assemblage and are localized in an area 800 m northeast of Adrian Lake. Here the mafic metavolcanic rocks are green-grey to green weathering and contain equant plagioclase and amphibole phenocrysts up to 3 mm in size in approximately equal proportions. It is the presence of these phenocrysts which distinguish the Shebandowan assemblage mafic metavolcanic rocks from the Greenwater assemblage mafic metavolcanic rocks (Table 2c).

The mafic metavolcanic rocks are composed of massive and pillowed flows, flow top breccia and minor tuff. These rocks are locally intruded by subvolcanic plagioclase and amphibole phyric dikes. Pillows are ovoid to well formed and vary from 50 to 150 cm long by 20 to 60 cm wide. Selvedges vary from less than 1 cm thick to up to 2 cm thick and there is generally very little interpillow material. Most commonly there are no vesicles in the smaller pillows; however, the larger pillows are commonly densely vesicular with tiny (< 1 mm in size) quartz and chlorite filled amygdules. Pillow shapes indicate stratigraphy youngs to the northeast. Flow top breccia is common and in thin section these rocks display well preserved hyaloclastite textures and relict volcanic glass.

Massive flows, flow top breccia and tuff were observed in narrow discontinuous units along the northeastern contact with the Greenwater assemblage. In this area the mafic rocks are interlayered with metasedimentary rocks, are finer-grained than northeast of Adrian Lake and contain mostly plagioclase phenocrysts. In thin section they are similar to intermediate

metavolcanic rocks of the Shebandowan assemblage but contain greater amounts of chlorite and epidote.

Intermediate Metavolcanic Rocks

Intermediate metavolcanic rocks underlie approximately 25% of the map area and occur in both the Greenwater and Shebandowan assemblages. There are distinct differences in morphology between the two assemblages which can be attributed to different paleodepositional environments. However, noted differences in mineralogy appear to be due to metamorphism rather than differences in composition. The characteristics of these rocks are most important in determining the differences between the two assemblages. The major macroscopic and microscopic features of these rocks are presented in Table 3.

Greenwater assemblage

Intermediate metavolcanic rocks comprise approximately 15-20% of the Greenwater assemblage and are composed predominantly of tuff and lapilli tuff. These rocks are generally interbedded with clastic metasedimentary rocks; however, they form two major easterly trending bands in southern Adrian Township. The more northern of these bands extends west from the Adrian Lake road through Twinbirch Lake to the western boundary of the map area. Tuff and crystal lapilli tuff are the most common rock types. These rocks are grey, dark grey and green weathering and commonly contain biotite and blue-green pleochroic hornblende in the matrix which is interpreted to result from upper greenschist grade metamorphism. The intermediate rocks are uniformly feldspathic with grain size varying between 1 and 7 mm. For the most part these deposits are massive, poorly to moderately sorted, ungraded and poorly stratified. They are commonly interbedded with narrow (less than 1 m thick) wacke and mudstone units.

Intermediate metavolcanic rocks in the more southern band extend from the south-central part of Adrian Township to the western boundary of the map area. A large "Z" fold is interpreted

to have deformed these rocks based on stratigraphic reversals and map pattern. These rocks are composed mostly of feldspathic tuff with minor lapilli tuff and tuff breccia. These rocks are similar in composition to the intermediate rocks described above but are commonly well bedded, moderately to well sorted and are massive to graded.

Intermediate metavolcanic rocks are interbedded with wacke and mudstone in many places in the Greenwater assemblage. The intemediate metavolcanic rocks are light grey to grey weathering, well bedded, commonly display grain gradation and are difficult to distinguish from clastic metasedimentary rocks in this setting. Reversals in stratigraphic tops are common and indicate that these units are folded about northeast trending axes interpreted to be related to a second period of deformation (see Structure and Metamorphism).

Intermediate metavolcanic rocks of the Greenwater assemblage are interpreted to have been deposited in deep water and were subjected to various amounts of reworking. There does not appear to be any amphibole phyric clasts and very few plagioclase phyric clasts in these deposits which may in part be due original winnowing of these fragments during deposition and reworking. Table 3 shows that the Greenwater assemblage rocks contain more quartz, plagioclase, biotite and amphibole and less chlorite, carbonate and sericite than Shebandowan assemblage rocks. This is probably due in large part to the higher metamorphic grade of the Greenwater assemblage rather than differences in original composition. Therefore, the author is uncertain whether these rocks are the distal equivalents of the Shebandowan assemblage or if they represent a separate suite of intermediate metavolcanic rocks.

Shebandowan assemblage

Intermediate metavolcanic rocks comprise approximately 90% of the Shebandowan assemblage in the map area. They form a distinctive northwest trending unit in the central and northern part of Adrian Township. These rocks are composed of flows and pyroclastic rocks and

contain euhedral plagioclase and hornblende phenocrysts which serve to distinguish them from intermediate metavolcanic rocks of the Greenwater assemblage. The Shebandowan assemblage rocks are generally grey, green and light yellow weathering and locally some of the fragments in the pyroclastic rocks are pink or pale green. Massive dacite flows and autoclastic flow breccias are common east of the Adrian Lake road near the northern boundary of Adrian Township. These flows are chalky white weathering and are aphanitic to plagioclase porphyritic with wispy fragments that are the same composition as the groundmass. Small quartz, carbonate and chlorite filled amygdules are common and in thin section porphyritic flows are seen to commonly contain trachytic textured plagioclase laths. It is possible that these are subaerial deposits related to welded tuffs. Plagioclase and hornblende phyric flows and variolitic flows were also observed north of Stephens Lake. Here round variolites from 1 mm up to 1 cm in size and composed of radial aggregates of plagioclase needles comprise up to 30% of individual flows. The varioles commonly "float" in an aphanitic dark green groundmass but coalesced varioles and chains of variolites are common.

Grey to green, heterolithic lapillistone (4 mm to 5 cm) is the most common rock type of this unit and is most abundant between Stephens Lake and the Adrian Lake road. These units are typically ungraded, unsorted, crudely stratified to unstratified and for the most part are clast supported. There are a variety of fragments types observed in outcrop with intermediate metavolcanic fragments most common. Felsic, mafic and previously fragmented fragments are less abundant. Brick red syenitic fragments, trachytic textured fragments and accidental jasper and laminated mudstone fragments were rarely observed. Pumice and quartz filled amygdules are locally abundant. In thin section the proportion of porphyritic fragments, trachytic textured fragments and chlorite filled amygdules is much greater than observed in outcrop (Photo 3). This indicates to the author that much of the metavolcanic material was violently erupted in either shallow water or a subaerial environment. In one outcrop on an old logging road north of Adrian Lake reaction rims were observed on some of the fragments which indicates the fragments were

either hot when deposited or that they reacted with hot fluids after deposition. Lapilli tuff from this outcrop is very similar to grey, dacitic lapilli tuff correlated with the Shebandowan assemblage observed by the author on the Shebandowan mine road approximately 26 km to the northwest. In this area the Shebandowan assemblage is inferred to unconformably overlie metavolcanic rocks of the Greenwater assemblage and has been interpreted to have been deposited in a subaerial to alluvial-fluvial environment (Williams et al 1991).

Intermediate tuff breccia is most common to the area west of Stephens Lake and is well exposed in a series of outcrops approximately 2 km northwest of Adrian Lake at the end of a logging road. Here heterolithic fragments up to 1 m in size are composed of flow laminated intermediate to felsic flows, feldspar and hornblende porphyry, mafic trachytic textured flows, intermediate pumice, previously brecciated clasts, jasper fragments and rare, red syenitic fragments (Photo 4). Fragments are angular to subrounded and clast to rarely matrix supported. These rocks are interpreted to be primary block and ash pyroclastic deposits which is indicative of explosive volcanism (Easton and Johns 1986).

Tuff is uncommon in the intermediate unit in the Shebandowan assemblage and where present occurs as narrow units interlayered with coarser-grained pyroclastic deposits. Tuff is commonly green with green, grey and less commonly pink lithic and feldspathic grains. Hornblende grains and crystals are locally present. Tuff is most commonly massive; however, locally grain gradation was observed and this indicates stratigraphy youngs to the west and southwest.

Plagioclase and hornblende phyric dikes were observed in two places. Along the northern part of the Adrian Lake road intrusion breccia accompanies the dikes. These dikes have chilled margins and contain xenoliths of Shebandowan assemblage pyroclastic rocks and locally

metasedimentary rocks. They are interpreted to have been local sources of magma for the Shebandowan assemblage.

In the northwestern part of the map area the Shebandowan assemblage was deformed by northeast trending shear zones. Rocks affected by the shearing are now strongly fissile schists and there was total destruction of primary textures in these rocks. Schist commonly grades into less intensely deformed plagioclase and hornblende phyric rocks which serves to distinguish them as members of the Shebandowan assemblage.

Williams et al (1991) have inferred that the Shebandowan assemblage unconformably overlies older greenstone assemblages. There is no direct evidence of an unconformable contact between the Shebandowan assemblage and the Greenwater assemblage in the map area. The contact of the lower unit of the Shebandowan assemblage, a jasper cobble conglomerate unit (see below), with the underlying metasedimentary rocks of the Greenwater assemblage is not exposed. However, it is inferred that the conglomerate represents a fault scarp deposit (see below) and this would imply a structurally controlled contact in the northeastern part of the assemblage. Plagioclase and hornblende phyric intermediate tuff and lapilli tuff were observed interbedded with metasedimentary rocks in northeastern Adrian Township which suggests that volcanism responsible for the Shebandowan assemblage commenced prior to cessation of the deep water sedimentation capping the Greenwater assemblage and that there was a rapid but transitional change from a deep water to a shallow water or subaerial depositional environment.

However, the Shebandowan assemblage rocks are less intensely deformed and less intensely metamorphosed (see Structure and Metamorphism) than the Greenwater assemblage which indicates that an unconformable contact may be present. Further, the airborne magnetic data (OGS 1991 a-d) indicates that some magnetite-jasper ironstone units of the Greenwater assemblage are discordant to the inferred distribution of the hornblende and plagioclase phyric

units which may indicate an unconformable contact. Detailed mapping along the strike of the jasper conglomerate unit may reveal the exact nature of the contact. The western contact between the Shebandowan and Greenwater assemblages is nowhere exposed but map pattern indicates that it is faulted and complexly deformed. It is possible that detailed mapping along the northwestern part of the map area may discover the actual contact.

In summary, the intermediate metavolcanic rocks of the Shebandowan assemblage are hornblende and plagioclase phyric which distinguishes them from the Greenwater assemblage intermediate metavolcanic rocks. The Shebandowan assemblage was deposited in a shallow water to subaerial, high energy, environment; whereas, the Greenwater assemblage was deposited in a deep water, low energy environment. The actual contact between the Shebandowan and Greenwater assemblages is not exposed in the map area; however, it is inferred that the contact was, in part, fault controlled and there appears to have been a rapidly transitional change from Greenwater to the Shebandowan assemblage.

Felsic Metavolcanic Rocks

Felsic metavolcanic rocks underlie less than 5% of the map area and are equally distributed between the Greenwater assemblage and the Shebandowan assemblage. The major macroscopic and microscopic features of the felsic rocks are presented in Table 4.

Greenwater assemblage

Felsic metavolcanic rocks are volumetrically minor and widely distributed in the Greenwater assemblage. Where they are interlayered with metasedimentary rocks the felsic rocks form narrow (less than 50 m thick) discontinuous units. They are composed mostly of tuff and lapilli tuff with minor quartz-feldspar porphyry. The felsic rocks are extensively recrystallized and most primary features are destroyed which hampers interpretation of these units.

Where the felsic metavolcanic rocks are interlayered with mafic amphibolite they form narrow (less than 200 m thick) semicontinuous units. They are composed mostly of quartz-feldspar porphyry interpreted as subvolcanic intrusions and aphanitic flows. Lapilli tuff and tuff occur as subordinate rock types. These rocks are also extensively recrystallized and highly metamorphosed; garnet was observed in felsic tuff in the northeastern part of Marks Township.

Table 4a shows that the Greenwater assemblage felsic metavolcanic rocks are mineralogically distinct from the felsic metavolcanic rocks of the Shebandowan assemblage, Table 4b. On average the Greenwater assemblage contains more quartz, microcline, biotite and tourmaline and much less plagioclase, than the Shebandowan assemblage. These mineralogical differences are, in large part, due to the higher metamorphic grade of the Greenwater assemblage but it may also reflect primary compositional differences.

Shebandowan assemblage

Felsic metavolcanic rocks are volumetrically minor in the Shebandowan assemblage. A major unit extends approximately 2500 m northwest along the Adrian Lake road and extends up to 600 m west of the road. This unit is composed principally of quartz-feldspar porphyry, massive and porphyritic flows and minor tuff and lapillistone. The quartz-feldspar porphyry is characterized by anhedral quartz and subhedral plagioclase phenocrysts up to 1 cm in size in a white plagioclase rich groundmass. Xenoliths of wacke and mudstone occur within the quartz-feldspar porphyry and metasedimentary rocks also occur along the southern contact of the unit. White to pale green weathering lapillistone and tuff hosting up to 10% pyrite occurs along strike of the quartz-feldspar to the northwest. These rocks are interlayered with intermediate lapilli tuff, tuff and schist of the Shebandowan assemblage. Autoclastic breccia is present locally. Where a major northwest trending fault (see Structure and Metamorphism) cuts this felsic unit pervasive carbonatization has affected the rocks and the contacts with other rock units are obscured. This felsic unit may represent a subvolcanic rhyolitic dome that breached the paleosurface and

created the autoclastic breccia and pyroclastic rocks. If this interpretation is correct it is a most favourable target for base metal exploration and the several weak to moderate strength airborne electromagnetic conductors (OGS, 1991a,c,d) associated with this unit warrant further exploration.

Elsewhere, aphanitic and plagioclase porphyritic flows and quartz-feldspar porphyry sills form narrow discontinuous units interlayered with intermediate metavolcanic rocks of the Shebandowan assemblage. Felsic pyroclastic rocks similar to those observed along the Adrian Lake road occur along the western contact with metasedimentary and mafic metavolcanic rocks of the Greenwater assemblage.

Table 4b shows that the Shebandowan assemblage felsic metavolcanic rocks contain more plagioclase, and less quartz than the Greenwater assemblage felsic metavolcanic rocks. This difference in mineralogy may be due to the higher metamorphic grade of the Greenwater assemblage but at least some of the difference between the two assemblages may be due to different primary compositions. Regardless of the cause the different mineralogy is an effective way to distinguish between the two assemblages.

Clastic and Chemical Metasedimentary Rocks

Greenwater assemblage

Clastic metasedimentary rocks within the Greenwater assemblage form two major bands in the map area and both are composed of wacke, siltstone, mudstone, conglomerate, derived schist and gneiss. Chemical metasedimentary rocks form large mappable units in both bands and these rocks are discussed separately (see below). One major band of clastic metasedimentary rocks extends from the northwestern boundary of Marks Township to the eastern boundary of the map area. Wacke derived from intermediate tuff and mudstone are the major rock types in this band. Brown to grey weathering wacke is thickly to thinly bedded and is predominantly massive.

Locally grain gradation and load casts are preserved and provide reliable stratigraphic younging directions. Reversals in stratigraphic facings indicate this metasedimentary unit is complexly folded. At one location on the Adrian Lake road wacke interbedded with mudstone displays excellent preservation of grain gradation, load casts and rare cross bedding (Photo 5). The grain gradation and cross bedding are interpreted as the "A" and "C" divisions of the Bouma sequence in deep water turbidite deposits. Intermediate tuff and crystal lapilli tuff are commonly interbedded with the wacke and mudstone. Where these metavolcanic rocks form narrow (less than 1 m thick) units they are very difficult to distinguish from the metasedimentary rocks.

Mudstone and siltstone are commonly black, laminated to thinly bedded and in a few places are graphitic. These rock types commonly occur at the top of wacke beds and are interpreted as the "E" division of the Bouma sequence in turbidite deposits in this setting. Mudstone and siltstone also occur as thick, massive to laminated units especially north of Marks Lake. In this setting they are interpreted as deep water, low energy basinal deposits.

Within this band of metasedimentary rocks there occurs several narrow conglomerate units including a distinctive quartz-bearing pebble conglomerate. These conglomerate units are generally less than 5 m thick and are polymictic composed predominantly of rounded to subangular chert and metasedimentary fragments including ironstone. Intermediate and mafic metavolcanic fragments are common. The quartz pebble conglomerate is composed predominantly of rounded to angular, sugary textured quartz pebbles up to 5 cm in size with subordinate mudstone, intermediate and mafic metavolcanic pebbles of comparable size. For the most part the pebbles are matrix supported in a recrystallized biotitic and hornblendic matrix that commonly contains up to 5% disseminated pyrrhotite and locally garnet. The quartz pebbles commonly display laminations and this indicates that they most likely originated as chert. In an area approximately 700 m east of the Adrian Lake road in south central Adrian Township quartz

pebble conglomerate was silicified and contains up to 20% pyrite and pyrrhotite. Anomalous gold is associated with the unit (sample 562, Table 9).

The conglomerate units required high energy to erode previously consolidated metasedimentary rocks and to redeposit them. Their association with deep water turbidites indicates that there was periodic influx of coarse material derived from a shallow water to subaerial environment into a low energy basin setting.

There is a pronounced change in metamorphic mineralogy from north to south in the wacke and mudstone units. Lower to middle greenschist grade metamorphic minerals such as chlorite, epidote and carbonate are more abundant north of Twinbirch Lake; whereas, upper greenschist to lower amphibolite grade metamorphic minerals such as biotite, blue-green pleochroic hornblende and garnet are more abundant south of Twinbirch Lake (Winkler, 1979).

Metasedimentary gneiss and migmatite occur only south of Twinbirch Lake within 1 km of the contact with the felsic intrusive rocks. Gneiss is typically dark brown weathering and characterized by planar foliation or weak gneissosity defined by biotite and hornblende. This rock type is gradational into more readily recognizable metasedimentary rocks which serves to distinguish the gneiss as metasedimentary derived. Migmatite is similar to the gneiss except that the foliation is contorted and locally quartzo-feldspathic segregations occur parallel to the foliation planes.

A second major band of clastic metasedimentary rocks occurs within the Greenwater assemblage and extends northwest from the east end of Stephens Lake to the north central part of Adrian township. Wacke and mudstone are the predominant rock types and they are commonly organized into laminated to thinly bedded (1 mm - 5 cm) couplets interpreted to be turbidites deposited in a deep water, relatively low energy environment. These rock types are very similar to

wacke and mudstone described above with the exception that wacke is more abundant and coarser-grained in the northwest trending belt. Grain gradation and load casts are well developed and they show several reversals in stratigraphy which is attributed to folding about northwest trending axes.

Chert, intermediate tuff, lapilli tuff and magnetite-jasper ironstone are interbedded with the clastic metasedimentary rocks and locally they comprise distinct, mappable units (see below). In a few places laminated chert and jasper overlie wacke and replace mudstone as the "E" division of the Bouma sequence. In fact Table 5 shows that opaque minerals, principally magnetite and hematite, are present in all clastic metasedimentary rocks in the Greenwater assemblage. This is interpreted by the author to indicate that chemical sedimentation was persistent throughout deposition of the clastic material. Chemical sediments accumulated during quiescent periods.

Pebble conglomerate is locally present and is composed of small rounded to angular quartz, intermediate and mafic metavolcanic and mud chip fragments from 4-9 mm in size in a sand to grit matrix. The pebbles are most commonly clast supported and densely packed; however, matrix supported, mud chip conglomerate is common. In most places the conglomerate is poorly sorted but in a few places it is composed of very well sorted intermediate and mafic metavolcanic clasts, some of which are plagioclase phyric. Pebble conglomerate generally forms discontinuous units interbedded with wacke and mudstone near the top of the Greenwater assemblage and occur most commonly north of Stephens Lake. The pebble conglomerate units indicate periodic influx of high energy deposits into an otherwise low energy deep, water environment. The presence of plagioclase phyric clasts indicates volcanism, responsible for formation of the Shebandowan assemblage, commenced prior to cessation of sedimentation. However, it remains uncertain if there was a significant hiatus between the Greenwater

assemblage volcanism and the Shebandowan assemblage volcanism because there are no age dates in this part of the Shebandowan greenstone belt.

Chemical metasedimentary rocks within the Greenwater assemblage are composed of chert, jasper-magnetite ironstone and sulphide facies ironstone. White to grey weathering chert is the most common chemical metasedimentary rock and commonly occurs as narrow (1-3 cm thick) interbeds within the clastic metasedimentary rocks. It rarely forms mappable units; however, interbedded chert, mudstone and graphitic-sulphiditic mudstone form thick units southeast of Adrian Lake, in the southern part of Adrian Township and locally northeast of Stephens Lake. These units are coincident with airborne electromagnetic conductors which effectively map the location of these units (OGS 1991 a-d).

Chert breccia is a field name applied to grey weathering chert that contains white silica net veining. The veining created grey chert fragments from 1 to 15 cm in size and units up to a few meters thick. Chert breccia is a minor rock type in the map area and is restricted to chemical metasedimentary units in southeastern Adrian Township. Whether the brecciation is tectonic or hydrothermal in origin is uncertain.

Thick, folded sequences of interlaminated chert and magnetite occur in the northeast part of Marks Township and are inferred from airborne geophysics (OGS 1991d) to underlie the north central part of Marks Township. White chert is most commonly recrystallized to sugary textured quartz and occurs in laminae up to 1 cm thick. The magnetite is generally very fine-grained, black and occurs in laminae and beds up to 15 cm thick. These units commonly display interference fold patterns which indicates that they were structurally thickened by multiple folding events. These deposits were explored by the Hanna Mining Company in 1962 and were determined to be too lean to be economic at that time (see Economic Geology).

Red and black jasper-magnetite ironstone occurs most commonly interbedded with the deep water turbiditic metasedimentary rocks extending southeast and northwest of Stephens Lake. Here laminated and bedded jasper and magnetite form units up to 20 m thick which can be followed more or less continuously along strike for up to 3 km. Wacke and less commonly mudstone are interbedded with the ironstone but they rarely comprise more than 10% of any individual unit. Shegelski (1978) concluded that oxide facies ironstones similar to those in the map area were formed in deep water as result of deposition of ferro-silicic precipitation. This constant "rain" of precipitates accumulated during quiescent periods of clastic sedimentation to form the laterally extensive ironstone deposits. It is inferred by the author that these units were the source of some of the jasper-magnetite clasts in the overlying conglomerate described below in the Shebandowan assemblage.

Jasper-magnetite ironstone also forms a mappable unit west of the Adrian Lake road approximately 1700 m north of Twinbirch Lake. Here the ironstone is interlayered with mudstone, wacke and minor chert and forms a unit up to 100 m thick which is hosted by mafic metavolcanic rocks. The ironstone appears to pass gradationally into chert and graphitic mudstone along strike to the northwest.

Thin bands of ironstone interbedded with wacke and mudstone were observed in several places in northwestern and southeastern Adrian Township but these units are generally not mappable. They indicate that chemical sedimentation was widespread throughout the Greenwater assemblage.

Graphitic metasedimentary rocks are widespread throughout the Greenwater assemblage but only form a mappable unit along the north shore of Adrian Lake and to the east. These rocks are black, fissile, thickly laminated and commonly contain trace to a few percent disseminated pyrite. Locally, graphite stringers and schist contain mudstone chips creating a

brecciated texture. A string of electromagnetic conductors (OGS 1991d) coincides with this unit and random sampling by the field crew indicates that gold, arsenic and zinc are locally anomalous (sample 340, Table 9).

Sulphide facies ironstone was located in one place along the northern boundary of the map area. Massive pyrite, chert and graphitic mudstone forms a unit up to 5 m thick and is hosted by Shebandowan assemblage intermediate lapilli tuff. Airborne electromagnetic conductors (OGS 1991a) coincide with this unit; however, random sampling failed to detect any anomalous mineralization (samples 363,364, Table 9).

Shebandowan assemblage

Metasedimentary rocks in the Shebandowan assemblage are composed of a distinctive jasper-magnetite cobble to boulder conglomerate unit at the base of the assemblage. This unit is restricted to a linear belt over 6 km long and less than 50 m thick extending from south of Stephens Lake to the northwest. This unit is best exposed approximately 800 m northwest of Stephens Lake where over 90 % of the cobbles and blocks are composed of angular to rounded jasper-magnetite ironstone (5 - 100 cm), and laminated mudstone . The remaining 10 % of the clasts are composed of intermediate and mafic metavolcanic cobbles which do not contain any phenocrysts. The conglomerate is clast to matrix supported in a texturally immature sand matrix. Several jasper clasts contain contorted bedding and quartz veins which do not extend into the matrix (Photo 7). Farther north jasper cobbles are less common and white to yellow bedded chert cobbles occur. This unit is a resedimented conglomerate and represents a distinctly different type of depositional environment from that of wacke and ironstone units of the Greenwater assemblage. The size, angularity and composition of the clasts indicates that the conglomerate was deposited in a high energy, most likely shallow water to subaerial depositional environment. The immaturity of the clasts and matrix indicate there was very little transportation of the sediment. It is possible that the unit represents a paleofault scarp or scree deposit. Further, the

contorted and quartz-veined nature of some of the clasts implies that the jasper-magnetite ironstone of the Greenwater assemblage was deformed prior to resedimentation. It is inferred by the author that a Pre-Kenoran orogeny affected the Neoarchean rocks in the map area and that this orogeny is most likely equivalent to the one inferred to have formed the Shebandowan assemblage (Williams et al, 1991).

Clearly, this conglomerate is a key unit to the interpretation of the geological history of the area. Further detailed study of this unit is strongly recommended.

Metamorphosed Ultramafic and Mafic Intrusive Rocks

Ultramafic and mafic intrusive rocks, underlie approximately 5% of the map area, are composed of peridotite, pyroxenite and gabbro and occur as dikes, sills and small stocks. Ultramafic rocks are found mostly within the Greenwater assemblage northeast of Stephens Lake. Some of the ultramafic rocks may represent the cumulate portions of komatiitic flows (Carter 1985); however, intrusive contacts with chert were observed in at least one place. Mafic intrusive rocks are most common in the Greenwater assemblage and are more widely distributed throughout the map area. The macroscopic and microscopic features of the ultramafic and mafic intrusive rocks are listed in Table 6a, b.

Peridotite is the most abundant ultramafic rock in the map area. It occurs most commonly in sills that strike northwest to west-northwest. Most peridotite is massive and medium-grained with a granular texture and it is uniformly moderately to strongly magnetic. Serpentine filled polygonal jointing is uncommon and where present it appears to be randomly distributed in outcrop. Asbestos was observed to fill the polygonal joints in two or three places. The peridotitic rocks appear to be homogeneous bodies and there is no obvious differentiation along or across strike at outcrop scale. Locally, peridotite is closely associated with spinifex textured basaltic

komatiites, gabbro and pyroxenite; however, nowhere were contact relations among these rock types observed.

Carter (1990) indicated that a succession of ultramafic and mafic rocks between Adair and Thunder lakes in northeastern Adrian Township were most likely thick komatiitic flows and ponded lava lakes interbedded with chert and graphitic mudstone. The present mapping indicated that this area contains much more gabbro, and anorthositic gabbro than previously recognized. Carter (1990) also reported that pillowed and amygdaloidal flows occurred in the vicinity of Thunder Lake. The present mapping in the northeast part of Adrian Township did not locate any pillowed flows but amygdules were observed in a coarse-grained gabbroic textured flow in only one location. Hill et al (1990) provided excellent descriptions of many world-wide occurrences of komatiitic flows. Many of the features they described are similar to those observed in the map area. Therefore, Carter's interpretation is probably correct but there are many complications in Adrian Township which require more detailed mapping and investigation.

As seen in thin section the peridotite most commonly displays an adcumulate to mesocumulate texture (Hill et al 1990) with relict anhedral to subhedral olivine altered to serpentine, talc and magnetite. Primary clinopyroxene and its altered equivalent, chlorite and talc, comprise less than 20% of the rock and commonly encompass many olivine grains. These rocks are weakly deformed and in many places primary pyroxene has been preserved.

Pyroxenite was found in one location approximately 200 m northeast of Peridotite Lake in northeastern Adrian Township. This massive rock is bright green weathering and is medium-grained. It is composed of 80% equant, subhedral clinopyroxene with subordinate serpentine and talc replacing olivine. The rock is weakly deformed and there has been very little alteration of the primary pyroxene. Contact relationships with nearby peridotite and basaltic komatiites were not observed and it is possible that the pyroxenite is part of a layered intrusion or flow.

Ultramafic schist is locally present and is dark green to orange brown weathering, commonly with a large proportion of iron carbonate. Schist is generally very fissile and has a greasy feel which is attributed to the presence of talc. Two samples of schist were collected for assay and their results are reported in Table 9.

Mafic intrusive rocks, composed of gabbro, are widespread throughout the Greenwater assemblage and occur locally in the Shebandowan assemblage. A number of subdivisions based on colour index and morphology were recognized in the field. Table 6b presents the major macroscopic and microscopic details of the gabbroic rocks.

Mafic intrusive rocks north and northeast of Stephens Lake are composed predominantly of gabbro and leucogabbro with minor amounts of intrusion breccia and anorthositic gabbro. These rocks are weakly deformed, low grade metamorphosed and commonly retain primary pyroxene and rarely relict olivine. Gabbro and leucogabbro are most commonly medium-grained and equigranular; however, locally, fine-grained gabbro occurs adjacent to rocks that are more clearly recognized as mafic flows. Graphic textured quartz and plagioclase intergrowths are common especially near Thunder Lake. Leucogabbro has a colour index between 35 and 60 which serves to distinguish this subdivision from gabbro.

Anorthositic gabbro occurs as a separate phase within gabbro on a large ridge southwest of Thunder Lake. This rock contains approximately 65% plagioclase and weathers light grey to pale green. Graphic textured quartz is common and this rock is interpreted as a differentiated phase of a larger intrusion.

A gabbro stock (approximately 4 km^2) underlies the west central part of Adrian Township. This intrusion is characterized by fine- to medium-grained, dark green, equigranular gabbro. The

gabbro is massive, weakly to non-magnetic and contains a typical greenschist grade metamorphic mineral assemblage composed of actinolite\hornblende, plagioclase, epidote and chlorite with minor quartz and carbonate. Minor knobby gabbro, pegmatitic gabbro and intrusion breccia occur in the northwest part of the intrusion.

Knobby gabbro is a field term applied to medium- to coarse-grained rock that contains rounded clusters (up to 1 cm in size) of mafic crystals in a feldspathic rich groundmass. This rock type occurs within the gabbroic stock described above and in dike-like intrusions along the northwestern boundary of the map area. The weathered surface is typically mottled green and white and has a distinct clotted texture.

Gabbroic intrusion breccia is characterized by knobby gabbro and gabbro fragments that are surrounded by chlorite filled net veins and less commonly pegmatitic gabbro patches and stringers. Rarely wall rock fragments are included in the breccia. Intrusion breccia is not common and appears to have formed more from late magmatic fluid migration rather than actual stoping.

Gabbroic rocks in Marks Township and southeastern Adrian Township occur mainly as dikes intruded into metasedimentary rocks. These intrusions are fine- to medium-grained and are locally sheared. Rarely the rocks contain small quartz filled amygdules which indicates they are hypabassal intrusions or flows.

Felsic Intrusive Rocks

Felsic intrusive rocks are predominantly composed of granodiorite, granite, and quartz monzonite with lesser quantities of diorite, tonalite, gneiss, migmatite and aplite dikes (Table 7). These rocks underlie the central and southwestern parts of Marks Township and comprise approximately 20% of the map area. All felsic intrusive rocks in the map are parts of the Northern Light-Perching Gull Lakes batholithic complex (Williams et al 1991).

The recently released bedrock geology map of Ontario (OGS 1991e) shows the distribution of the felsic intrusive suites in the map area. Foliated and gneissic tonalite most commonly occurs in southwestern Marks Township as poorly defined units and as large xenoliths within granodiorite and quartz monzonite. Foliation and gneissosity trend north-northwest to northwest in the tonalite; whereas, the granodiorite is massive to weakly fractured with northeast trending joint sets. The tonalitic rocks are the oldest in the batholithic complex (Williams et al 1991).

Granodiorite to quartz monzonite is the most common rock type in the central part of Marks Township and is most commonly massive, medium-grained and equigranular. In many places a weakly developed northwest trending penetrative foliation to spaced fracture set is present and in a few places this fabric is overprinted by a weakly developed northeast trending foliation. Locally, amphibolite and gneissic tonalite xenoliths are present but they rarely constitute more than 1% of the rock. The granodiorite to quartz monzonite phase displays gradational and intrusive contacts with the gneissic tonalite in the southwestern part of Marks Township and displays gradational contacts with granitic rocks farther to the north and east. According to Williams et al (1991) the granodiorite phase of the Northern Light-Perching Gulls Lakes batholithic complex is younger than the tonalitic phase. It appears that the granodiorite phase in the map area intruded the tonalite mainly by stoping.

Equigranular to potassium feldspar porphyritic granite is common adjacent to the "granite-greenstone" contact and in the northeastern part of Marks Township. The equigranular granite is commonly dark pink to red weathering, quartz rich and commonly contains more hornblende than biotite. The porphyritic granite is easily recognized in the field by the presence of euhedral pink and white feldspar crystals (to 3 cm in size) in a pink to mottled dark green and pink groundmass. The granitic rocks are most commonly massive and become progressively more

foliated as the contact with the supracrustal rocks is approached. The contact with the supracrustal rocks appears to be abrupt, although it was not observed; whereas, the granite displays gradational contacts with the other phases of felsic intrusive rocks. Williams et al (1991) included the granitic rocks with the granodioritic rocks previously described.

Late Mafic Intrusive Rocks

Lamprohyre is widely scattered throughout the map area. Lamprophyre dikes from a few centimetres to over 5 m wide intruded the supracrustal rocks is many places. These dikes are dark green to black weathering and are distinguished by the presence of abundant biotite comprising up to 20% of the rock. The lamprophyre is equigranular to biotite porphyritic and contains essential tremolite\actinolite, plagioclase and biotite with accessory quartz, microcline, apatite and titanite.

Lamprophyre also occurs as large xenoliths hosted in granitic migmatite and cut by granitic and tonalitic aplite dikes in one outcrop on Highway 590 in Marks Township. Here the lamprophyre is dark green, equigranular and contains essential biotite and amphibole with accessory plagioclase, quartz, apatite and titanite.

Paleoproterozoic

Animikie Group

The Animikie Group is divided into the Gunflint Formation and the overlying Rove Formation (Sutcliffe, 1991). Members of the Gunflint Formation underlie approximately 10% of the map area in the southeastern part of Marks Township. These rocks are composed of taconite, chert and algal mat chert with minor argillite and rarely quartz pebble conglomerate. Moorhouse (1960a,b) mapped the Gunflint Formation in the map area as part of a larger study. The present mapping indicates that the contact of the lower Gunflint Formation and the Archean granitic rocks is farther south than Moorhouse (1960a) indicated. Proterozoic outcrop on the fourth concession

road in Marks Township is an outlier surrounded by granodiorite rather than being contiguous with other members of the Gunflint Formation.

Taconite, the most common rock type in the map area, is a term applied to any bedded ferruginous chert or jaspery rock with at least 25% iron content (AGI 1987). In the map area, taconite consists of various proportions of granular, hematitic chert that contains hematite and magnetite stringers and/or hematitic oolites. Taconite forms thin, flat lying beds that vary from very friable to well indurated depending upon the amount of silica in the rock. Well developed, red, oolitic taconite is exposed on the first concession road along the boundary between Marks and Lybster townships. In thin section this rock is characterized by hematitic, spherical to oval ooliths "floating" in a recrystallized and chalcedonic quartz matrix (Photo 8). Individual ooliths are up to 5 mm in size and are rarely in contact with each other.

Chert and algal mat chert are exposed in a few places in Marks Township. Red algal chert occurs on the second side road in southern Marks Township. Here, flat lying, laminated to wavy algal chert is the predominant rock type and locally granular to oolitic taconite occurs between laminae. Sporadically, hemispherical to columnar algal chert mounds are developed within the laminated sequence. These mounds are typically 8 to 15 cm in diameter, rarely up to 30 cm in diameter and were observed in one place to stand up to 15 cm high.

Black laminated algal chert interbedded with brown friable taconite was observed on the fourth concession road in Marks Township where it occurs as an in situ outlier. At this location the algal chert unconformably overlies Neoarchean granodiorite and is characterized by thin to thick straight to wavy laminae. Taconite nodules up to 1 cm in size commonly occur between laminae as do thin taconite beds. In thin section it is common to find individual taconitic ooliths between laminae. This indicates that continuous iron sedimentation occurred as the stromatolites were being formed.

Quartz pebble-bearing conglomerate was observed in only one location as an outlier surrounded by quartz diorite and granodiorite on the second side road in Concession IV, Marks Township. The conglomerate is exposed over 1 m^2 and consists of quartz pebbles in a coarse quartz rich sand matrix. Goodwin (1956) inferred that the conglomerate was continentally derived and formed on a pediment similar to Mesozoic equivalents.

The flat lying Proterozoic metasediments overlie Archean foliated granodiorite and quartz diorite on the fourth concession road, Marks Township. The Archean rocks weather white, pink or brown-grey and the colouration is very variable over the outcrop. The brown-grey weathered rock is generally more friable than the other coloured varieties and the friability persists to at least 4 or 5 cm below the surface in places. The colour variation is gradational over centimeters and there does not appear to be any pattern to the changes. Farther west from the unconformity there does not appear to be any such colour variations and the weathered granitic rocks are typically pink and well indurated.

Goodwin (1956) indicated that, for the most part, there was no extensive weathering of the Archean rocks prior to deposition of the Gunflint Formation. If this were true then the colour variation and friability of the rocks in the map area could be accounted for by hydrothermal alteration. Kronberg and Fralick (1992) indicated that Proterozoic alteration did occur and that it extended up to 3 m into Archean granodiorite. This alteration was manifested most greatly in the ferromagnesian minerals which were amphibole and biotite compositions in the unaltered granodiorite and assumed chlorite chemistry in altered rock (Kronberg and Fralick 1992). The chemical changes were accompanied by colour changes from green-black in unaltered ferromagnesian minerals to green in altered mineralogy and from white in unaltered feldspar to pink in the altered minerals (Kronberg and Fralick 1992).

The presence of stromatolites and oolitic taconite indicate that the Gunflint Formation was deposited in shallow, agitated water (Goodwin, 1956, Moorhouse, 1960b).

It is probable that members of the upper Gunflint Formation underlie the extreme southeast corner of Marks Township. Logs from water wells drilled for farms in this area indicate the Gunflint Formation is up to 43 m thick. Moorhouse (1960b) indicated that the lower Gunflint Formation was no more than 14 m thick.

Mesoproterozoic

Keweenawan Supergroup

Two outliers of Keweenawan diabase were mapped in Adrian Township. Both occurrences are located on topographic highs and both appear to lie directly on top of intermediate metavolcanic rocks of the Neoarchean Shebandowan assemblage. The diabase is orange-brown weathering and is brown on fresh surface. The rocks are medium-grained, equigranular, massive and undeformed. In thin section the diabase has a subophitic texture and is characterized by unaltered plagioclase laths (An 34-48), euhedral to subhedral clinopyroxene and small, anhedral olivine. Accessory minerals include magnetite and rare biotite.

Sutcliffe (1991) indicated that the Logan diabase sills intruded the Paleoproterozoic Animikie Group south and west of Thunder Bay and it is most likely that the diabase outliers in Adrian Township are members of the Logan sills. The Logan sills are quartz normative tholeiites, are 1100 Ma old and were deposited in and along the margins of the Midcontinent Rift (Sutcliffe 1991).

Cenozoic

Quaternary and Recent

The Quaternary and Recent geology of the map area is characterized by different land forms and glacial events. The most prominent glacial feature is the Marks moraine (Burwasser 1977) which strikes easterly across the central part of Marks Township and is coincident with the Boreal road. Burwasser (1977) indicated that the Marks moraine marked the maximum extent of the Superior ice lobe during its last major advance west of the Superior basin (Marquette advance; Barnett 1992). The moraine contains material derived from the east and is characterized by short, narrow eskers and crevasse fillings in Marks Township (Burwasser 1977). There are a number of small kettle lakes also associated with the moraine in the map area.

North of the moraine the terrain is rocky and covered by thin discontinuous till and Recent organic deposits in low lying areas. Red clay occurs locally in the northern part of Adrian Township and these deposits have been found as far west as Dryden in deposits related to glacial lake Agassiz (Barnett 1992). Glacial striae are common and are oriented between 135° and 235° with most oriented between 185° and 195°.

South of Marks moraine the terrain is characterized by rocky hills in areas underlain by Neoarchean granitic rocks. Recent organic deposits are common in low lying areas. The area underlain by the flat lying Paleoproterozoic rocks is characterized by flat to rolling hills topography with the greatest relief (up to 20 m) in river valleys. Glacial striae in this area are oriented between 265° and 275° and indicate easterly ice advance related to the Lake Superior ice lobe (Burwasser 1977).

Logs from water wells drilled in the southeastern part of Marks Township indicate that there are two major aquifers in this area. The first and more continuous aquifer is located at the interface between the Quaternary deposits and the Gunflint Formation which is generally less than 20 m below surface. The second aquifer which is discontinuous is located at the contact between the Gunflint Formation and the Archean rocks.

Geochemistry

Forty-three rock samples from various rock types throughout the map area were picked for whole rock and selected trace element analysis (Figure 3a). These samples were submitted to X-Ray Assay Laboratories in Don Mills, Ontario for analysis and results are presented in Appendix 1. The purpose of the geochemistry was to chemically characterize a wide range of the Neoarchean rock types in the map area especially the metavolcanic rocks of the Shebandowan assemblage. These data were plotted on a variety of discrimination diagrams with the intention of graphically displaying trends and any differences between the two supracrustal assemblages.

The geochemistry was largely unsuccessful in detecting any major oxide or trace element differences between the two supracrustal assemblages. Both assemblages are subalkalic (Figure 4) and both display mixed tholeiitic and calc-alkalic geochemical affinities (Figure 5). The REE patterns are essentially the same for both assemblages and show enrichment of the light REE in relationship to the heavy REE (Figure 6). Figure 5 shows that a significant number of Shebandowan assemblage intermediate metavolcanic rocks have a tholeiitic geochemical affinity. This trend was not recognized by Carter (1990) or by Williams et al (1991); both of these sources indicated that the Shebandowan assemblage was predominantly calc-alkalic to alkalic geochemical affinity. Therefore, the geochemistry must be examined very critically (Appendix 1).

The most noticeable difference between the two assemblages is the high CO_2 and LOI (loss on ignition) values associated with most Shebandowan assemblage rock samples. This is interpreted by the author to indicate widespread alteration of the Shebandowan assemblage and calls into question the validity of the geochemistry presented herein for these rocks. In thin section the alteration is manifested as very fine-grained carbonate and white mica which was not apparent in hand sample. Further, petrographic studies revealed that many of the Shebandowan assemblage samples submitted for geochemistry contained pervasive iron chlorite which was

most commonly present in microscopic amygdules. Again, the extent of the chloritization and vesiculation of the rocks was not obvious in either hand sample or outcrop.

It is possible that regional low grade metamorphism is responsible for development of the hydrous minerals and widespread carbonatization of the Shebandowan assemblage. This would account for the high CO_2 and LOI values. It is also possible that the hydrous minerals and pervasive carbonate alteration were developed by hydrothermal alteration processes related to either base metal or precious metal mineralization.

Structure and Metamorphism

The Neoarchean supracrustal rocks are complexly folded and faulted with at least two periods of deformation evident in the Greenwater assemblage. The first deformation is characterized by northwest trending isoclinal fold axes and is commonly accompanied by a layer parallel foliation. This style of folding is best displayed north of Stephens Lake where reversals in stratigraphic facings define the axes of several anticlines and synclines over several hundred metres. Mesoscopic "Z" and "S" folds are locally well developed in the ironstone units along the flanks of the inferred folds and these structures indicate fold closures to the southeast. A major southeast closing anticline as defined by stratigraphic facings underlies the central part of Adrian Township.

The second deformation is apparent in the Greenwater assemblage as northeast trending faults, folds and foliations. Interference fold patterns are locally well developed within the clastic and chemical metasedimentary rocks and where present permit characterization of the style of folding. In the northwest part of the map area northwest striking isoclinal folds in wacke and ironstone are clearly refolded and faulted about northeast striking faults and folds. In all cases northeast striking faults display sinistral offset and are characterized by moderate to steep stretching and mineral lineations. In the southern part of Marks Township interference fold

patterns similar to those associated with orthogonal fold axes are displayed in ironstone units within mafic amphibolite (cf. Hobbs et al. 1976)(Photo 9). Northeast striking foliations are common throughout the Greenwater assemblage and it is always the younger foliation wherever cross cutting relationships were observed.

In contrast, the Shebandowan assemblage is less complexly deformed and evidence for the northeast trending fabric is most common. In many places the intermediate metavolcanic rocks are relatively undeformed and limited stratigraphic facings indicate the Shebandowan assemblage is homoclinal and youngs to the west. In the northwest part of Adrian Township, the northeast trending shear zones are locally well developed. In this area southwest plunging mineral and stretching lineations are commonly developed on the foliation planes. Locally, the northeast foliation is accompanied by and in some places cut by an east striking fabric that displays sinistral offset.

A major northwest striking fault coincident with the Weigand River is inferred to cut the supracrustal rocks. Subhorizontal slickensides indicate movement was largely strike - slip and the map pattern suggests movement was predominantly dextral. Intense iron carbonate alteration, sparse disseminated pyrite, chalcopyrite and green mica were observed in the northern part of the fault. Geochemically anomalous gold and arsenic accompany the alteration and sulphide mineralization (see Economic Geology).

A penetrative, northwest striking vertical to northeast dipping foliation is weakly to well developed in the felsic intrusive rocks in the southern part of the map area. Southeast and rarely northwest plunging mineral lineations are locally developed. Near the contact with the Neoarchean supracrustal rocks foliations are locally east-west. A northeast striking foliation to spaced fracture set is weakly developed in the southwestern and central part of Marks Township and clearly overprints the northwestern foliation where cross cutting relationships were observed.

Locally, shallow to moderate southwest plunging mineral lineations and rarely shallow northeast plunging intersection lineations were observed on this foliation. The northeast foliation is inferred to be part of a more regional northeast trend which was interpreted by Sutcliffe (1991) to be Proterozoic. However, there is little physical evidence in the field for a prominent northeast striking fault portrayed on the Atikokan-Lakehead compilation map (ODM 1964). If this trend is Proterozoic its effect upon granitic rocks and the Shebandowan greenstone belt in the map area is poorly understood.

Williams et al (1991) indicated that the Shebandowan greenstone belt underwent 2 deformations. The first deformation encompassed the entire belt and is characterized by westerly plunging mineral and stretching lineations. The second deformation apparently overprinted parts of the belt most notably the northern part. The second deformation is characterized by easterly plunging lineations adjacent to and into the Quetico Subprovince and these lineations become southwest plunging in the southwestern part of the belt (Williams et al 1991). Brittle-ductile shear zones, some of which host gold mineralization, were formed by the second deformation. The Shebandowan assemblage shows no record of the first deformation (Williams et al 1991). The present field mapping largely substantiates these conclusions. The mapping shows that the second deformation affected the southern part of the Shebandowan greenstone belt and that rocks correlated with the Shebandowan assemblage were deformed only by the second event.

Jirsa et al (1992) carried out detailed structural analysis of the western Wawa Subprovince in Minnesota which is the southwest extension of the Shebandowan greenstone belt into the United States. They recognized three periods of deformation which consisted of a D_1 event that produced recumbent nappe structures; a D_2 event which overprinted D_1 and produced up right northeast trending fold axes and foliations and a D_3 event which generated northeast and northwest trending faults, local crenulation zones and a weak northeast trending fabric in some of the plutonic rocks. There are remarkable similarities between structures produced by the latter

two deformations and those in Adrian and Marks Township. The exact nature of the structures of the first deformation in the map area requires more study.

The Paleoproterozoic metasedimentary rocks are essentially undeformed with a widely spaced, east striking joint set only locally developed. These rocks are flat lying and sit unconformably on top of the Neoarchean granitic rocks.

There are two important metamorphic features in the map area. Firstly, the southern part of the supracrustal rocks attained higher grade metamorphic conditions than the supracrustal rocks in the northern part of the map area. Secondly, members of the Shebandowan assemblage generally display lower grade metamorphic minerals than members of the Greenwater assemblage in the same vicinity.

With respect to the first feature garnet, blue-green pleochroic amphibole and biotite are commonly present in wacke in the southern part of the supracrustal rocks. Gneiss, migmatite and mafic amphibolite occur only in the southern part of the greenstone belt and are most common within 1 km of the contact with the felsic intrusive rocks. Most rocks in this area are extensively recrystallized and contain minerals indicative of upper greenschist to lower amphibolite facies metamorphism (Winkler 1979).

In contrast, wacke from the northern part of the map area commonly contains epidote, chlorite and carbonate with various amounts of biotite and white mica. Primary textures and mineralogy are better preserved; it is common to find primary pyroxene and plagioclase in the mafic and ultramafic rocks. Metamorphic mineral assemblages in all rock types are compatible with lower to middle grade greenschist metamorphism (Winkler 1979).

The higher metamorphic grade in the southern part of the supracrustal rocks may have been caused by intrusion of the granitic rocks which formed a metamorphic aureole adjacent to the "granite-greenstone" contact. However, the high grade metamorphic rocks extend up to 2.5 km from the contact which appears to be anomalously great. It is possible that the granitic rocks extend under the supracrustal rocks and are relatively close to surface.

The second important metamorphic feature is the apparent difference in metamorphic grade between the Shebandowan and Greenwater assemblages. Intermediate metavolcanic rocks comprise the bulk of the Shebandowan assemblage and most commonly these rocks contain chlorite, white mica and carbonate with lesser amounts of epidote. Primary pyroxene and amphibole are locally preserved and chalcedonic quartz is common in amygdules. Primary textures such as flow banding, pumice, welded tuff and trachytic textured fragments are common and well preserved. Low grade greenschist to possibly burial grade metamorphism is indicated (Winkler 1979) and this feature can be used to effectively distinguish between members of the Shebandowan and Greenwater assemblages.

Intermediate metavolcanic rocks of the Greenwater assemblage commonly contain epidote, biotite and blue-green amphibole indicative of middle to upper grade greenschist metamorphism. Wacke adjacent to the Shebandowan assemblage contains epidote and biotite with lesser quantities of chlorite. In addition, members of the Greenwater assemblage are more likely to be recrystallized with fewer primary features than the members of the Shebandowan assemblage.

Economic Geology

There are no known economic mineral deposits in the map area; however, exploration activity has been limited. The Hanna Mining Company explored the northern part of Marks Township and the southeastern part of Adrian Township for iron in 1962 and discovered

magnetite, jasper and chert ironstone associated with mafic amphibolite and wacke. Surface and diamond drill exploration of these ironstones determined that the iron content was too low to be economic at that time.

Exploration for base metals has been limited to parts of Adrian Township and there are no known occurrences in the map area. Noranda Exploration Company Limited and Canadian Nickel Company Limited diamond drilled selected airborne magnetic and electromagnetic anomalies in 1966 - 67 without encountering significant mineralization (Table 8).

Tanton (1931) reported that amethyst and quartz crystals occurred in granite in lot 4, Concession VI, Marks Township and that an amethyst vein was reported to occur in Lot 12, Concession I of Marks Township. There was no report that either of these occurrences were subsequently explored and neither of these occurrences were located during the field season. However, traverses by the field crews did discover new two amethyst occurrences east of Echo Lake.

Amethyst

There are a number of high quality amethyst deposits in the Thunder Bay area (Fyon et al 1992). All amethyst occurrences occur at or near the subhorizontal unconformity between the Archean and Proterozoic rocks and are commonly localized in vein sets trending 045°, parallel to major Keweenawan faults, or 090 +- 10° (Garland 1992). The two amethyst occurrences in Marks Township are hosted in Neoarchean granodiorite and are more thoroughly described below.

A number of mining claims were in good standing in Adrian and Marks townships at the end of 1992. Most of these claims were staked to cover airborne electromagnetic and magnetic anomalies detected by the Ontario Geological Survey Shebandowan area survey of which four

sheets cover Adrian and most of Marks townships (OGS 1991a-d). Prospecting, line cutting and ground geophysical surveys were carried out on some of these claims during the summer of 1992 but results of these data were not available at the time of writing.

Fifty rock samples from mineralized and prospective areas were collected by members of the field crew during the summer and were sent to Temiskaming Testing Laboratories, Ministry of Northern Development and Mines, Cobalt for analysis (Table 9). Other assay values referred to in this section were obtained from reports filed for assessment work credits (Assessment Files Research Office (AFRO), Toronto).

Table 8 summarizes the exploration history of the map area and was compiled from reports filed for work assessment credits (AFRO). Readers are referred to these sources for detailed accounts of previous work.

Description of Properties and Occurrences

Amalta Oils and Minerals Limited (1967)

Ground magnetic and horizontal loop electromagnetic surveys were carried out on portions of lot 3, Concession VI and VII in Marks Township for Amalta Oils and Minerals Limited in 1967. The objective of these surveys was to delineate magnetite ironstone units believed to underlie the property. Two areas with high magnetic responses were detected and attributed to magnetite ironstone. Electromagnetic anomalies displaying strong in-phase distortions were observed to closely correspond with the ironstone. No follow - up was reported and the claims were allowed to lapse.

Canadian Nickel Company Limited (1966)

In 1966, the Canadian Nickel Company Limited completed 5 diamond drillholes (total 857.3 m) in Adrian Township to test airborne electromagnetic conductors. All 5 holes were drilled north of Stephens Lake in areas underlain by diverse geology and each hole encountered alternating intermediate and felsic metavolcanic rocks, metasedimentary rocks and ultramafic intrusive rocks. The author infers that the electromagnetic conductors were caused by graphitic schist found in 4 of the holes. The fifth hole encountered peridotite and the cause of the conductor is not explained. None of the holes encountered significant sulphide mineralization and no further work was carried out.

Hanna Mining Company (1961-62)

Hanna Mining Company carried out work on 3 properties in the map area in 1961 and 1962. All work was done to evaluate the economic potential of magnetite ironstones inferred to underlie each property.

Eleven claims covering parts of lots 4 and 6, concessions VI and VII, Marks Township were subjected to ground magnetometer and geology surveys. This work was done to follow-up previous work by New Fortune Mines Limited (see below) in order to better define the grade and tonnage of magnetite ironstone units on the claims. Two folded ironstone bands were outlined one being approximately 425 m long by 26 m wide and the other being approximately 213 m long by 24 m wide. No further work was carried out on this claim group.

Traverses by the field crew through this area indicate that the thinly bedded to laminated magnetite - chert ironstone bands are interlayered with mafic and felsic metavolcanic rocks of the Greenwater assemblage. These units are complexly folded and they are metamorphosed to upper greenschist grade (Winkler 1979). Poor exposure hampers a more thorough assessment of this area.

The second property that Hanna Mining Company explored was lots 1 to 4, Concession VII in Marks Township. Ground magnetic and geology surveys were carried out to delineate in detail magnetite-chert ironstone units on the property. This work was carried out subsequent to 7 diamond drill holes being completed by Port Arthur Iron Ore Corporation (see below) to test the ironstone units. Results from the ground surveys indicated that the ironstone units were interlayered with "andesitic" metavolcanic rocks and that the units were complexly folded. Three bands of ironstone were outlined: one being 640 m long by 53 m wide; the second being 213 m long by 21 m wide and the third being 518 m long by 21 m wide. No further work was completed and the claims were allowed to lapse.

The third area explored by Hanna Mining Company was in the southeastern part of Adrian Township and extended eastward into adjacent Conmee Township. Ground magnetic and geology surveys were carried out to determine the cause of a large airborne magnetic anomaly previously detected. The surveys outlined several discontinuous magnetite-jasper ironstone units varying from 60 to 520 m long. Mafic metavolcanic and clastic metasedimentary units were host to the ironstone and served to dilute the overall tenor of the iron mineralization. No further work was carried out and the claims were allowed to lapse.

Traverses carried out by the field crew in this area encountered laminated to thinly bedded jasper, magnetite and chert beds hosted in wacke and in a few places hosted by thick chert breccia units. Less commonly mafic metavolcanic flows and plagioclase and amphibole phyric intermediate pyroclastic and epiclastic rocks are interbedded with the ironstone. The ironstone units generally display mesoscopic isoclinal folds about northwest trending axes and contorted bedding and small scale brittle fracturing is common. However, in many places there is minimal deformation and throughout the area there is little evidence that hydrothermal alteration affected the rocks. The ironstone units are interpreted by the author to be in the upper part of the Greenwater assemblage near the contact with the Shebandowan assemblage.

Kukkee, K (1986)

In 1986, rock samples were submitted for assay from claims west of Adrian Lake. There is no report of assay results or of the type of rock material submitted.

Outcrops of graphitic schist, some containing up to 10% disseminated pyrite occur in the vicinity of Adrian Lake and it is possible that some of this material was submitted for assay. Samples 340 and 344 (Table 9) collected by the author are representative samples of the graphitic schist in this area.

New Fortune Mines Limited (1957)

In 1957, New Fortune Mines Limited held several mining claims throughout the northern part of Marks Township. One diamond drill hole (Table 8) was put down on lot 5, Concession VII to test the subsurface tenor of magnetite ironstone known to occur in the area. Approximately 24 m of magnetite ironstone was encountered with an average grade of 30.8% Fe. The ironstone unit was hosted in chert and metasedimentary schist and was associated with mafic metavolcanic rocks. No further work was carried out by New Fortune Mines Limited; however, the area was explored again in 1961 by Hanna Mining Company (see above) and it was determined that the ironstone was too lean to be economic at that time.

Traverses by the field crew in this area failed to locate the diamond drill hole. Sparse outcrop in this area indicate that mafic amphibolite correlated with the Greenwater assemblage is the predominate rock type and the metasedimentary rocks, including the ironstone occur as narrow units interlayered with the mafic metavolcanic rocks. Narrow felsic pyroclastic and quartz-feldspar porphyritic units also occur in the area.

Noranda Exploration Company Limited (1967, 1976)

Noranda Exploration Company Limited (Noranda) carried out extensive exploration in Adrian Township for base metals. In 1967 Noranda held 78 mining claims in central Adrian Township west of Adrian Lake referred to as the Turn Lake group. Ground magnetic and electromagnetic surveys were carried out subsequent to an airborne survey to locate electromagnetic anomalies characteristic of sulphide ore. Many electromagnetic conductors were detected and these were grouped into 6 areas. Conductors in one area were attributed to a highly permeable source characteristic of the magnetite ironstone that occurs in the area. Conductors in 2 areas were attributed to graphitic schist that occurred in nearby outcrops. Conductors in the other 3 areas were unexplained. No further work was carried out on this group.

Traverses by the field crew west of Adrian Lake and north of Twinbirch Lake indicate this area is underlain by mafic and intermediate metavolcanic rocks, clastic and chemical metasedimentary rocks and gabbro intrusions of the Greenwater assemblage. The Shebandowan area airborne magnetic and electromagnetic survey (OGS 1991d) covers this area and has reproduced the conductors detected by Noranda. The author concurs with the conclusions of the Noranda report and notes that many of the conductors approximately correspond with the contacts between lithological units. Assay sample 319 (Table 9) was collected by the author from graphitic and pyrrhotitic schist from the northern part of this claim group.

Noranda Exploration Company Limited held four claims referred to as the one pond group in the northern part of Adrian Township in 1967. Ground magnetic and electromagnetic surveys were carried out and based on these data 1 diamond drill hole (Table 8) was sunk to test an electromagnetic conductor. This hole encountered banded graphite and silica with pyrite interlayered with felsic metavolcanic rocks. Significant base metal mineralization was not encountered and no further work was carried out.

Traverses carried out by the field crew indicate this area is underlain by intermediate pyroclastic rocks of the Shebandowan assemblage in contact with clastic and chemical metasedimentary rocks of the Greenwater assemblage. In particular, pyritic ironstone overlies wacke and pebble conglomerate in the area of the drill hole. Sample 079 (Table 9) was collected from the pyritic ironstone. It is probable that other airborne electromagnetic anomalies in this area are caused by similar material (OGS 1991b).

Noranda Exploration Company also held several mining claims in the Weigand River area in 1967 and sank 2 diamond drill holes (Table 9) to explore the cause of vertical loop ground electromagnetic conductors. Each hole encountered graphitic and pyritic schist hosted in intermediate and felsic tuff and breccia. Significant base metal mineralization was not encountered and no further work was carried out.

Intermediate and felsic flows and pyroclastic rocks of the Shebandowan assemblage underlie the Weigand river area. Pyrite occurs interbanded with flow breccia in one place along the Adrian Lake road and also occurs as sulphide facies ironstone along the northern boundary of Adrian Township. A prominent northwest trending fault occurs in the area explored by Noranda and it is possible that this structure was intersected by the diamond drill holes. There are other untested airborne electromagnetic anomalies in this vicinity which may warrant further examination (OGS 1991a,b).

In 1976, Noranda Exploration Company Limited staked 10 mining claims in the north central part of Adrian Township to cover electromagnetic anomalies detected by an airborne survey. Ground magnetic, electromagnetic, geological and soil surveys were carried out. Five electromagnetic conductors semi-parallel to stratigraphy were outlined and three of these had associated copper, nickel and/or zinc soil geochemical anomalies. The geological survey concluded that 4 of the 5 conductors were caused by graphitic and pyritic metasedimentary rocks

interbedded with intermediate and felsic metavolcanic rocks. The fifth conductor was unexplained. Some of the elevated copper and nickel soil geochemistry was attributed to peridotite intrusions in the northeastern part of the property. No further work was carried out and the claims were allowed to lapse.

This area is underlain by very complex geology. Intermediate and felsic metavolcanic rocks of the Shebandowan assemblage underlie the southwestern part of the property. The Noranda geologist recognized the lower conglomerate unit of the Shebandowan assemblage and attributed its origin to either a laharic debris flow or "slump breccia". Ultramafic and mafic intrusions interbedded with wacke, mudstone and intermediate tuff of the Greenwater assemblage occur in the northeastern part of the property.

Port Arthur Iron Ore Corporation (1958)

In 1958 Port Arthur Iron Ore Corporation sank 7 diamond drill holes (Table 8) in lot 3, Concession VII, Marks Township to test the subsurface of iron mineralization exposed at surface. Each of the 7 drill holes encountered magnetite-chert ironstone hosted in mafic metavolcanic rocks. Only minor sulphide mineralization was observed and no further work was carried out until Hanna Mining Company acquired the property (see above).

Traverses carried out by the field crew indicate that several discontinuous magnetite-chert ironstone bands occur in this area. The ironstone displays complex interference fold patterns indicative of at least two periods of folding. The ironstone is hosted in massive and pillowed mafic metavolcanic rocks of the Greenwater assemblage. Microscopic blue-green pleochroic hornblende in the mafic rocks and rarely garnet in the metasedimentary rocks indicate upper greenschist to lower amphibolite grade metamorphism has affected these rocks. The exploration to date appears to have adequately tested the economic potential for iron of this area.

Tanton (1931) reported that an amethyst vein was reported to be located in Lot 12, Concession I in Marks Township near Echo Lake. This occurrence was not located but traverses by the field crews discovered two amethyst occurrences east of Echo Lake. The first occurrence is located in Lot 10, Concession II of Marks Township approximately 600 m north of a gravel pit at the end of the Concession II road. Here a single northeast striking vein of purple amethyst is hosted in pink to red weathering granodiorite to granite. The vein is only a few centimeters wide and is exposed for slightly over 1 m. Crystals are small (5 mm - 1 cm in size) and there did not appear to be extensive alteration associated with the vein.

The second occurrence is located 600 m east of Echo Lake in Lot 11, Concession II. Here six veins hosted in pink weathering granodiorite were found over an area of 30 m by 5 m (Figure 7). Four veins are northeast striking and the other two strike easterly. The most easterly vein (No. 1) contains well developed smokey quartz crystals and minor galena, chalcopyrite and less commonly green fluorite were observed. The vein is vuggy and there is extensive silicification of the footwall. The three other northeast striking veins contain large (up to 4 cm in size) clear, purple and dark purple amethyst crystals. The largest and darkest purple crystals were obtained from a vein exposed over 1 m along strike at the edge of a talus slope (vein 5, Figure 7). Only limited stripping of this vein was undertaken by the field crew. Each of these three veins dips between 65^{o} and 85^{o} to the east and in each of these three veins the best crystals are developed on the hanging wall.

The two easterly striking veins contain well formed white to purple crystals up to 2 cm in size. One of these veins (vein 3, Figure 7) contains smoky and purple crystals with the colour concentrated in the points and along the crystal septa. Vein 6 (Figure 7) contains well formed clear and frosted crystals up to 1 cm in size resting on botyroidal, clear and purple fluorite.

These two occurrences appear to be similar to other amethyst occurrences in the Thunder Bay area in that they are localized along northeast trending veins. However, there are no well developed northeast trending structures in the host granodiorite as indicated on the Atikokan-Lakehead geological compilation map (ODM 1964). Fyon et al (1992) noted that amethyst occurrences west of Thunder Bay were spatially associated with silver-calcite veins and that such minerals as calcite, barite, galena, sphalerite, fluorite and silver minerals were common accessories. These veins indicate that there is much untested amethyst potential in southwestern Marks Township and that further exploration of this area is warranted.

Recommendations to Prospectors

Base metal exploration has been limited to parts of Adrian Township and there has been none reported since 1976. Previous exploration concentrated on testing selected airborne electromagnetic anomalies and the recently released Shebandowan area airborne survey (OGS 1991 a-d) indicated that there are many untested anomalies in Adrian and Marks townships. In particular, there are a number of anomalies associated with the quartz phyric, felsic metavolcanic rocks in north central Adrian Township west of the Adrian Lake road that warrant examination (OGS 1991a, b, d). Pyrite accompanies the felsic rocks and this area has not been previously explored.

There are two isolated strings of electromagnetic conductors (OGS 1991d) in southwestern Adrian Township that may warrant examination. Outcrop in the vicinity indicate the conductors are near the contact between intermediate tuff and cherty ironstone with pyrite and graphite. Although this environment is not highly favourable for base metals the limited extent of the conductivity warrants exploration in the authors opinion.

Approximately 450 m north of Twinbirch Lake there is a single line isolated strong intensity electromagnetic conductor (OGS 1991d). This the type of conductor has been,

historically, the most favoured target of explorationists. Carbonate altered and quartz veined intermediate metavolcanic rocks occur in the vicinity of the anomaly but no cause for the conductor was located. This area was staked prior to the field season and the author infers that surface exploration was ongoing at the time of writing.

Another strong intensity isolated conductor was detected approximately 600 m north of the Boreal road near Pete Lake in Marks Township (OGS 1991c). This area is underlain by mafic amphibolite and no apparent cause for the conductor was located by the field crew.

In northeastern Adrian Township moderate to strong electromagnetic conductors are associated with ultramafic and mafic rocks east of Peridotite Lake (OGS 1991b). Given the occurrence of copper and nickel mineralization at the Shebandowan mine in similar rocks, approximately 40 km to the northwest, these anomalies warrant investigation.

Although there are no known gold occurrences in the map area there are several areas where alteration and sulphide mineralization suitable for hosting gold occur. The major northwest striking fault in central Adrian Township contains intense pervasive iron carbonate alteration and veining, disseminated pyrite, chalcopyrite and green mica. Several samples were collected by the author from this area and values up to 0.009 ounce gold per ton and 465 ppm arsenic were returned (Table 9). This fault should be thoroughly explored.

Approximately 1500 m east of the Adrian Lake road in the northern part of Adrian Township intense iron carbonate alteration has affected a 200 m^2 area of intermediate metavolcanic rocks of the upper assemblage. This area is coincident with a pronounced airborne magnetic high and may be worthy of further exploration (OGS 1991b, d).

In the south central part of Adrian Township a pyritic and silicified outcrop of pebble conglomerate was sampled by the field crew. Sample 562 (Table 9) returned 0.014 ounce gold per ton which is geochemically anomalous. This outcrop is on the southern flank of an airborne magnetic high and it is recommended that this area be explored for its gold potential.

Asbestos was observed in two or three places within the peridotitic rocks in northeastern Adrian Township. Fiber length was up to 1.5 mm and locally up to 10 % of the rock was mineralized. There is potential for more of this type of mineralization in the ultramafic rocks.

Amethyst occurs in southwestern Marks Township. Several veins containing well formed purple, blue and smokey crystals and accompanied by fluorite, galena and chalcopyrite were discovered in two areas. Further exploration is warranted throughout this area and to the southwest of Marks Township.

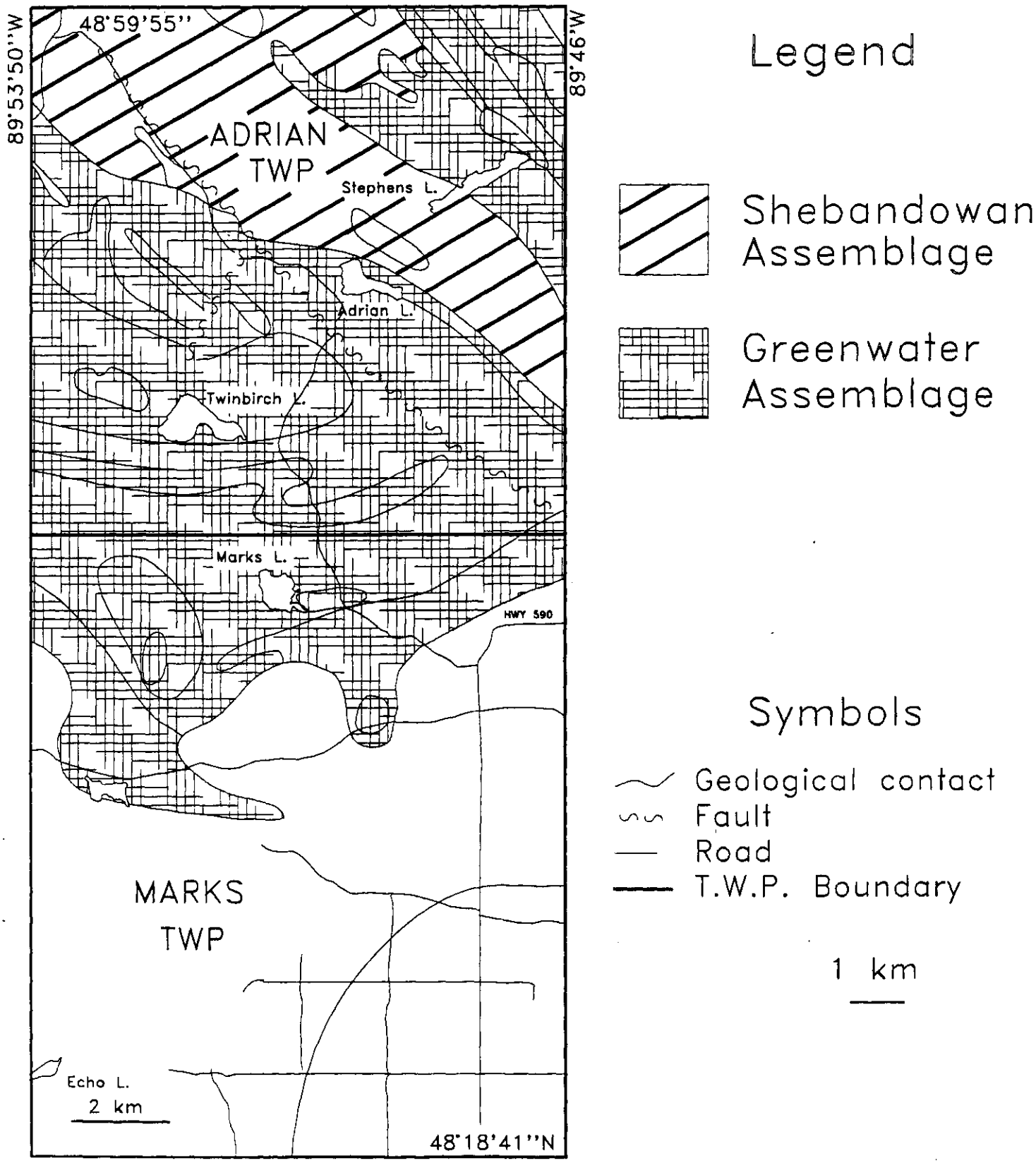


FIGURE 2 - Map showing the location of the supracrustal assemblages in Marks and Adrian Townships

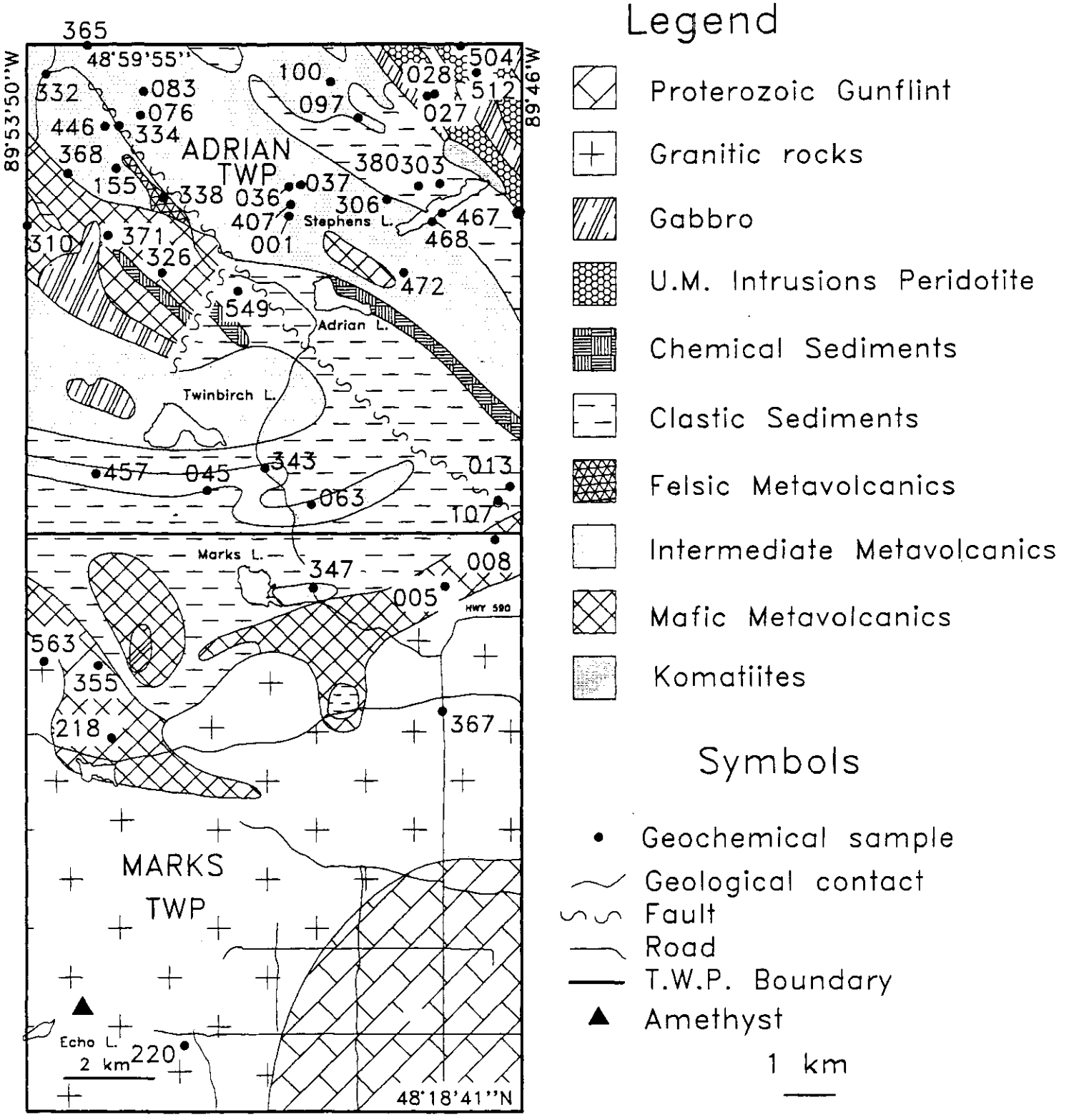


FIGURE 3 - Map showing the location of geochemical and assay samples from Marks and Adrian Townships

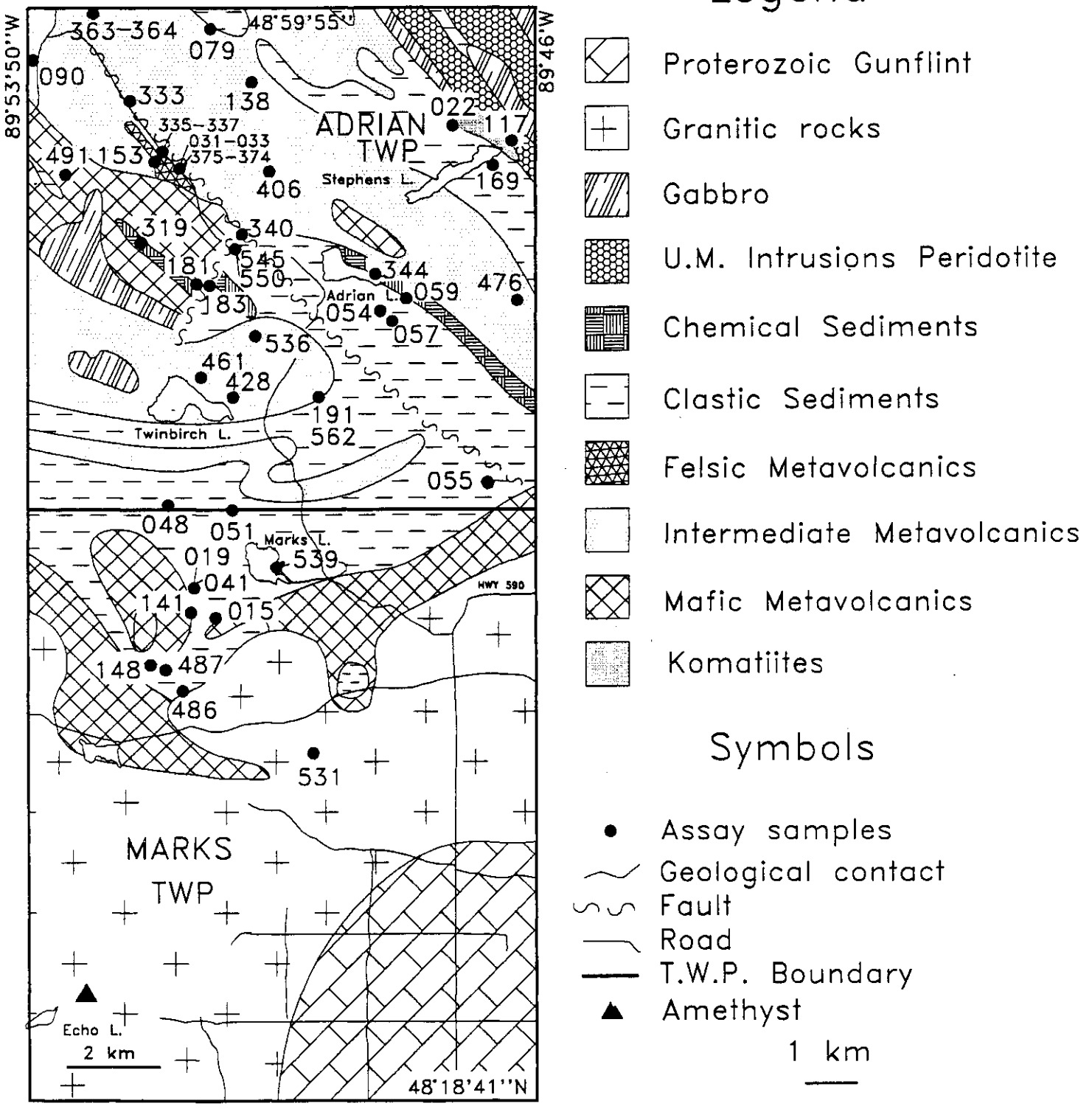


FIGURE 4 - SiO2 vs Total alkalis for the Shebandowan and Greenwater assemblages; Marks and Adrian Townships

Figure 4. SiO2 vs. Total Alkalis for Greenwater and Shebandowan Assemblages (after Irvine and Barager 1971).

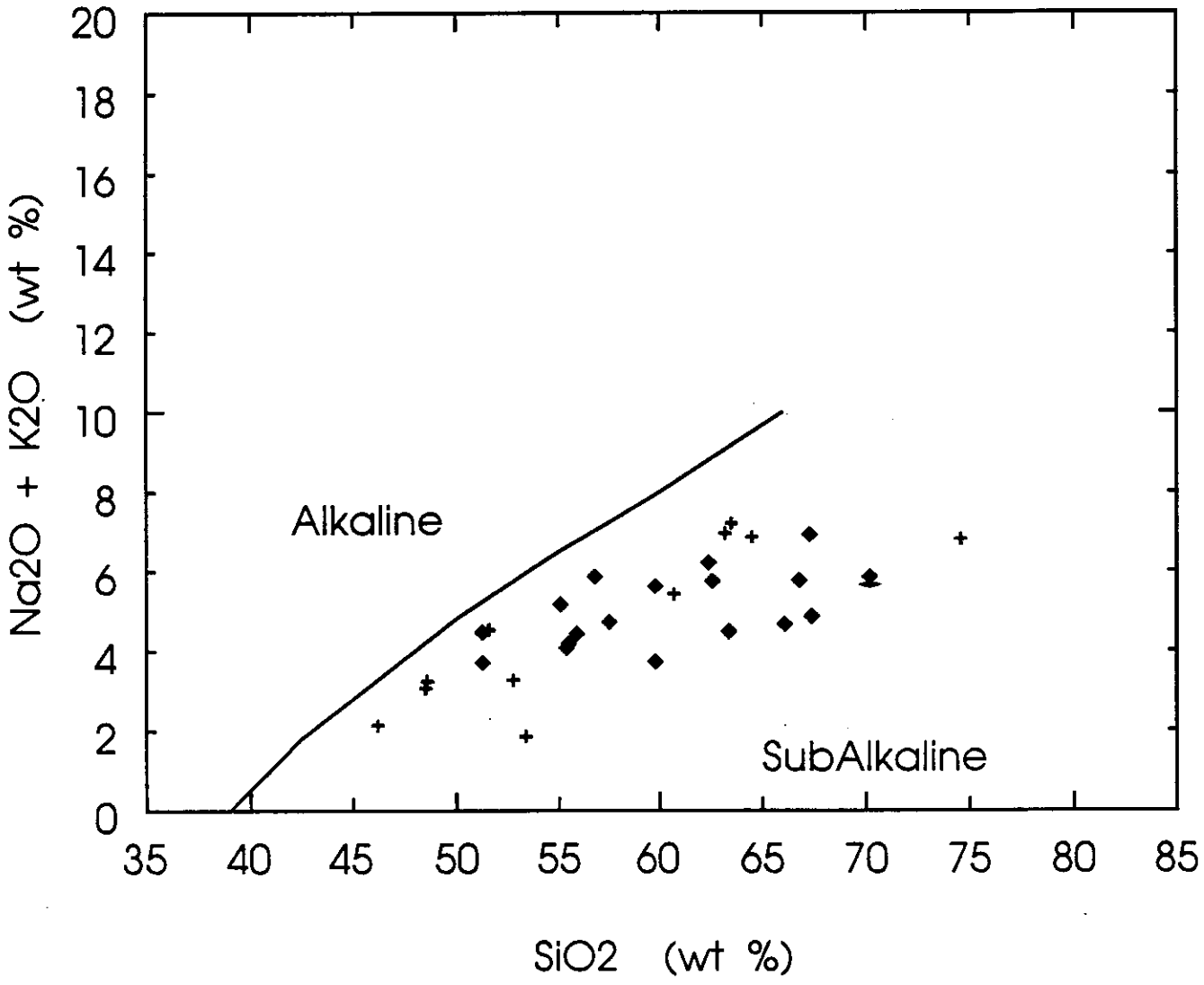


Figure 5. Cation Plot of the Greenwater and Shebandowan Metavolcanic Assemblages Marks and Adrian townships (after Jensen 1976).

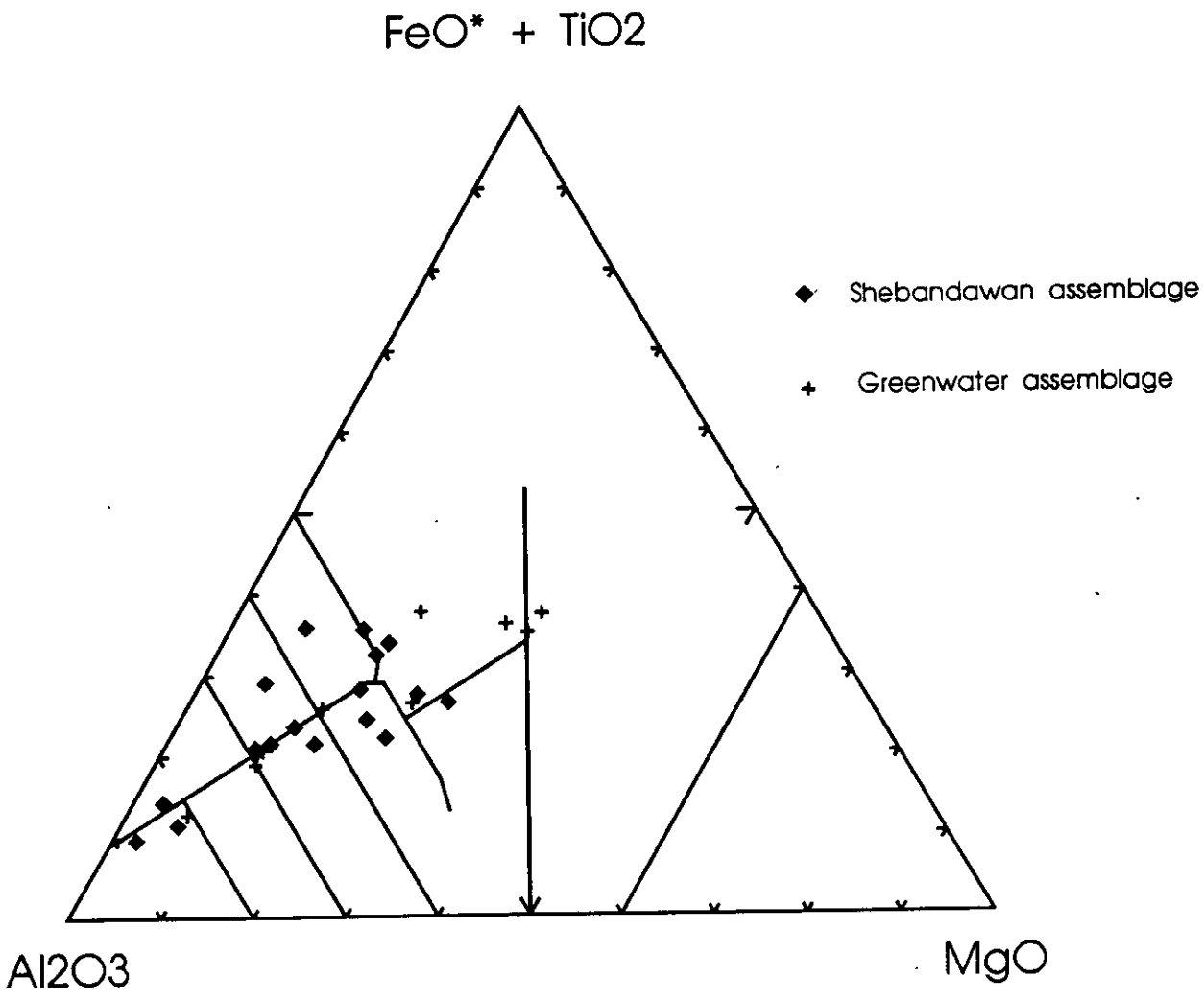
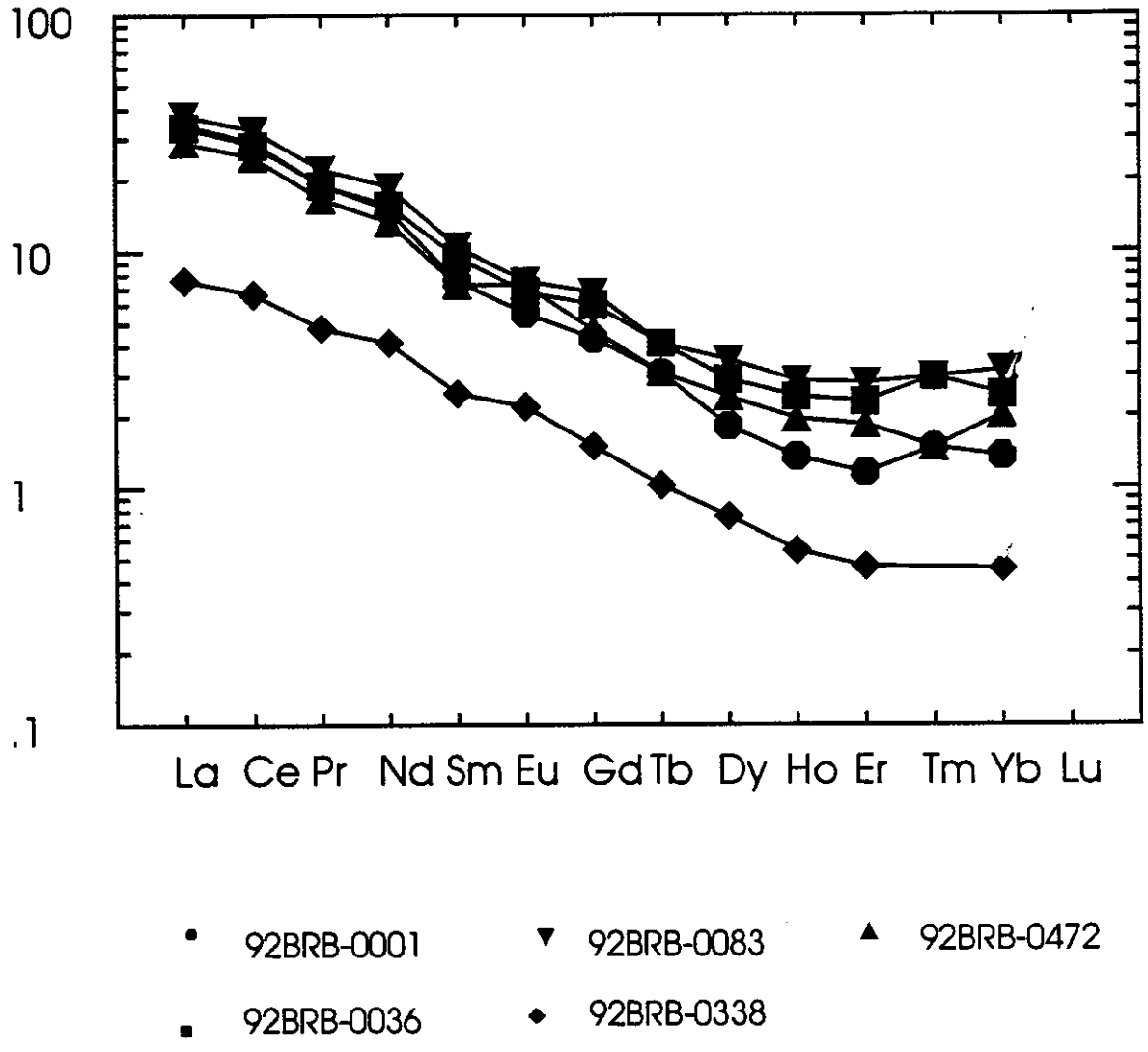


Figure 6. REE pattern for the Shebandowan Assemblage



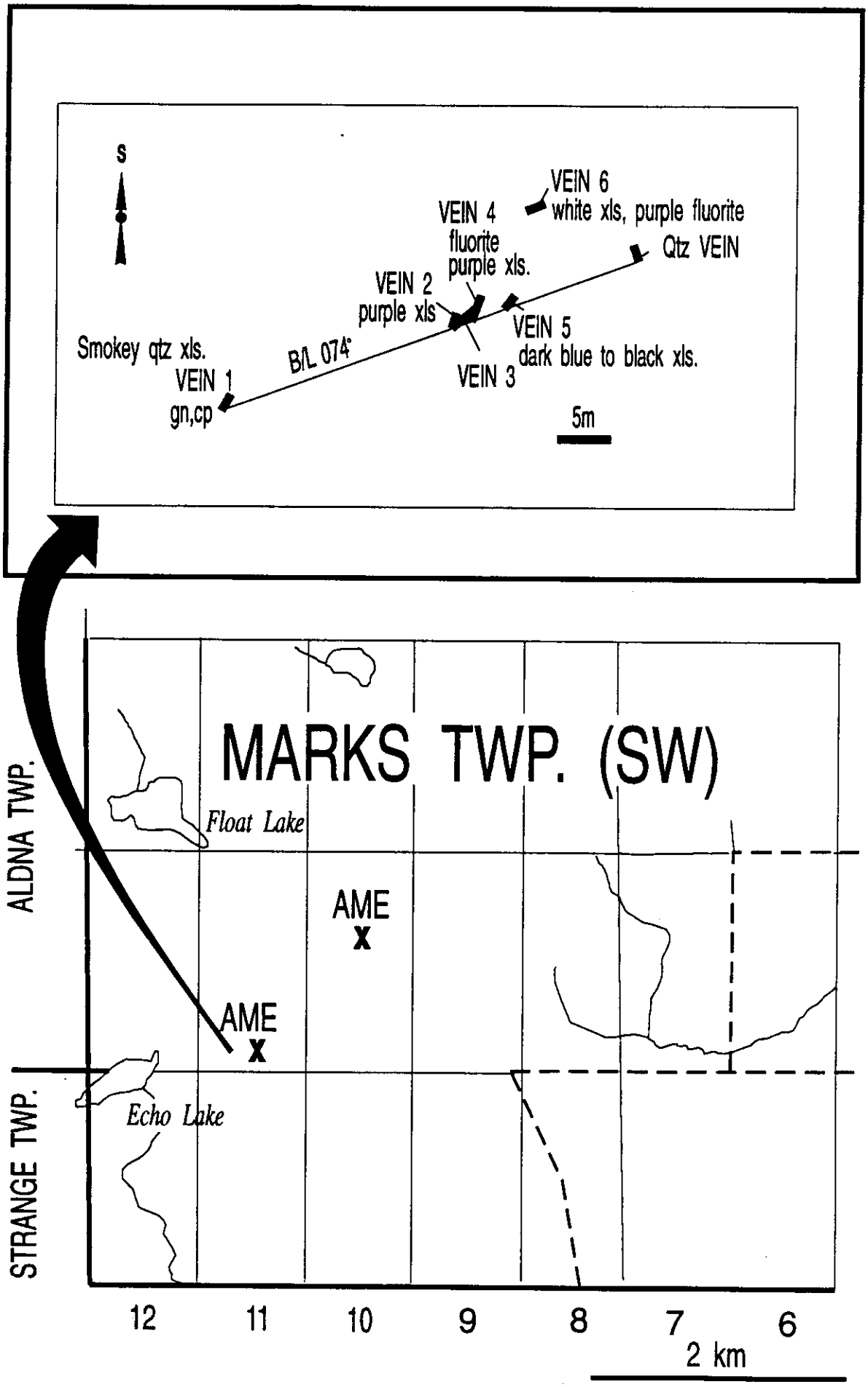


FIGURE 7 - Sketch of amethyst veins at the Echo Lake showing; Marks Township

PHOTO 1 - Pyroxene spinifex texture: long bladed clinopyroxene with microlitic plagioclase and pyroxene from basaltic komatiitic flow in northern Adrian Township. filed of view 8 mm; polarized light

PHOTO 2 - Pyroxene spinifex: cross section of clinopyroxene showing hollow core attributed to rapid cooling. field of view 2 mm; polarized light.

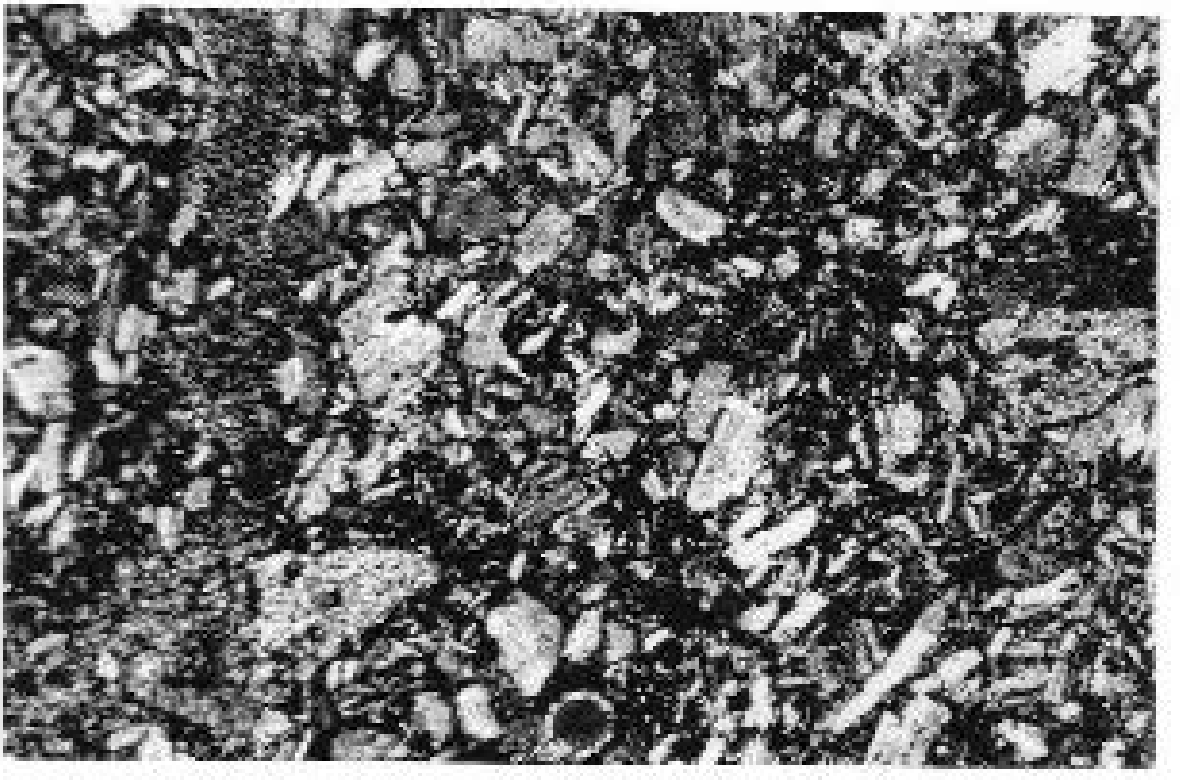


PHOTO 3 - Shebandowan assemblage lapillistone: well developed trachyitic textured fragment in heterolithic lapillistone (note chlorite and quartz filled amygdule in bottom part of photograph); field of view 8 mm, polarized light. Adrian Township.

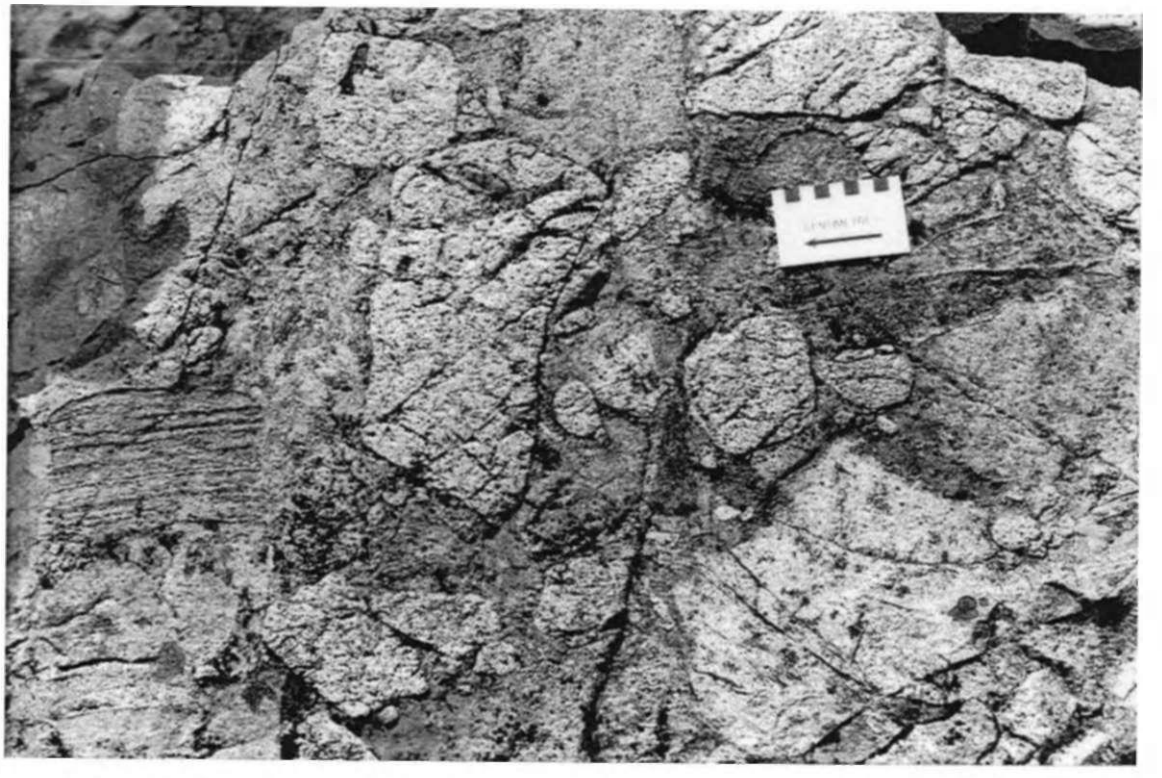


PHOTO 4 - Shebandowan assemblage intermediate tuff breccia: note flow laminated fragment (lower left) and previously fragmented fragment (upper center); Adrian Township.

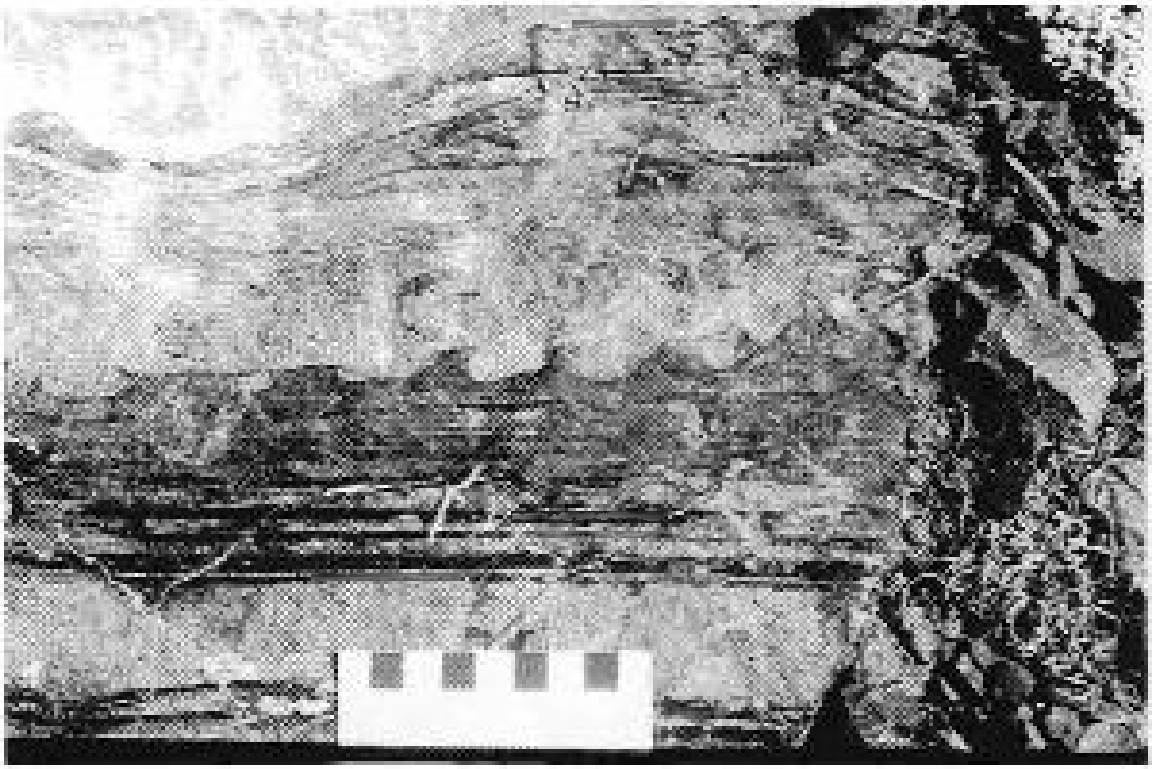


PHOTO 5 - Greenwater assemblage clastic metasedimentary rocks: well preserved grain gradation and load clasts in wacke and mudstone units from central Adrian Township.

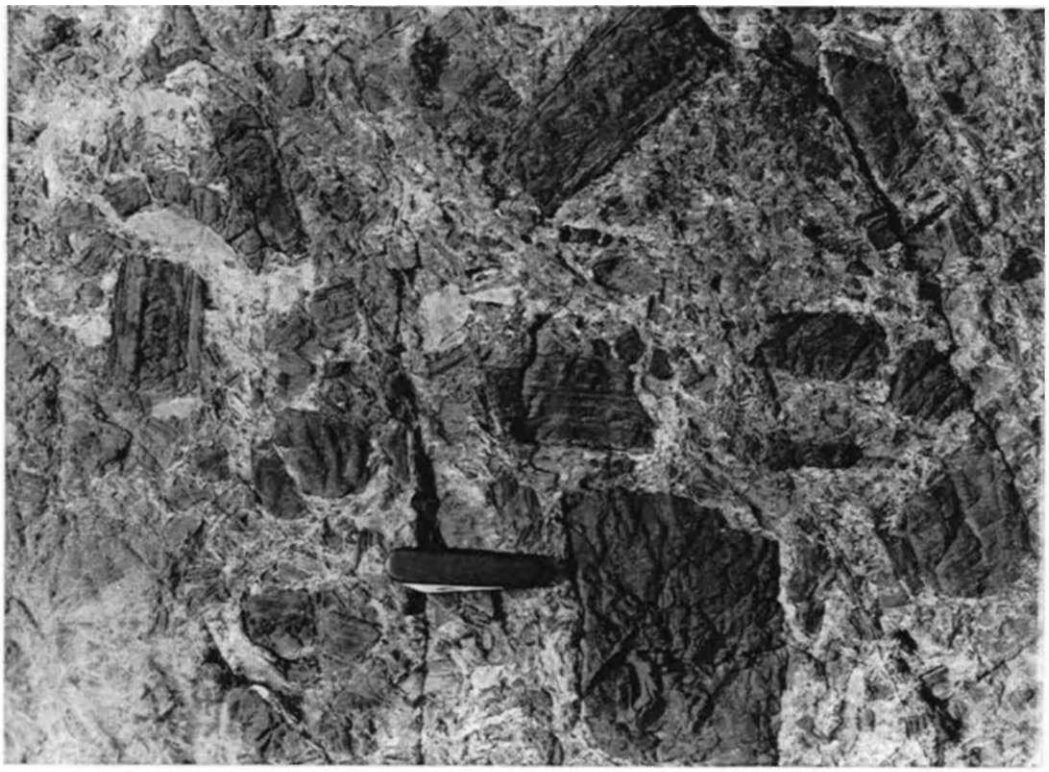


PHOTO 6 - Jasper and magnetite clast conglomerate; lower unit of Shebandowan assemblage. Note angularity and compaction of clasts; knife is 8 cm long.

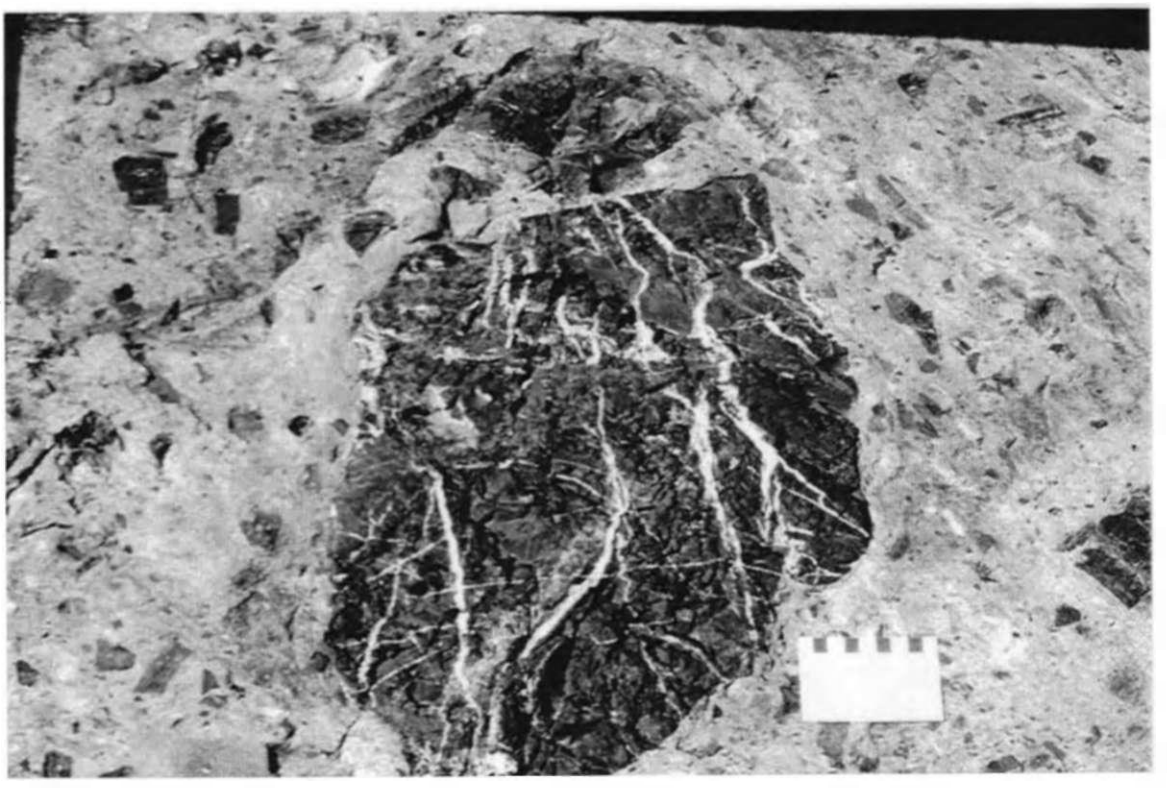


PHOTO 7 - Large jasper-magnetite boulder in basal conglomerate unit of the Shebandowan assemblage. Note the quartz veining that is restricted to the boulder and is indicative of tectonism prior to resedimentation of the boulder. Adrian Township.

PHOTO 8 - Oolites in taconite from the Gunflint Formation of the Animikie Group. Note how the oolites are "floating" in a quartz matrix. Field of view is 8 mm; polarized light. Second sideroad. Concession 1, Marks Township.

PHOTO 9 - Interference fold pattern in laminated ironstone and wacke from the Greenwater assemblage in northern Marks Township

TABLE 1 LITHOLOGICAL UNITS FOR ADRIAN AND MARKS TOWNSHIPS

PHANEROZOIC
CENOZOIC
QUATERNARY
RECENT

Lake, stream, wetland deposits

PLEISTOCENE

Glacial, glaciofluvial deposits; sand, gravel, clay, till

unconformity

PRECAMBRIAN
PROTEROZOIC
MESOPROTEROZOIC
KEWEENAWAN SUPERGROUP

Diabase

PALEOPROTEROZOIC
ANIMIKIE GROUP
GUNFLINT FORMATION

massive and oolitic taconite, algae mat chert, jasper and chert, conglomerate, argillite

ARCHEAN
NEOARCHEAN

Mafic intrusive rocks

Lamprophyre

Felsic and intermediate intrusive rocks

Diorite, tonalite, quartz diorite, granodiorite, quartz monzonite, granite, aplite dikes, granodioritic to tonalitic gneiss, migmatite

Metamorphosed mafic intrusive rocks

Gabbro, leucocratic gabbro, knobby gabbro, intrusion breccia, pegmatitic gabbro,and anorthositic gabbro

Metamorphosed ultramafic intrusive rocks

Peridotite, pyroxenite, and schist

Chemical metasedimentary rocks

Magnetite-jasper ironstone, bedded chert +/- magnetite +/- carbonate facies ironstone, and sulphide facies ironstone, chert, and chert breccia

Clastic metasedimentary rocks

Wacke, siltstone, mudstone, graphitic mudstone, quartz pebble-mudchip and lithic clast conglomerate, jasper-mudstone +/- lithic clast conglomerate, biotite-hornblende gneiss, schist and migmatite

Felsic metavolcanic rocks

massive and flow laminated flows, tuff, lapilli tuff, tuff breccia, quartz-feldspar porphyry (possibly crystal tuff), schist, and autoclastic breccia

Intermediate metavolcanic rocks

Massive, pillowed and spherulitic flows, pillow and/or flow top breccia, hyaloclastite, tuff, crystal tuff, lapilli tuff, crystal lapilli tuff, lapillistone, tuff breccia, breccia, hornblende and/or plagioclase phenocrystic rocks, schist, amphibolite, hornblende and plagioclase phyric dikes, intrusion breccia,and autoclastic breccia

Mafic metavolcanic rocks

Massive, pillowed and variolitic flows, pillow and flow top breccia, tuff, lapilli tuff, amphibolite, tuff breccia, hornblende or plagioclase phenocrystic rocks, schist, and basaltic dikes

Ultramafic and mafic metavolcanic rocks

Spinifex and polysuture textured flows, cumulate textured massive flows, flow breccia

Table 2A: DESCRIPTION OF ULTRAMAFIC AND MAFIC METAVOLCANIC ROCKS (KOMATIITES)

Map Units: 1a,b,c

Field Names: spinifex and polysutured flows, massive flows, flow breccia

Location: north and northeast of Stephens Lake in Adrian Township; Greenwater assemblage

Colour - Fresh: green to dark green
Weathered: green to light grey-green

Grain Size: 0.01mm to 3mm

Morphology: spinifex textured flows are more abundant than polysutured textured flows which are more abundant than flow top breccia and massive flows. Most flows are non-magnetic, basaltic komatiites

Modal Mineralogy (estimated)

	range	median n=4
Quartz	1-4	1
Plagioclase	15-35	20
Epidote	12-37	14
Amphibole	0-5	0
Chlorite	10-25	20
Carbonate	1-5	2
Pyroxene	25-35	30
Other	tr-1	talc, opaques, apatite

Table 2B: DESCRIPTION OF GREENWATER ASSEMBLAGE MAFIC METAVOLCANIC ROCKS

Map Units: 2a,b,c,d,e,f,g,h,j

Field Names: metabasalts, massive, pillowed, variolitic flows, flow breccia, tuff, lapilli tuff, amphibolite schist

Location: major units along the boundary with the granitic rocks in northern Marks Twp and along the northwestern boundary of the map area in Adrian Twp

Colour - Fresh: dark green to black
Weathered: dark green to green

Grain Size: 0.5 mm to 5 mm

Morphology: predominantly massive amphibolite, less commonly pillowed, pyroclastic rocks rare

Modal Mineralogy (estimated)

	range	median	n=7
Quartz	0-15	5	
Plagioclase	10-56	15	
Epidote	0-30	5	
Amphibole	25-75	45	
Chlorite	0-10	3	
Carbonate	0-tr	0	
Opaques	0-15	3	
Other	0-30	0	white mica, leucoxene

Table 2C: DESCRIPTION OF SHEBANDOWAN ASSEMBLAGE MAFIC METAVOLCANIC ROCKS

Map Units: 2a,b,e,f,g,i,k

Field Names: plagioclase and amphibole phyric metabasalts, massive, pillowed flows, flow breccia, tuff, schist

Location: major unit 800m northeast of Adrian Lake, small discontinuous units along northeastern contact with Greenwater assemblage

Colour - Fresh: green to green-grey
Weathered: grey-green to green

Grain Size: 0.5mm to 1mm groundmass
up to 3 mm phenocrysts

Morphology: massive and pillowed flows, flow top breccia common, pyroclastic rocks rare

Modal Mineralogy (estimated)

	range	n=2
Quartz	0-10	
Plagioclase	tr-20	
Epidote	20-25	
Amphibole	15-20	
Chlorite	5-40	
Carbonate	5-10	
Opaques	0-1	
Other	15-20	biotite, glass

Table : DESCRIPTION OF GREENWATER ASSEMBLAGE INTERMEDIATE METAVOLCANIC ROCKS

Map Units: 3a,e,f,g,j

Field Names: massive flows, tuff, lapilli tuff and tuff breccia

Location: southern Adrian Township and northern Marks Township

Colour - Fresh: green, grey with white plagioclase phenocrysts
Weathered: grey, green dark green, brown-green

Grain Size: 0.25 - 1 mm matrix
1mm - 15 cm fragments, 4-9 mm avg

Morphology: tuff and crystal tuff greater than lapilli tuff and crystal lapilli tuff which is much greater than tuff breccia and massive flows. poorly bedded and poorly to moderately sorted, massive beds much greater than graded beds

Modal Mineralogy (estimated)

	range	median n=8	
Quartz	5-25	20	
Plagioclase	22-45	35	
Epidote	0-10	tr	
Amphibole	0-25	9	
Chlorite	0-20	1	
Carbonate	0-7	1	
Sericite	0-15	0	
Biotite	0-30	15	
Opaques	tr-20	1	pyrite and magnetite
Other	0-10	0	tourmaline, apatite, microcline

Table : DESCRIPTION OF SHEBANDOWAN ASSEMBLAGE INTERMEDIATE METAVOLCANIC ROCKS

Map Units: 3a,b,c,d,e,f,g,h,i,k,l,m

Field Names: amphibole and plagioclase phyric, massive, pillowed and spherulitic flows, flow top breccia, tuff, crystal tuff, lapilli tuff, lapillistone crystal lapilli tuff, tuff breccia and breccia, dikes, intrusion breccia, autoclastic flow breccia and schist

Location: a northwest trending unit in central and northern Adrian Township

Colour - Fresh: green, grey, white, creamy white, pink tints
Weathered: green, dark green, grey, pink tints

Grain Size: 0.1 mm groundmass
0.25-2mm phenocrysts
0.5 - 2 mm matrix
1mm - 75cm fragments; avg 5-6cm

Morphology: lapilli tuff and tuff breccia greater than tuff and flows which are much greater than dikes, intrusion breccia and autoclastic flow breccia. These rocks are characterized by the presence of plagioclase and/or amphibole phenocrysts.

Modal Mineralogy (estimated)

fragmental rocks	range	median n=19	
Quartz	1-35	10	
Plagioclase	10-45	30	
Epidote	0-25	2	
Amphibole	0-15	0	
Chlorite	6-25	15	
Carbonate	0-25	10	
Sericite	0-50	15	
Opaques	0-10	3	
Other	0-31	0	apatite, pyroxene, biotite

Modal Mineralogy (estimated)

Flows	range	median n=8	
Quartz	0-25	8	
Plagioclase	tr-35	25	
Epidote	0-75	5	
Chlorite	0-21	15	
Carbonate	2-30	15	
Sericite	0-40	15	
Opaques	0-10	5	
Other	0-20	0	apatite, biotite

Table 4a: DESCRIPTION OF GREENWATER ASSEMBLAGE FELSIC METAVOLCANIC ROCKS

Map Units: 4a,b,c,e,f,g

Field Names: felsic flows, tuff, lapilli tuff and lapillistone, quartz-feldspar porphyry, schist and autoclastic breccia

Location: mainly in northern Marks Township south and east of Marks Lake

Colour - Fresh: brown, black or light grey
Weathered: white, brown or brown-grey

Grain Size: <0.1mm to 1 mm in groundmass
fragments up to 5 cm, most commonly 2 to 7 mm

Morphology: most commonly as recrystallized tuff in narrow units interlayered with wacke; less commonly as lapilli tuff; quartz-feldpsar porphyry, flow laminated and autoclastic breccia restricted to northeastern Marks Township.

Modal Mineralogy (estimated)

	range	median	n=6
Quartz	20-60	40	
Plagioclase	0-25	10	An 11-29
Epidote	0-5	0	
Chlorite	0-5	0	
Carbonate	0-15	0	
Sericite	3-34	20	
Microcline	0-5	0	
Biotite	3-15	10	
Opaques	0-10	tr	mainly pyrite
Tourmaline	0-3	tr	
Other	0-15	0	amphibole

Table 4b: DESCRIPTION OF SHEBANDOWAN ASSEMBLAGE FELSIC METAVOLCANIC ROCKS

Map Units: 4a,b,c,d,e,f,g

Field Names: massive and autoclastic felsic flows, tuff, lapilli tuff and lapillistone, tuff breccia and schist

Location: a major unit west of Adrian Lake road in west central Adrian Township, narrow units and small subvolcanic intrusions in northern and western part of Adrian Township

Colour - Fresh: white to pale yellow
Weathered: white to pale yellow

Grain Size: < 0.1mm in groundmass
phenocrysts up to 5 mm
fragments up to 15 cm, average 1 cm in lapillistone

Morphology: Lapilli tuff and tuff most common, quartz-feldspar porphyry common, porphyritic and aphanitic flows rare, autoclastic breccia and schist very rare

Modal Mineralogy (estimated)

	range	median n=7	
Quartz	7-30	15	
Plagioclase	20-50	40	An 11-29
Epidote	0-9	0	
Chlorite	0-15	5	
Carbonate	0-23	7	
Sericite	3-40	25	
Opaques	1-10	4	pyrite and hematite
Apatite	0-3	tr	
Other	0-1	tr	zircon and biotite

Table 5 .DESCRIPTION OF CLASTIC AND CHEMICAL METASEDIMENTARY ROCKS OF THE GREENWATER ASSEMBLAGE

Map Units: 5a,b,c,d,e,f,g,h and 6a,b,c,d,e

Field Names: wacke, siltstone and mudstone, quartz-lithic clasts-mudchip conglomerate, biotite-hornblende gneiss, schist and migmatite. magnetite-jasper ironstone, magnetite-chert ironstone, sulphide facies ironstone, chert and chert breccia

Location: northern Marks Township, southern and central Adrian Township, northeastern Adrian Township

Colour - Fresh: grey, brown and black for clastic rocks
red, black, grey and white for chemical rocks
Weathered: grey, brown, light grey for clastic rocks
red, black, white and creamy white for chemical rocks

Grain Size: <0.1 mm to 4mm in matrix
1mm to 1.5m clasts

Morphology: wacke greater than siltstone and mudstone which is greater than conglomerate.
thinly bedded to massive, well sorted to chaotic
chert and chert breccia much greater than oxide ironstones which are much greater than sulphide ironstones

Modal Mineralogy (estimated)

	range	median	n=16
Quartz	2-50	20	
Plagioclase	0-54	20	
Epidote	0-35	2	
Amphibole	0-40	0	
Chlorite	0-25	0	
Carbonate	0-40	1	
Sericite	0-35	2	
Biotite	0-30	tr	
Opaques	1-30	10	
Other	0-10	0	tourmaline, garnet, apatite, zircon

Table 6A: DESCRIPTION OF ULTRAMAFIC INTRUSIVE ROCKS

Map Units: 7a,b,d

Field Names: peridotite, pyroxenite, schist and carbonate schist

Location: restricted to the northeast part of Adrian Township, within the Greenwater assemblage

Colour - Fresh: black, dark to light green
Weathered: black, dark green

Grain Size: 0.5 to 1.5 mm

Morphology: massive, medium-grained, equigranular peridotite is much more abundant than pyroxenite and schist

Modal Mineralogy (estimated)

	range	median	n=4
Plagioclase	0-tr	0	
Epidote	0-13	0	
Chlorite	1-5	1	
Serpentine + talc	18-80	70	
Pyroxene	2-80	5	
Opaques (magnetite)	1-13	3	
Other (asbestos)	0-2	0	

Table 6B: DESCRIPTION OF MAFIC INTRUSIVE ROCKS

Map Units: 8a,b,c,d,e,f

Field Names: gabbro, leucocratic, knobby, pegmatitic and anorthositic gabbro, intrusion breccia

Location: in various places throughout the Greenwater assemblage, concentrated in the northeast part of Adrian Township with ultramafic rocks and north of Twinbirch Lake

Colour - Fresh: dark green, green, light green and whitish green
Weathered: dark green, green and pale green

Grain Size: 0.1 to 2 mm groundmass.
up to 1 cm mafic crystal clusters in knobby gabbro

Morphology: leucocratic and massive gabbro much greater than knobby gabbro and intrusion breccia which is greater than pegmatitic and anorthositic gabbro. Textures vary from fine-grained to medium-grained.

Modal Mineralogy (estimated)

	range	median	n=11
Quartz	0-15	10	
Plagioclase	3-65	15	
Epidote	0-25	5	
Amphibole	0-55	25	
Chlorite	1-36	13	
Carbonate	0-5	1	
Talc	0-15	5	
Opaques	0-10	2	
Other	0-46	0	pyroxene, serpentine, biotite, titanite, apatite

Table 7. DESCRIPTION OF FELSIC INTRUSIVE ROCKS

Map Units: 9a,b,c,d,e,f,g

Field Names: diorite, tonalite, granodiorite to quartz monzonite, equigranular and potash feldspar porphyritic granite, gneiss, migmatite and aplite dikes

Location: central and southwestern Marks Township

Colour - Fresh: white, pink and grey
Weathered: pink, white and mottled grey, green and white

Grain Size: 1 to 5mm groundmass
up to 3 cm quartz and feldspar phenocrysts

Morphology: massive equigranular rocks are of greater proportion than foliated equigranular rocks; porphyritic rocks common, gneiss, migmatite and aplite dikes uncommon to rare

Modal Mineralogy (estimated)

	range	median n=6	
Quartz	10-25	20	
Plagioclase	24-50	45	
Microcline	5-20	12	
Biotite	0-10	5	
Amphibole	0-25	5	
Chlorite	0-12	1	
Carbonate	0-4	0	
Sericite	3-14	4	
Other	0-tr	tr	opaques, apatite, zircon, epidote, titanite

TABLE 8- EXPLORATION CHART FOR ADRIAN AND MARKS TOWNSHIP

COMPANY	PROPERTY LOCATION	YEAR	WORK	SIGNIFICANT RESULTS
Amalta Oils and Minerals Limited	lot 3, concessions VI & VII, Marks Twp	1967	ground EM and magnetic surveys	magnetic highs attributed to ironstone
Canadian Nickel Company Limited	NE part of Adrian Twp	1966	5 ddh total 857.3m	encountered ultramafic intrusions and graphitic schist
Hanna Mining Company	lots 4 & 6, concessions VI & VII, Marks Twp	1961	ground magnetic and geology surveys	a narrow and folded magnetite ironstone was detected
Hanna Mining Company	lot 3, concession VII, Marks Twp	1962	ground magnetic and geology surveys,	mapped magnetite - chert ironstone units
Hanna Mining Company	SE corner Adrian Twp	1962	ground magnetic and geology surveys	outlined several magnetite-jasper ironstone units
Kukkee, Ed	west side of Adrian Lake, Adrian Twp	1986	assaying	results not reported
New Fortune Mines Limited	lot 5, concession VII, Marks Twp	1957	1 ddh - 44.2m	encountered magnetite and chert ironstone hosted by wacke and amphibolite
Noranda Exploration Company Limited	Twinbirch Lake area Adrian Twp	1967	ground magnetic, EM and geology surveys	outlined general geology of area
Noranda Exploration Company Adrian Twp	One Pond property,	1967	ground magnetic and EM surveys,1 ddh - 107.3m	encountered pyritic and cherty Limited N ironstone, minor chalcopyrite

COMPANY	PROPERTY LOCATION	YEAR	WORK	SIGNIFICANT RESULTS
Noranda Exploration Company Limited	Weigand River property, N Adrian Twp	1967	3 ddh - 214.3m	encountered minor sulphide concentrations with graphite in felsic pyroclastic rocks
Noranda Exploration Company Limited	Adrian 1-76 property Adrian Twp	1976	ground magnetic, EM, soil and geology surveys	outlined complex geology
Port Arthur Iron Ore Corporation	lot 3, Concession VII, Marks Twp.	1958	7 ddh, total 898.3m	discovered and tested magnetite - chert ironstones

TABLE 9 - ASSAY RESULTS FOR MARKS AND ADRIAN TOWNSHIPS

Sample No.	Au(oz/t)	Cu1	Ni	Zn	Pb	As	Location	Material
BRB-015	tr2	204	60	16	<10	<10	NW part of Marks Twp	Po in metawacke
-019	tr	58	41	31	<10	<10		Po in conglomerate
-022	nil	99	983	29	<10	<10	480m N of Stephens L	Fe-carb alt'd peridotite
-031	tr	57	28	110	<10	<10	Adrian Lake road	graphitic schist
-032	.009	49	77	30	<10	25	Adrian Lake road	Fe-carb breccia
-033	.004	21	103	53	<10	50	Adrian Lake road	Fe-carb breccia
-041	nil	25	4	4	<10	<10	Near sample 019	Quartz vein in wacke schist
-048	.002	35	22	42	<10	<10	1500m S of Twinbirch L	disseminated py in wacke
-051	nil	53	32	54	<10	<10	450m W of Twist L	pyritic ironstone conglomerate
-054	tr	29	28	31	<10	<10	600m SE of Adrian L	rusty, cherty metasedimentary rocks, tr py
-055	nil	43	22	75	<10	<10	SE corner of Adrian Twp	py and graphite in wacke
-057	tr	20	48	33	<10	<10	175m SE of 054	rusty, magnetite ironstone
-058	.005	29	14	4	<10	<10	S shore of small lake 800m east of Adrian L	graphitic mudstone
-079	nil	26	43	88	<10	<10	north central part of Adrian Twp	pyritic ironstone
-090	tr	31	19	41	<10	<10	W side of logging road, NW Adrian Twp	Qtz vein with methane odour
-117	nil	8	647	17	<10	<10	450m east of Stephens L	carbonatized peridotite
-138	.002	15	140	88	<10	<10	2800m east of Adrian L road, N Adrian Twp	carbonate altered NW shear zone
-141	tr	74	49	18	<10	<10	Marks Twp	pyritic metawacke schist
-148	nil	97	4	17	<10	<10	Marks Twp	pyritic NW shear zone in metawacke

Sample No.	Au(oz/t)	Cu1	Ni	Zn	Pb	As	Location	Material
-153	nil	44	40	60	<10	<10	400m W of Adrian Lake road	carbonate altered felsic lapilli tuff
-169	il	15	25	39	<10	<10	225m SE of Stephens Lake	pyritic jasper conglomerate
-181	nil	40	15	15	<10	<10	800m NE of Rockstone L	jasper ironstone
-183	nil	34	16	4	<10	<10	225m East of 181	quartz vein in mafic tuff
-191	nil	44	47	37	<10	<10	700m E of Adrian Lake road	pyritic and silicified conglomerate
-319	nil	186	80	380	<10	<10	850m N of Rockstone L	py and po in cherty ironstone
-333	tr	36	113	47	<10	65	Adrian Lake road, Adrian Twp	py in dacite flow breccia
-335	nil	86	271	34	19	135	Adrian Lake road	quartz vein with Fe-carb alteration and green mica
-337	tr	97	300	44	<10	465	Adrian Lake road	similar to 335 with 10-15% py and asp
-340	.002	80	102	191	<10	85	Adrian Lake road	graphitic mudstone
-344	nil	38	14	31	<10	<10	N shore of Adrian Lake	graphitic schist, tr py
-363	nil	28	28	37	<10	<10	N boundary of Adrian Twp	sulphide facies ironstone
-364	nil	31	63	56	<10	<10	same as 363	same as 363
-375	nil	23	72	39	<10	<10	Adrian Lake raod	carbonate breccia over .9m
-376	nil	38	102	47	<10	<10	as 375	sericite altered intermediate pyroclastic over .2m
-377	nil	21	121	108	<10	40	as 375	sericite and carbonate alteration tr cp
-378	tr	187	134	128	<10	<10	as 375	cp and py in chloritic alteration fractures

Sample No.	Au(oz/t)	Cu1	Ni	Zn	Pb	As	Location	Material
-379	nil	29	110	113	<10	<10	as 375	tr to 5% py in carbonate breccia
-406	nil	47	61	77	<10	<10	2100n NW Adrian L	tr carbonate in intermediate tuff breccia
-428	nil	62	78	79	<10	<10	350m NE of Twinbirch L	quartz in intermediate tuff
-461	nil	37	76	89	<10	<10	400m N of Twinbirch L	carbonate altered intermediate tuff
-476	tr	35	41	155	<10	<10	400m W of east boundary of Adrian Twp	py in jasper ironstone
-486	nil	47	22	41	<10	<10	Marks Twp	py in granodioritic schist
-487	nil	22	10	56	<10	<10	Marks Twp	py in felsic schist
-491	[illegible]	161	56	127	<10	<10	NW Adrian Twp	py in mafic schist
-531	[illegible]	25	19	33	<10	<10	Marks Twp	quartz stringers in granodiorite
-536	nil	25	53	69	<10	<10	Adrian Twp	py in intermediate lapilli tuff
-539	nil	51	52	32	<10	<10	SE shore Marks Lake	py in sheared mafic amphibolite
-545	tr	87	70	97	<10	<10	Adrian Twp	py in mafic schist
-550	nil	85	65	96	<10	<10	as 545	py in mafic schist
-562	014	45	80	45	<10	<10	same as 191	resample of py in conglomerate

1 values in ppm
2 tr values are <34 ppb and >25 ppb

asp - arsenopyrite
carb - carbonate
cp - chalcopyrite
Fe - iron
qtz - quartz
po - pyrrhotite
py - pyrite

Sample Number	Field Name	Easting	Northing	Township	Assemblage
92-BRB-001	Intermediate tuff	290550	5372575	Adrian	Shebandowan
92-BRB-005	Mafic Amphibolite	293685	5364550	Marks	Greenwater
92-BRB-008	Quartz Porphry	293685	5365515	Marks	Greenwater
92-BRB-013	Massive Mafic flow	295265	5368270	Marks	Greenwater
92-BRB-027	Peridotite	294120	5374035	Adrian	Greenwater
92-BRB-028	Massive Mafic flow	293805	5374150	Adrian	Greenwater
92-BRB-036	Intermediate tuff	290675	5372915	Adrian	Shebandowan
92-BRB-037	Intermediate flow	290760	5372950	Adrian	Shebandowan
92-BRB-045	Inter. crystal tuff	287580	5365500	Marks	Greenwater
92-BRB-063	Inter crystal tuff	291660	5366190	Marks	Greenwater
92-BRB-076	Dacite flow	288140	5374300	Adrian	Shebandowan
92-BRB-083	Intermediate flow	288000	5374900	Adrian	Shebandowan
92-BRB-097	Mafic-Inter. flow	291910	5373350	Adrian	Shebandowan
92-BRB-100	Basaltic Komatiite	292100	5374300	Adrian	Greenwater
92-BRB-107	Gabbro	295185	5367795	Adrian	Greenwater
92-BRB-155	Inter. lapilli tuff	287910	5372380	Adrian	Shebandowan
92-BRB-218	Mafic Amphibolite	288260	5355730	Marks	Greenwater
92-BRB-220	Quartz Monzonite	288260	5355730	Marks	
92-BRB-303	Intermediate tuff	293560	5372525	Adrian	Shebandowan
92-BRB-306	Intermediate tuff	292420	5372800	Adrian	Shebandowan
92-BRB-310	Gabbro	285820	5372300	Adrian	Greenwater
92-BRB-326	Massive Basalt	288450	5370750	Adrian	Greenwater
92-BRB-332	Intermediate tuff	286380	5374785	Adrian	Shebandowan
92-BRB-334	Autoclastic Breccia	287390	5374785	Adrian	Shebandowan
92-BRB-338	Quartz Porphry	288960	5371705	Adrian	Shebandowan
92-BRB-343	Sedimentary wacke	290315	5367090	Adrian	Greenwater
92-BRB-347	~~Sedimentary wacke~~	291150	5364750	Marks	Greenwater
92-BRB-355	Mafic Amphibolite	287000	5363510	Marks	Greenwater
92-BRB-365	Intermediate flow	287380	5375500	Adrian	Shebandowan
92-BRB-367	Lamprophyre	293550	5362250	Marks	
92-BRB-368	Felsic flow	287050	5372450	Adrian	Shebandowan
92-BRB-371	Lamprophyre	287910	5371430	Adrian	
92-BRB-380	Intermediate tuff	293100	5372635	Adrian	Shebandowan
92-BRB-407	Intermediate flow	290230	5372520	Adrian	Shebandowan
92-BRB-446	Keewanwan Diabase	287950	5373100	Adrian	
92-BRB-457	Inter. crystal tuff	287105	5366995	Adrian	Greenwater
92-BRB-467	Gabbro	294175	5372135	Adrian	Greenwater
92-BRB-468	Intermediate tuff	293840	5372010	Adrian	Shebandowan
92-BRB-472	Intermediate flow	293405	5370410	Adrian	Shebandowan
92-BRB-504	Gabbro	294315	5375915	Adrian	Greenwater
92-BRB-512	Peridotite	294960	5374575	Adrian	Greenwater
92-BRB-549	Intermediate	289700	5370400	Adrian	Shebandowan
92-BRB-563	Equigranular Granite	286205	5363100	Adrian	

Whole Rock Geochemistry for Marks and Adrian Townships.

Sample Name	SiO2	TiO2	Al2O3	Fe2O3	FeO	MnO	MgO	CaO	Na2O	K2O	P2O5	CO2	LOI	TOTAL
92BRB-0001	66.10	0.52	13.30	4.11	2.60	0.05	2.15	3.32	2.77	1.90	0.16	2.33	3.95	101.15
92BRB-0005	48.50	1.36	14.40	12.20	9.30	0.21	9.90	6.66	2.71	0.36	0.26	0.20	1.70	107.60
92BRB-0006	74.60	0.18	12.90	2.12	0.80	0.05	0.84	0.75	0.33	6.46	0.04	0.41	1.20	100.32
92BRB-0013	52.80	1.40	15.40	10.90	8.10	0.10	5.63	7.29	3.09	0.18	0.34	0.06	1.45	106.68
92BRB-0027	38.10	0.22	3.00	9.45	2.10	0.17	33.90	2.31	-0.01	0.02	0.03	0.06	11.30	100.59
92BRB-0028	49.40	1.77	11.40	19.90	14.70	0.25	4.26	9.66	0.61	0.25	0.11	0.13	2.35	114.90
92BRB-0036	55.50	0.65	14.90	7.33	5.10	0.09	7.34	4.58	3.39	0.79	0.19	0.96	4.10	103.96
92BRB-0037	59.80	0.56	13.40	7.62	5.80	0.08	4.01	4.03	2.61	1.12	0.16	3.12	4.50	103.89
92BRB-0045	64.50	0.53	16.40	3.91	3.00	0.06	2.07	2.73	5.29	1.56	0.12	0.60	1.45	101.64
92BRB-0063	63.20	0.49	16.50	4.05	2.20	0.07	2.05	3.84	5.44	1.52	0.13	0.10	1.05	100.54
92BRB-0076	66.80	0.86	16.00	2.16	1.20	0.07	0.50	3.04	3.86	1.90	0.34	1.91	3.25	100.00
92BRB-0083	51.30	0.86	16.30	9.25	7.30	0.14	3.76	6.84	3.10	0.61	0.25	4.99	7.85	107.37
92BRB-0097	55.10	0.74	15.10	7.92	6.00	0.10	4.17	4.31	3.05	2.12	0.14	3.12	5.90	104.64
92BRB-0100	48.60	0.80	13.20	11.50	9.10	0.17	10.50	6.26	2.92	0.33	0.07	0.08	3.75	107.22
92BRB-0107	47.40	1.16	10.90	12.60	9.50	0.20	14.70	6.48	2.14	0.20	0.29	0.07	3.80	109.57
92BRB-0155	67.40	0.69	14.80	5.33	4.10	0.04	1.30	1.53	3.14	1.73	0.19	0.88	2.50	102.75
92BRB-0218	46.20	0.50	20.00	6.96	6.60	0.12	7.80	11.00	1.52	0.62	0.05	0.05	1.50	104.89
92BRB-0220	69.90	0.19	15.50	1.65	1.00	0.04	0.82	1.00	5.24	3.23	0.07	0.15	1.25	99.89
92BRB-0303	57.50	0.72	15.20	7.13	5.20	0.11	6.06	3.69	3.50	1.23	0.15	2.47	5.15	105.66
92BRB-0306	55.90	0.62	14.70	6.19	4.70	0.12	3.84	5.88	2.97	1.46	0.14	4.29	7.20	103.72
92BRB-0310	49.10	1.03	14.70	14.90	11.50	0.19	8.03	6.99	1.15	0.58	0.09	0.60	3.35	111.61
92BRB-0326	51.60	1.64	13.80	14.50	9.80	0.17	5.30	4.69	3.79	0.74	0.24	0.16	2.05	108.32
92BRB-0332	62.60	0.56	14.80	3.96	2.60	0.06	1.99	3.84	3.51	2.24	0.18	2.65	4.40	100.76
92BRB-0334	55.40	0.93	13.60	9.80	8.10	0.30	1.39	5.40	3.29	0.79	0.27	8.23	7.55	106.82
92BRB-0336	67.30	0.23	14.80	1.80	1.10	0.05	0.86	3.60	5.90	1.03	0.07	2.96	3.40	100.16
92BRB-0343	63.50	0.47	16.90	4.14	2.80	0.07	2.04	2.92	5.30	1.91	0.16	0.33	0.85	101.06
92BRB-0347	67.10	0.45	15.10	3.16	2.00	0.04	1.34	3.08	3.01	3.44	0.12	0.20	1.00	99.84
92BRB-0355	53.40	0.59	10.40	11.20	7.90	0.22	9.16	12.00	1.83	0.53	0.05	0.11	0.95	108.03
92BRB-0365	51.30	1.20	15.90	7.87	6.20	0.23	1.85	6.67	3.27	1.21	0.36	8.20	9.12	105.20
92BRB-0367	49.70	0.51	7.12	7.83	5.60	0.20	19.40	8.02	0.56	1.69	0.21	0.39	3.20	104.24
92BRB-0368	70.20	0.59	14.80	1.20	0.70	0.09	0.35	2.77	4.39	1.46	0.15	1.74	2.95	99.65
92BRB-0371	45.10	0.56	8.61	11.50	8.90	0.21	14.10	10.20	1.28	0.41	0.45	2.55	5.65	108.97
92BRB-0380	62.40	0.55	14.40	4.99	3.30	0.07	4.93	2.64	3.66	2.56	0.16	1.74	3.00	102.66
92BRB-0407	63.40	0.59	14.80	3.79	2.40	0.06	1.70	4.36	2.74	1.75	0.18	3.41	5.30	101.11
92BRB-0446	46.90	0.97	14.20	13.30	9.90	0.20	7.62	10.40	1.95	0.35	0.12	0.10	0.35	106.26
92BRB-0457	60.70	0.74	15.90	5.89	3.80	0.09	3.15	4.96	4.16	1.27	0.21	0.27	1.20	102.07
92BRB-0467	50.40	0.85	14.00	11.20	8.40	0.17	7.28	9.15	1.55	0.76	0.10	0.85	3.00	106.66
92BRB-0488	56.80	0.64	15.60	4.64	2.80	0.10	3.20	5.73	2.61	3.06	0.17	4.18	6.55	102.10
92BRB-0472	59.80	0.54	15.60	5.82	4.00	0.10	4.55	3.45	4.45	1.17	0.12	1.31	2.85	102.45
92BRB-0504	48.10	0.96	13.60	14.90	11.40	0.23	6.71	8.13	1.44	0.44	0.08	0.30	4.05	110.04
92BRB-0512	35.70	0.20	2.55	11.70	2.80	0.16	33.10	1.41	-0.01	-0.01	0.02	0.11	11.60	99.42
92BRB-0549	60.30	1.72	18.10	5.97	4.90	0.16	1.46	4.01	3.49	1.07	0.19	0.62	2.10	103.47
92BRB-0563	70.60	0.17	15.20	1.21	0.40	0.04	0.64	1.56	5.11	3.37	0.07	0.03	0.75	99.11

Whole Rock Geochemistry for Marks and Adrian Townships
Normalized

Sample Name	SiO2	TiO2	Al2O3	Fe2O3	FeO	MnO	MgO	CaO	Na2O	K2O	P2O5	CO2	LOI	TOTAL
92BRB-0001	63.88	0.50	12.85	3.97	2.71	0.05	2.08	3.21	2.68	1.84	0.17	2.25	3.82	100.00
92BRB-0005	44.99	1.28	13.36	11.32	8.63	0.19	9.18	6.18	2.51	0.33	0.26	0.19	1.58	100.00
92BRB-0008	74.06	0.18	12.81	2.10	0.79	0.05	0.83	0.77	0.33	6.43	0.04	0.41	1.19	100.00
92BRB-0013	49.47	1.31	14.43	10.21	7.59	0.09	5.27	6.83	2.89	0.17	0.32	0.06	1.36	100.00
92BRB-0027	37.85	0.21	2.98	9.39	2.09	0.17	33.68	2.29	0.00	0.02	0.03	0.06	11.23	100.00
92BRB-0028	42.95	1.54	9.91	17.30	12.78	0.22	3.72	8.42	0.70	0.22	0.10	0.11	2.04	100.00
92BRB-0036	52.89	0.62	14.20	6.98	4.86	0.09	6.99	4.36	3.23	0.75	0.18	0.93	3.91	100.00
92BRB-0037	55.88	0.52	12.52	7.31	5.42	0.07	3.75	3.77	2.44	1.05	0.15	2.92	4.21	100.00
92BRB-0045	63.09	0.52	16.04	3.82	2.93	0.06	2.02	2.67	5.17	1.55	0.12	0.59	1.42	100.00
92BRB-0063	62.90	0.49	16.39	4.02	2.19	0.07	2.04	3.82	5.41	1.51	0.13	0.10	1.04	100.00
92BRB-0076	65.55	0.84	15.70	2.12	1.18	0.07	0.49	2.98	3.81	1.86	0.33	1.87	3.19	100.00
92BRB-0083	45.65	0.76	14.51	8.23	6.50	0.12	3.36	6.09	2.76	0.54	0.22	4.44	6.81	100.00
92BRB-0097	51.13	0.68	14.01	7.35	5.57	0.09	3.87	4.00	2.83	1.97	0.13	2.90	5.47	100.00
92BRB-0100	45.29	0.74	12.30	10.72	8.46	0.16	9.79	5.85	2.72	0.31	0.07	0.07	3.49	100.00
92BRB-0107	43.23	1.06	9.94	11.67	8.66	0.18	13.41	5.91	1.95	0.18	0.26	0.06	3.47	100.00
92BRB-0155	65.04	0.67	14.28	5.14	3.96	0.04	1.25	1.48	3.03	1.67	0.18	0.85	2.41	100.00
92BRB-0218	44.03	0.47	19.06	8.56	6.29	0.11	7.43	10.48	1.45	0.59	0.05	0.05	1.43	100.00
92BRB-0220	69.87	0.19	15.49	1.65	1.00	0.04	0.82	1.00	5.24	3.23	0.07	0.15	1.25	100.00
92BRB-0303	53.17	0.67	14.06	6.59	4.81	0.10	5.62	3.41	3.24	1.14	0.14	2.28	4.76	100.00
92BRB-0306	51.76	0.57	13.61	5.73	4.35	0.11	3.56	5.44	2.75	1.35	0.13	3.97	6.67	100.00
92BRB-0310	43.76	0.92	13.10	13.28	10.25	0.17	7.16	6.23	1.02	0.52	0.08	0.53	2.99	100.00
92BRB-0326	47.57	1.51	12.72	13.37	9.03	0.16	4.89	4.32	3.49	0.68	0.22	0.15	1.89	100.00
92BRB-0332	60.53	0.54	14.31	3.85	2.51	0.06	1.92	3.71	3.39	2.17	0.17	2.56	4.25	100.00
92BRB-0334	49.00	0.82	12.03	8.67	7.16	0.27	1.23	4.78	2.91	0.70	0.24	5.51	6.68	100.00
92BRB-0338	65.27	0.22	14.35	1.75	1.07	0.05	0.85	3.49	5.72	1.00	0.07	2.87	3.30	100.00
92BRB-0343	62.63	0.46	16.67	4.08	2.76	0.07	2.01	2.88	5.23	1.88	0.16	0.33	0.84	100.00
92BRB-0347	67.07	0.45	15.09	3.16	2.00	0.04	1.34	3.08	3.01	3.44	0.12	0.20	1.00	100.00
92BRB-0355	49.36	0.55	9.62	10.36	7.31	0.20	8.47	11.10	1.51	0.49	0.05	0.10	0.88	100.00
92BRB-0365	45.24	1.06	14.02	6.94	5.47	0.20	1.63	5.88	2.88	1.07	0.34	7.23	8.04	100.00
92BRB-0367	47.50	0.49	6.80	7.48	5.35	0.19	18.54	7.66	0.54	1.81	0.20	0.37	3.06	100.00
92BRB-0368	69.24	0.58	14.60	1.18	0.69	0.09	0.35	2.73	4.33	1.44	0.15	1.72	2.91	100.00
92BRB-0371	41.18	0.51	7.86	10.50	8.13	0.19	12.87	9.31	1.17	0.37	0.41	2.33	5.16	100.00
92BRB-0380	59.77	0.52	13.79	4.78	3.16	0.07	4.72	2.53	3.51	2.45	0.15	1.67	2.87	100.00
92BRB-0407	60.66	0.57	14.16	3.63	2.30	0.08	1.63	4.19	2.62	1.67	0.17	3.26	5.07	100.00
92BRB-0446	45.13	0.89	13.10	12.27	9.14	0.18	7.03	9.60	1.80	0.32	0.11	0.09	0.32	100.00
92BRB-0457	59.31	0.73	15.54	5.76	3.71	0.09	3.08	4.85	4.06	1.24	0.21	0.26	1.17	100.00
92BRB-0467	46.79	0.79	13.00	10.40	7.80	0.16	6.76	8.49	1.44	0.72	0.09	0.79	2.78	100.00
92BRB-0468	53.44	0.61	14.68	4.37	2.63	0.09	3.01	5.39	2.64	2.88	0.16	3.93	6.16	100.00
92BRB-0472	57.63	0.52	15.03	5.61	3.85	0.10	4.38	3.32	4.29	1.13	0.12	1.26	2.75	100.00
92BRB-0504	43.59	0.87	12.33	13.50	10.33	0.21	6.08	7.37	1.31	0.40	0.07	0.27	3.67	100.00
92BRB-0512	35.67	0.20	2.56	11.76	2.81	0.16	33.26	1.42	-0.01	-0.01	0.02	0.11	11.86	100.00
92BRB-0549	57.93	1.65	17.39	5.74	4.71	0.15	1.40	3.85	3.35	1.03	0.18	0.60	2.02	100.00
92BRB-0563	71.21	0.17	15.33	1.22	0.40	0.04	0.65	1.57	5.15	3.40	0.07	0.03	0.76	100.00

Whole Rock Geochemistry for Marks and Adrian Townships.
Continued.

Sample Name	Ni	Co	Sc	V	Cu	Pb	Zn	Bi	Cd	Mo	S	As	Sb	Ag
92BRB-0001	82.00	17.00	9.40	78.00	34.40	2.00	59.40	5.00	-1.00	1.00	-0.01	-3.00	-5.00	-0.10
92BRB-0005	383.00	64.00	21.40	132.00	63.80	-2.00	111.00	8.00	-1.00	-1.00	0.04	-3.00	-5.00	-0.10
92BRB-0008	1.00	1.00	4.40	3.00	3.40	-2.00	33.40	-3.00	-1.00	-1.00	0.04	-3.00	-5.00	-0.10
92BRB-0013	63.00	26.00	30.40	203.00	15.60	-2.00	23.30	-3.00	-1.00	-1.00	0.02	-3.00	-5.00	-0.10
92BRB-0027	1710.00	114.00	12.60	39.00	5.40	3.00	83.60	-3.00	-1.00	-1.00	0.02	-3.00	8.00	-0.10
92BRB-0028	14.00	67.00	50.20	545.00	146.00	-2.00	109.00	7.00	1.00	-1.00	0.29	-3.00	-5.00	-0.10
92BRB-0036	146.00	33.00	19.00	145.00	43.20	-2.00	92.00	-3.00	-1.00	-1.00	0.01	-3.00	-5.00	0.90
92BRB-0037	156.00	35.00	19.50	85.00	37.90	-2.00	84.80	-3.00	-1.00	-1.00	0.07	-3.00	-5.00	-0.10
92BRB-0045	29.00	12.00	7.50	52.00	20.30	-2.00	71.70	-3.00	-1.00	-1.00	0.04	-3.00	-5.00	-0.10
92BRB-0063	30.00	12.00	8.00	57.00	17.80	-2.00	73.40	-3.00	-1.00	1.00	0.04	-3.00	-5.00	-0.10
92BRB-0076	9.00	3.00	7.50	45.00	11.30	-2.00	30.70	-3.00	-1.00	-1.00	-0.01	-3.00	-5.00	-0.10
92BRB-0083	132.00	36.00	32.10	149.00	57.50	-2.00	96.90	-3.00	-1.00	-1.00	-0.01	-3.00	-5.00	-0.10
92BRB-0097	68.00	24.00	17.80	107.00	53.20	-2.00	77.50	-3.00	-1.00	-1.00	-0.01	-3.00	-5.00	-0.10
92BRB-0100	137.00	54.00	43.70	269.00	134.00	-2.00	83.40	-3.00	-1.00	-1.00	0.01	-3.00	-5.00	-0.10
92BRB-0107	485.00	63.00	20.80	134.00	48.50	-2.00	128.00	6.00	-1.00	-1.00	-0.01	-3.00	-5.00	-0.10
92BRB-0155	35.00	8.00	6.70	54.00	15.20	-2.00	62.30	4.00	-1.00	-1.00	-0.01	-3.00	-5.00	-0.10
92BRB-0218	208.00	42.00	25.10	131.00	115.00	-2.00	54.70	-3.00	-1.00	-1.00	0.09	-3.00	6.00	-0.10
92BRB-0220	7.00	3.00	2.50	22.00	2.30	31.00	29.50	-3.00	-1.00	-1.00	0.01	-3.00	10.00	-0.10
92BRB-0303	66.00	25.00	18.50	105.00	8.90	-2.00	79.80	-3.00	-1.00	-1.00	0.01	-3.00	-5.00	-0.10
92BRB-0306	76.00	19.00	17.30	82.00	7.60	-2.00	50.70	-3.00	-1.00	-1.00	0.01	-3.00	-5.00	-0.10
92BRB-0310	34.00	46.00	37.80	297.00	85.70	-2.00	75.80	4.00	-1.00	-1.00	0.15	-3.00	-5.00	0.20
92BRB-0326	42.00	37.00	38.50	219.00	91.60	-2.00	108.00	3.00	-1.00	-1.00	0.02	-3.00	-5.00	-0.10
92BRB-0332	41.00	13.00	10.80	71.00	29.70	-2.00	57.10	5.00	-1.00	-1.00	0.01	-3.00	-5.00	-0.10
92BRB-0334	19.00	15.00	16.80	118.00	47.00	-2.00	174.00	-3.00	-1.00	9.00	0.02	-3.00	-5.00	-0.10
92BRB-0338	9.00	5.00	4.10	23.00	6.50	-2.00	38.10	-3.00	-1.00	-1.00	0.07	-3.00	-5.00	0.40
92BRB-0343	23.00	12.00	9.00	90.00	19.20	-2.00	69.40	-3.00	-1.00	-1.00	0.02	-3.00	-5.00	-0.10
92BRB-0347	28.00	10.00	7.30	52.00	43.20	-2.00	69.70	-3.00	-1.00	-1.00	0.14	-3.00	-5.00	-0.10
92BRB-0355	103.00	51.00	42.20	156.00	23.50	-2.00	63.70	7.00	-1.00	-1.00	-0.01	-3.00	6.00	0.20
92BRB-0365	90.00	43.00	17.70	119.00	43.50	-2.00	65.40	-3.00	-1.00	-1.00	0.07	-3.00	-5.00	-0.10
92BRB-0367	684.00	63.00	20.00	78.00	14.10	-2.00	87.70	5.00	-1.00	-1.00	-0.01	-3.00	7.00	-0.10
92BRB-0368	6.00	5.00	5.00	49.00	21.80	-2.00	10.10	-3.00	-1.00	1.00	0.02	-3.00	-5.00	-0.10
92BRB-0371	449.00	55.00	26.80	186.00	10.80	-2.00	140.00	9.00	-1.00	-1.00	-0.01	-3.00	9.00	-0.10
92BRB-0380	86.00	15.00	11.00	76.00	26.60	-2.00	72.40	-3.00	-1.00	-1.00	0.01	-3.00	-5.00	-0.10
92BRB-0407	43.00	11.00	11.90	77.00	56.20	-2.00	54.60	-3.00	-1.00	-1.00	0.02	-3.00	-5.00	0.70
92BRB-0446	132.00	57.00	38.30	248.00	117.00	-2.00	91.80	-3.00	-1.00	-1.00	0.01	-3.00	-5.00	0.30
92BRB-0457	56.00	21.00	12.10	91.00	52.60	-2.00	83.10	-3.00	-1.00	-1.00	0.16	-3.00	-5.00	-0.10
92BRB-0467	64.00	41.00	40.10	175.00	82.60	-2.00	73.20	-3.00	-1.00	-1.00	0.11	-3.00	-5.00	-0.10
92BRB-0468	101.00	17.00	16.30	96.00	49.90	-2.00	82.50	-3.00	-1.00	-1.00	0.02	-3.00	-5.00	-0.10
92BRB-0472	163.00	28.00	13.00	109.00	132.00	-2.00	172.00	-3.00	-1.00	2.00	0.28	-3.00	5.00	-0.10
92BRB-0504	193.00	66.00	44.30	268.00	150.00	-2.00	73.20	8.00	-1.00	-1.00	0.03	-3.00	-5.00	-0.10
92BRB-0512	1550.00	125.00	12.60	63.00	50.10	-2.00	95.30	5.00	-1.00	-1.00	0.01	-3.00	11.00	0.40
92BRB-0549	211.00	75.00	32.30	236.00	105.00	-2.00	92.50	3.00	-1.00	-1.00	0.08	21.00	-5.00	-0.10
92BRB-0563	5.00	3.00	2.20	11.00	5.00	5.00	34.60	-3.00	-1.00	-1.00	-0.01	-3.00	-5.00	-0.10

Whole Rock Geochemistry for Marks and Adrian Townships.
Continued

Sample Name	Hg	Rb	Li	Nb	Y	Th	La	F	Cl	Be	Pr	Sm	Eu	Tb
92BRB-0001	-5.00	56.00	13.00	12.00	7.10	1.80	21.70	219.00	250.00	1.20	4.8	3.0	0.8	0
92BRB-0005	-5.00	14.00	26.00	30.00	18.40	-	-	358.00	180.00	2.00	-	-	-	-
92BRB-0008	-5.00	123.00	23.00	13.00	12.50	-	-	180.00	180.00	1.00	-	-	-	-
92BRB-0013	-5.00	-10.00	16.00	20.00	19.40	1.00	19.10	383.00	250.00	1.90	5.7	5.1	1.4	1
92BRB-0027	-5.00	17.00	11.00	10.00	3.30	-	-	49.00	250.00	1.00	-	-	-	-
92BRB-0028	8.00	28.00	20.00	19.00	24.00	-	-	99.00	200.00	2.60	-	-	-	-
92BRB-0036	-5.00	29.00	34.00	22.00	12.50	2.30	21.10	321.00	60.00	1.70	4.8	3.8	1.0	0
92BRB-0037	11.00	41.00	27.00	25.00	8.90	-	-	239.00	260.00	1.40	-	-	-	-
92BRB-0045	-5.00	50.00	36.00	11.00	6.40	-	-	310.00	160.00	1.30	-	-	-	-
92BRB-0063	-5.00	45.00	29.00	17.00	7.00	-	-	301.00	50.00	1.20	-	-	-	-
92BRB-0076	-5.00	54.00	6.00	13.00	12.50	-	-	387.00	230.00	1.00	-	-	-	-
92BRB-0083	-5.00	23.00	23.00	30.00	12.40	1.40	23.70	265.00	50.00	1.50	5.6	4.2	1.1	0
92BRB-0097	5.00	77.00	38.00	-10.00	9.30	-	-	292.00	80.00	1.60	-	-	-	-
92BRB-0100	6.00	26.00	44.00	18.00	17.80	-	-	81.00	-50.00	1.40	-	-	-	-
92BRB-0107	-5.00	29.00	25.00	16.00	12.70	-	-	321.00	120.00	1.80	-	-	-	-
92BRB-0155	-5.00	69.00	21.00	11.00	8.00	-	-	480.00	70.00	1.60	-	-	-	-
92BRB-0218	-5.00	47.00	30.00	18.00	9.30	-	-	20.00	100.00	1.10	-	-	-	-
92BRB-0220	6.00	110.00	15.00	-10.00	1.80	-	-	271.00	200.00	1.20	-	-	-	-
92BRB-0303	-5.00	42.00	36.00	19.00	9.60	-	-	306.00	120.00	1.40	-	-	-	-
92BRB-0306	-5.00	43.00	39.00	36.00	9.50	-	-	364.00	110.00	1.30	-	-	-	-
92BRB-0310	5.00	19.00	20.00	17.00	18.60	-	-	117.00	170.00	1.80	-	-	-	-
92BRB-0326	-5.00	23.00	17.00	27.00	43.90	-	-	307.00	110.00	2.40	-	-	-	-
92BRB-0332	-5.00	57.00	18.00	21.00	8.30	-	-	318.00	170.00	1.30	-	-	-	-
92BRB-0334	13.00	31.00	20.00	19.00	15.40	-	-	387.00	250.00	1.80	-	-	-	-
92BRB-0338	7.00	23.00	24.00	24.00	3.00	-	-	196.00	240.00	0.80	1.2	1.0	0.3	0
92BRB-0343	-5.00	49.00	34.00	25.00	8.50	-	-	400.00	250.00	1.50	-	-	-	-
92BRB-0347	8.00	78.00	27.00	25.00	10.30	-	-	335.00	60.00	1.60	-	-	-	-
92BRB-0355	-5.00	36.00	8.00	-10.00	11.10	-	-	173.00	270.00	1.40	-	-	-	-
92BRB-0365	8.00	35.00	18.00	17.00	15.60	-	-	414.00	160.00	1.60	-	-	-	-
92BRB-0367	-5.00	78.00	54.00	23.00	7.30	-	-	970.00	100.00	1.80	-	-	-	-
92BRB-0368	-5.00	59.00	9.00	16.00	7.00	-	-	217.00	210.00	0.90	-	-	-	-
92BRB-0371	6.00	-10.00	27.00	24.00	19.00	-	-	981.00	-50.00	3.20	-	-	-	-
92BRB-0380	-5.00	52.00	30.00	-10.00	6.60	-	-	260.00	130.00	1.30	-	-	-	-
92BRB-0407	-5.00	73.00	20.00	-10.00	7.90	-	-	289.00	-50.00	1.40	-	-	-	-
92BRB-0446	-5.00	19.00	17.00	21.00	18.40	-	-	163.00	180.00	1.80	-	-	-	-
92BRB-0457	-5.00	50.00	26.00	20.00	10.40	-	-	332.00	170.00	1.60	-	-	-	-
92BRB-0467	-5.00	18.00	20.00	26.00	24.60	-	-	100.00	60.00	1.60	-	-	-	-
92BRB-0468	-5.00	88.00	17.00	10.00	10.00	-	-	295.00	120.00	1.50	-	-	-	-
92BRB-0472	25.00	24.00	26.00	12.00	9.90	1.50	-	212.00	130.00	1.50	4.2	2.9	1.1	0
92BRB-0504	-5.00	15.00	39.00	34.00	16.40	-	-	158.00	320.00	1.90	-	-	-	-
92BRB-0512	-5.00	22.00	9.00	24.00	4.10	-	-	31.00	390.00	1.30	-	-	-	-
92BRB-0549	-5.00	38.00	30.00	-10.00	16.80	-	-	270.00	90.00	1.40	-	-	-	-
92BRB-0563	-5.00	105.00	37.00	16.00	4.30	-	-	219.00	170.00	1.80	-	-	-	-

Whole Rock Geochemistry for Marks and Adrian Townships.
Continued

Sample Name	Ho	Lu	Ce	Nd	Gd	Dy	Er	Tm	Yb
92BRB-0001	0.20	0	46.1	18.1	2.3	1	1	-	0.60
92BRB-0005	-0	-	-	-	-	-	-	-	
92BRB-0008	-0	-	-	-	-	-	-	-	
92BRB-0013	0.58	1	47.9	24.3	4.7	3	2	-	1.80
92BRB-0027	-0	-	-	-	-	-	-	-	
92BRB-0028	-0	-	-	-	-	-	-	-	
92BRB-0036	0.36	0	44.8	18.9	3.2	2	1	-	1.10
92BRB-0037	-0	-	-	-	-	-	-	-	-
92BRB-0045	-0	-	-	-	-	-	-	-	-
92BRB-0063	-0	-	-	-	-	-	-	-	-
92BRB-0076	-0	-	-	-	-	-	-	-	-
92BRB-0083	0.42	1	51.9	22.6	3.6	2	1		1.40
92BRB-0097	-0	-	-	-	-	-	-	-	-
92BRB-0100	-0	-	-	-	-	-	-	-	-
92BRB-0107	-0	-	-	-	-	-	-	-	-
92BRB-0155	-0	-	-	-	-	-	-	-	-
92BRB-0218	-0	-	-	-	-	-	-	-	-
92BRB-0220	-0	-	-	-	-	-	-	-	-
92BRB-0303	-0	-	-	-	-	-	-	-	-
92BRB-0306	-0	-	-	-	-	-	-	-	-
92BRB-0310	-0	-	-	-	-	-	-	-	-
92BRB-0326	-0	-	-	-	-	-	-	-	-
92BRB-0332	-0	-	-	-	-	-	-	-	-
92BRB-0334	-0	-	-	-	-	-	-	-	-
92BRB-0338	0.08	0	10.6	5.0	0.8	1	-	-	0.20
92BRB-0343	-0	-	-	-			-	-	
92BRB-0347	-0	-	-	-	-	-	-	-	-
92BRB-0355	-0	-	-	-	-	-	-	-	-
92BRB-0365	-0	-	-	-	-	-	-	-	-
92BRB-0367	-0	-	-	-	-	-	-	-	-
92BRB-0368	-0	-	-	-	-	-	-	-	-
92BRB-0371	-0	-	-	-	-	-	-	-	-
92BRB-0380	-0	-	-	-	-	-	-	-	-
92BRB-0407	-0	-	-	-	-	-	-	-	-
92BRB-0446	-0	-	-	-	-	-	-	-	-
92BRB-0457	-0	-	-	-	-	-	-	-	-
92BRB-0467	-0	-	-	-	-	-	-	-	-
92BRB-0468	-0	-	-	-	-	-	-	-	-
92BRB-0472	0.29	1	-	16.1	2.5	2	1		0.90
92BRB-0504	-0	-	-	-	-	-	-	-	-
92BRB-0512	-0	-	-	-	-	-	-	-	-
92BRB-0549	-0	-	-	-	-	-	-	-	-
92BRB-0563	-0	-	-	-	-	-	-	-	-

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1991 c. Airborne electromagnetic and total intensity magnetic survey, Shebandowan Area; Ontario Geological Survey, Map 81590, scale 1:20 000

1991 d. Airborne electromagnetic and total intensity magnetic survey, Shebandowan Area; Ontario Geological Survey, Map 81591, scale 1:20 000

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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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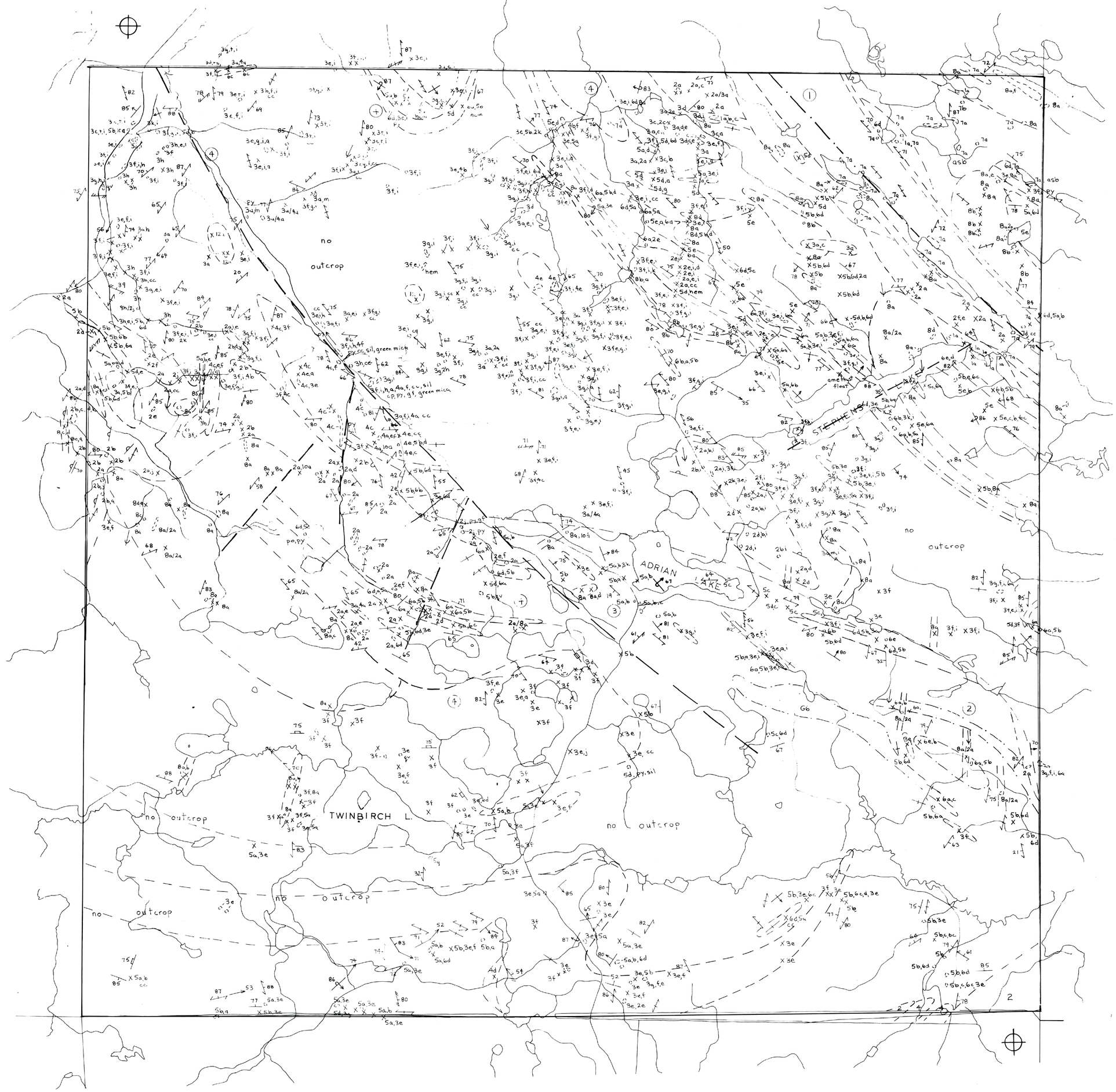

LEGEND[a]

PHANEROZOIC

CENOZOIC

QUATERNARY

RECENT

Lake, stream, wetland deposits

PLEISTOCENE

Glacial, glaciofluvial deposits: sand, gravel, clay, till

UNCONFORMITY

PRECAMBRIAN

PROTEROZOIC

MESOPROTEROZOIC

KEWEENAWAN SUPERGROUP

12 Mafic Intrusive Rocks
- 12a Diabase[b]

INTRUSIVE CONTACT

PALEOPROTEROZOIC

Animikie Group

Gunflint Formation

11 Sedimentary Rocks
- 11a Taconite: massive and oolitic
- 11b Algae mat chert, jasper and chert
- 11c Conglomerate
- 11d Argillite

ARCHEAN

NEOARCHEAN

10 Mafic Intrusive Rocks
- 10a Lamprophyre

9 Felsic and Intermediate Intrusive Rocks
- 9a Diorite
- 9b Tonalite to quartz diorite
- 9c Granodiorite to quartz monzonite
- 9d Granite, potassium-feldspar megacrystic to equigranular
- 9e Aplite dikes
- 9f Gneiss, granodioritic to tonalitic
- 9g Migmatite

8 Metamorphosed Mafic Intrusions
- 8a Gabbro
- 8b Leucocratic gabbro
- 8c Knobby gabbro
- 8d Intrusion breccia
- 8e Pegmatitic gabbro
- 8f Anorthositic gabbro

INTRUSIVE CONTACT

7 Metamorphosed Ultramafic Intrusions[b]
- 7a Peridotite
- 7b Pyroxenite
- 7d Schist, commonly, with iron carbonate

Metavolcanic and Metasedimentary Rocks

6 Chemical Metasedimentary Rocks
- 6a Magnetite-jasper ironstone
- 6b Bedded chert ± magnetite ± carbonate-facies ironstone
- 6c Sulphide-facies ironstone
- 6d Chert
- 6e Chert breccia

5 Clastic Metasedimentary Rocks
- 5a Wacke
- 5b Siltstone and mudstone
- 5c Graphitic mudstone
- 5d Conglomerate, quartz pebbles, mud chips and lithic clasts
- 5e Conglomerate, jasper ± mudstone ± intermediate metavolcanic clasts
- 5f Biotite-hornblende gneiss
- 5g Schist
- 5h Migmatite

4 Felsic Metavolcanic Rocks
- 4a Flows, massive and flow laminated
- 4b Tuff
- 4c Lapilli Tuff
- 4d Tuff breccia
- 4e Quartz-feldspar porphyry (possibly crystal tuff)
- 4f Schist
- 4g Autoclastic breccia

3 Intermediate Metavolcanic Rocks
- 3a Flows, massive
- 3b Flows, pillowed
- 3c Flows, spherulitic
- 3d Pillow and/or flow-top breccia, hyaloclastite
- 3e Tuff and/or crystal tuff
- 3f Lapilli tuff and/or crystal lapilli tuff
- 3g Tuff breccia to breccia
- 3i Hornblende or plagioclase phenocrystic, interpreted as Temiskaming-like
- 3n Schist
- 3j Amphibolite
- 3k Dikes, hornblende and plagioclase-phyric[b]
- 3l Intrusion breccia
- 3m Autoclastic breccia

2 Mafic Metavolcanic Rocks
- 2a Flows, massive
- 2b Flows, pillowed
- 2c Flows, variolitic
- 2g Pillow and flow-top breccia
- 2e Tuff
- 2f Lapilli tuff
- 2g Amphibolite
- 2h Tuff breccia
- 2i Hornblende or plagioclase phenocrystic, interpreted as Temiskaming-like
- 2j Schist
- 2k Basaltic dikes

1 Ultramafic and Mafic Metavolcanic Rocks
- 1a Flows, spinifex and/or polysutured textured
- 1b Cumulate-textured massive flow
- 1c Flow breccia

[a] *This is a field legend and may be changed as a result of subsequent laboratory investigations.*

[b] *These rocks may, in part, be extrusive.*

The letter "C" preceding a code refers to data compiled from previously published maps and unpublished maps from mineral exploration companies covering portions of Marks and Tekwan townships area.

The letter "D" preceding a code refers to data compiled from plans and geological reports for assessment work credits on file with the Resident Geologist's Office, Ministry of Environment at Thunder Bay.

The letter "G" preceding a code refers to data interpreted from published geophysical data.

Rocks codes designated with a "/" (e.g. 8/2) indicate the lithology may contain both rock types but the first number (code) is inferred to predominate.

SYMBOLS

- Small bedrock outcrop
- Area of bedrock outcrop
- Bedding, top unknown, (inclined, vertical)
- Bedding, top indicated by arrow, (inclined, vertical, overturned)
- Lava flow, top known, (dip indicated by arrow, dip unknown, overturned)
- Foliation, (inclined, vertical)
- Second foliation (inclined, vertical)
- Fractures, (inclined, vertical)
- Lineation with plunge
- Lineation, vertical
- Glacial striae
- Geological boundary, observed
- Geological boundary, position interpreted
- Geological boundary, inferred from geophysics
- Lineament
- Fault
- Water well (drill hole, (vertical, total depth in metres)

ABBREVIATIONS

amy	amethyst	gn	galena
asb	asbestos	hem	hematite
cc	carbonate alteration	po	pyrrhotite
cp	chalcopyrite	py	pyrite
fluor	fluorite	qv	quartz vein
gf	graphite	sil	silicified zone

PROPERTIES[a]

MARKS TOWNSHIP

1 Amulta Oils and Minerals Limited (1967)
2 Hanna Mining Company (1962)
3 New Fortune Mines Limited (1957)

ADRIAN TOWNSHIP

1 Canadian Nickel Company Limited (1966)
2 Hanna Mining Company (1962)
3 Kukkee, E. (1986)
4 Noranda Exploration Company, Limited (1967, 1975)

[a] *Date in parentheses indicates the last year of active exploration.*

SOURCES OF INFORMATION

Base map from maps of the Forest Resources Inventory, Ministry of Lands and Waters Group, Ontario Ministry of Natural Resources, at a scale of 1:15 840.

Base maps modified and updated from Ontario Basic Maps numbers 20 16 2800 53500, 20 16 2800 53600, 20 16 2800 53700, 20 16 2900 53500, 20 16 2900 53600 and 20 16 2900 53700 at a scale of 1:20 000.

Metric conversion factor: 1 foot = 0.3048 m

Geology not tied to surveyed lines.

Magnetic declination approximately 2° 30' W, 1990.

OGS Geophysical/Geochemical Series maps 81579, 81580 and 81581, Airborne Electromagnetic Survey, Ontario Geological Survey, Shebandowan Area, District of Thunder Bay, 1981, 1:20 000.

Assessment Files Research Office, Ministry of Northern Development and Mines, Sudbury and assessment files in the Resident Geologist's Office, Thunder Bay.

CREDITS

Geology by B.R. Berger, J.P. Edwards and V.L. Bannister, 1992

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Ministry of Northern Development and Mines
Ontario

Mines and Minerals
Ontario Geological Survey

MAP P.3194

PRECAMBRIAN GEOLOGY

ADRIAN TOWNSHIP

Scale 1:15 840

500 m 0 500 1000 1500 2000 m

NTS Reference: 52 A 5

Queen's Printer for Ontario, 1993

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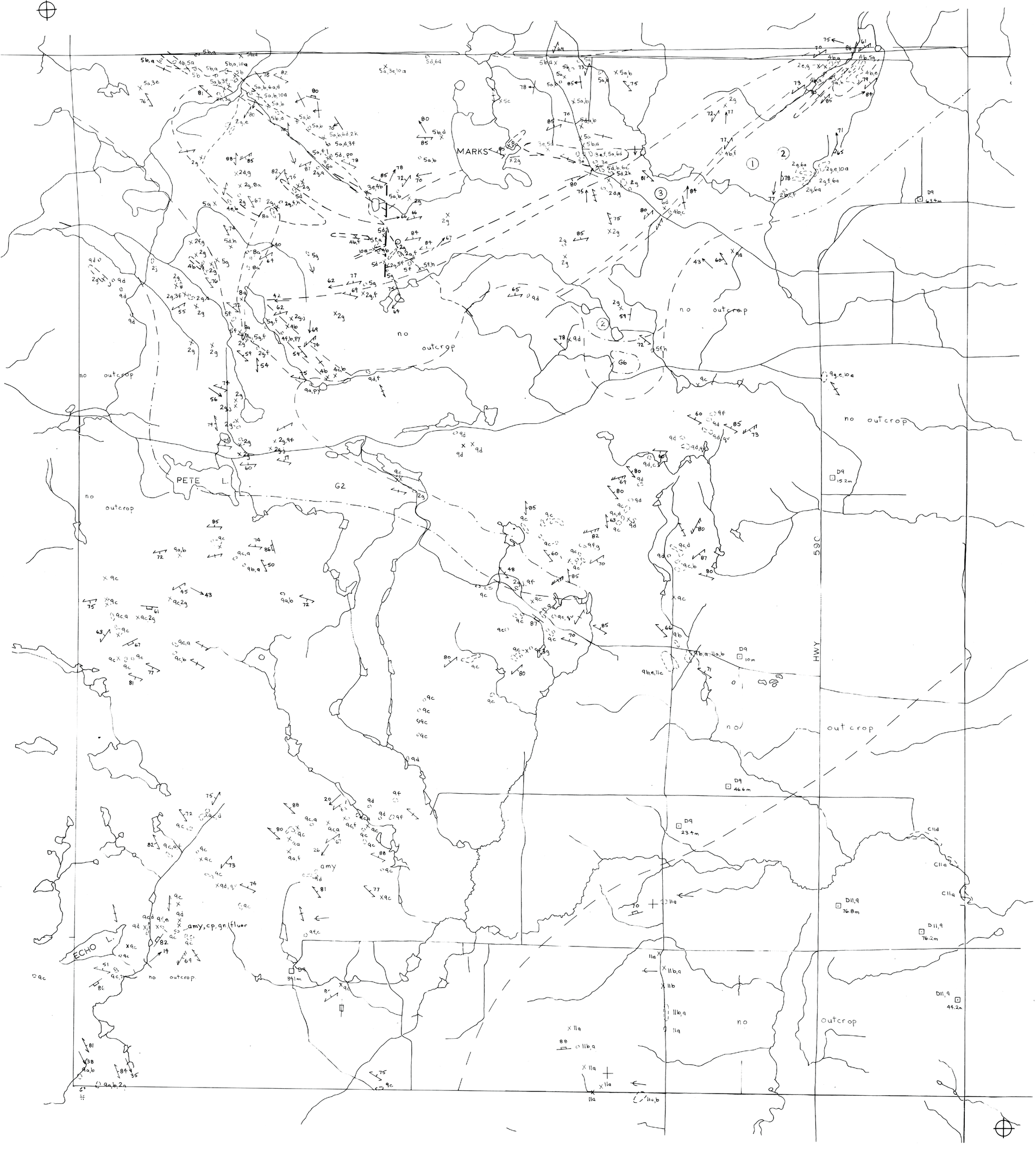

LEGEND[a]

PHANEROZOIC

CENOZOIC

QUATERNARY

RECENT

Lake, stream, wetland deposits

PLEISTOCENE

Glacial, glaciofluvial deposits: sand, gravel, clay, till

UNCONFORMITY

PRECAMBRIAN

PROTEROZOIC

MESOPROTEROZOIC

KEWEENAWAN SUPERGROUP

12 **Mafic Intrusive Rocks**
- 12a Diabase[b]

INTRUSIVE CONTACT

PALEOPROTEROZOIC

Animikie Group

Gunflint Formation

11 **Sedimentary Rocks**
- 11a Taconite: massive and oolitic
- 11b Algae mat chert, jasper and chert
- 11c Conglomerate
- 11d Argillite

ARCHEAN

NEOARCHEAN

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

9 **Felsic and Intermediate Intrusive Rocks**
- 9a Diorite
- 9b Tonalite to quartz diorite
- 9c Granodiorite to quartz monzonite
- 9d Granite, potassium feldspar megacrystic to equigranular
- 9e Aplite dikes
- 9f Gneiss, granodiorite to tonalitic
- 9g Migmatite

8 **Metamorphosed Mafic Intrusions**
- 8a Gabbro
- 8b Leucocratic gabbro
- 8c Knobby gabbro
- 8d Intrusion breccia
- 8e Pegmatitic gabbro
- 8f Anorthositic gabbro

INTRUSIVE CONTACT

7 **Metamorphosed Ultramafic Intrusions[b]**
- 7a Peridotite
- 7b Pyroxenite
- 7d Schist, commonly with iron carbonate

INTRUSIVE CONTACT

Metavolcanic and Metasedimentary Rocks

6 **Chemical Metasedimentary Rocks**
- 6a Magnetite-jasper ironstone
- 6b Bedded chert ± magnetite ± carbonate-facies ironstone
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- 6d Chert
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5 **Clastic Metasedimentary Rocks**
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- 4a Flows, massive and flow laminated
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- 3h Schist
- 3j Amphibolite
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- 3l Intrusion breccia
- 3m Autoclastic breccia

2 **Mafic Metavolcanic Rocks**
- 2a Flows, massive
- 2b Flows, pillowed
- 2c Flows, variolitic
- 2d Pillow and flow-top breccia
- 2e Tuff
- 2f Lapilli tuff
- 2g Amphibolite
- 2h Tuff breccia
- 2i Hornblende or plagioclase phenocrystic, interpreted as Temiskaming-like
- 2j Schist
- 2k Basaltic dikes

1 **Ultramafic and Mafic Metavolcanic Rocks**
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Ministry of Northern Development and Mines
Ontario

Mines and Minerals
Ontario Geological Survey

MAP P.3195

PRECAMBRIAN GEOLOGY

MARKS TOWNSHIP

Scale 1:15 840

500 m 0 0.5 1 km

Mile 1:4 0 1:2 Mile

NTS Reference: 52 A/5

[c]Queen's Printer for Ontario, 1993

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- Bedding, top indicated by arrow; (inclined, vertical, overturned)
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- Second foliation; (inclined, vertical)
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- Lineation with plunge
- Lineation, vertical
- Glacial striae
- Geological boundary, observed
- Geological boundary, position interpreted
- Geological boundary, inferred from geophysics
- Lineament
- Fault
- Water well drill hole, (vertical, total depth in metres)

ABBREVIATIONS

amy	amethyst	gn	galena
asb	asbestos	hem	hematite
cc	carbonate alteration	po	pyrrhotite
cp	chalcopyrite	py	pyrite
fluor	fluorite	qv	quartz vein
gf	graphite	sil	silicified zone

PROPERTIES[a]

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1. Amalta Oils and Minerals Limited (1967)
2. Hanna Mining Company (1962)
3. New Fortune Mines Limited (1957)

ADRIAN TOWNSHIP
1. Canadian Nickel Company Limited (1966)
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