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The Geology and Tectonic History of the Central Uchi Subprovince

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The Geology and Tectonic History of the Central Uchi Subprovince

by

G.M. Stott

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The Geology and Tectonic History of the Central Uchi Subprovince

by G.M. Stott
Precambrian Geoscience Section

Foreword

This report summarizes the results of a reconnaissance mapping project in the central part of the Uchi Subprovince in northwestern Ontario. The objective of the project was to update the structural and stratigraphic framework of the region and, in conjunction with age determinations made by F. Corfu at the Jack Satterly Geochronology Laboratory, Royal Ontario Museum, to establish the general sequence of tectonic events. The results have significantly revised our understanding of the evolution of this part of the Superior Province and also provided the initial stimulus to produce the map of Tectonic Assemblages of Ontario, which was published in 1992.

Abstract

The central part of the Uchi Subprovince, an Archean domain in northwestern Ontario, is composed of several interconnected greenstone belts surrounded by or internally intruded by felsic and mafic plutons. The three principal greenstone belts described in this report encompass a volcanic history of more than 200 million years, comparable to the record of plutonism in this region. Within each of the greenstone belts, contrasts in age of volcanism, and association of rock types, and the presence of tectonic boundaries or major unconformities permit us to subdivide the belts into tectonic assemblages. The tectonic assemblages provide the basic framework for description of rock units mapped principally at a 1:50 000 scale during a 4 year project. An accompanying geochronology program by F. Corfu of the Royal Ontario Museum permits us to not only erect this framework but to establish a sequence of magmatic and deformational events for the region.

The map region has been subdivided for this report into three greenstone belts: the Meen-Dempster belt, the Pickle Lake belt and the Lake St. Joseph belt. Amongst these interconnecting belts, the volcanic strata can be subdivided into at least 4 tectonic assemblages and the sedimentary strata into 2 assemblages. The volcanic assemblages comprise: the Pickle Crow assemblage, *circa* 2860 Ma; the Woman assemblage, *circa* 2840-2825 Ma; the Confederation assemblage, *circa* 2744-2740 Ma; and the St. Joseph assemblage, *circa* 2724-2713 Ma. Each of these assemblages are characterized by a basal platform of subaqueous flows of massive to pillowed tholeiitic basalt with banded magnetite iron formation, and an upper sequence of dacitic to locally rhyolitic pyroclastic deposits. These flows are similar in their tabular form to modern oceanic basalt sequences. Komatiitic volcanic units are notably absent or rare in this region. Locally, the upper intermediate to felsic sequences form prominent edifices that comprise volcanic centres that are identified, from the presence of coarser clast sizes in pyroclastic deposits, on Meen Lake and western Lake St. Joseph. Local coarser pyroclastic concentrations are observed south of Muskegsagagen Lake in the Meen-Dempster belt and in eastern Lake St. Joseph. Where the coarser pyroclastic material is evident, the strata thicken to form a prism as expected for a volcanic centre. Most of the dacitic pyroclastic units in all of the assemblages are composed of massive beds of tuff and in some units, the vertical and lateral succession of primary structures is consistent with ash flow deposits. These upper pyroclastic sequences are comparable to deposits on modern island arcs. A compilation of whole rock and trace element geochemistry illustrates the geochemical character of parts of the volcanic assemblages.

The major sedimentary sequences comprise 2 tectonic assemblages: the Billett assemblage along the southern flank of the Meen-Dempster belt and the Eagle Island assemblage in western Lake St. Joseph. These assemblages are dominated by clastic sedimentary deposits of wacke, arenite and local conglomerate consistent with submarine fan deposits, interbedded with banded magnetite iron formation. Evidence of late orogenic uplift and erosion of volcanic and plutonic terrains is recorded in these younger sedimentary sequences. At least part of the conglomerate deposits of the Billett assemblage are derived from the nearby Dobie Lake Pluton to the north, based on similarity of age and lithologic characteristics. Similarly, part of the basal conglomerate deposits of the Eagle Island assemblage resemble felsic volcanic rocks of the underlying St. Joseph assemblage.

Volumetrically significant alteration of volcanic sequences is limited to 1) synvolcanic carbonate alteration in the volcanic centre at western Lake St. Joseph where small clasts of massive sulphide occur and 2) iron carbonate alteration in the vicinity of broad zones containing brittle-ductile shear zones associated with gold mineralization in the northern half of the Pickle Lake belt and 3) intense silicification of basalt locally in the Pickle Crow-Central Patricia region of the Pickle Lake belt. Less volumetrically significant alteration zones occur as narrow biotitized or sericitized zones of potassium metasomatism in shear zones in northern Meen-Dempster belt, including the shear zone associated with the Golden Patricia gold mine; and the sulphidization of iron formation plus other alteration associated with the Dona Lake gold mine, east of Ochig Lake pluton in the Pickle Lake belt.

The structural geological record is best illustrated from the pattern of mineral and stretching lineations within the schistosity. A sequence of structural events has been documented in each of the three greenstone belts and correlated with the magmatic events to construct an overall tectonic history of the region. The various tectonic assemblages that comprise the volcanic belts generally young to the south, with the oldest assemblage in the Pickle Lake belt, and the youngest assemblage close to the southern boundary of the Uchi Subprovince on Lake St. Joseph. Most individual assemblages show stratigraphic younging that face consistently in one direction within the assemblage, dominantly south and southeastward in the Meen-Dempster and Pickle Lake belts. The geological patterns and sequence of events are consistent with a history of episodic additions of crustal units to the margin of a growing continent comprising the core of the Sachigo and Uchi subprovinces. The evidence from the central part of the Uchi Subprovince suggests that the subprovince formed the leading edge of an evolving microcontinent that developed over several hundred million years. The crustal accumulation over time to form the subprovince can be postulated as an accretion of terranes and growth along a convergent, subduction margin, which terminated when the Uchi-Sachigo microcontinent and its fore-arc accretionary prism (the English River assemblage), collided with another microcontinent (converging from the south during the Kenoran Orogeny.

Introduction

This report is based on 4 field seasons of geological mapping in the central part of the Uchi Subprovince in northwestern Ontario (Figure 1). This program involved 1: 15 840 scale detailed mapping of the Meen Lake area in 1982, and 1: 50 000 scale reconnaissance mapping of the Muskegsagagen-Bancroft lakes area in 1984, the Lake St. Joseph area (1985) and the Pickle Lake area (1986) (*see* Figure 2). Mapping was supplemented by a geochronological program with analyses of samples by F. Corfu of the Royal Ontario Museum.

The results of the mapping and geochronology programs permit a subdivision of the central Uchi greenstone belts into **tectonic assemblages**. *The rock units of a tectonic assemblage are inferred to have been deposited during a discrete interval of time in a common depositional setting, and commonly share similar structural, metamorphic, geochemical and geophysical characteristics. The rock units may display features of primary stratification but may not necessarily conform to the Law of Superposition in places where there has been tectonic interleaving of strata within the assemblage (Ontario Geological Survey 1992b).*

Although tectonic assemblages are interpretive subdivisions of greenstone belts, they shall serve for ease of reference as the basic subheadings under which the rock descriptions and stratigraphic characteristics are presented in this report (Figure 4). An overview of the tectonic assemblages concept and its application to the Uchi Subprovince is given in Stott and Corfu (1991) and in the explanatory notes for the map of Tectonic Assemblages of Ontario (Ontario Geological Survey 1992b). Stott and Corfu (1991) also provides a regional summary based on the principal results of the 4 summers mapping in this project and consequently includes some parts of this report.

Detailed, computerized field notes for 1984 to 1986 with accompanying station location maps have been deposited with the resident geologist at the Sioux Lookout office and are available for examination to supplement the generalized descriptions in this report.

Location and Access

As shown on Figure 2, the region has been subdivided into three areas:

1 (Meen-Kasagiminnis greenstone belt and the Dobie Lake pluton) is centred approximately 60 km west of Pickle Lake and access is by float plane to shallow lakes (typically with water depths only up to 4 metres) and along a network of portages to various lakes in this area, most of which were cut during this mapping program in 1982 and 1984, and subsequently used and widened by numerous gold explorationists, after the 1986 discovery of the gold deposit that forms the Golden Patricia Mine of St. Joe Canada Inc. (now owned by Lac Minerals Ltd).

2 (Pickle Lake greenstone belt) at the end of Highway 599 is accessible by a network of roads and the Kawinogans River system.

3 (Lake St. Joseph greenstone belt and granitoid batholith) is centred on Lake St. Joseph, which serves as a large, shallow reservoir for hydroelectric power generation. Many of the major lakes and rivers of this area can be accessed from Highway 599.

Previous Investigations

The geology of Area 1, the Meen-Kasagiminnis greenstone belt, was first investigated by Harding (1936) who noted that the sparce information on the rocks of this area at that time was likely due to the relative difficulty in travelling through the area with few convenient waterways, and to the extensive glacial overburden. Harding's report gives a bibliographic summary of geological investigations of central Uchi Subprovince up to that time. Some of the mapping in the 1930's focussed on the Pickle Lake region (Hurst 1931; Thomson 1939; Evans, 1941) where newly discovered gold deposits had stimulated considerable exploration. Subsequent detailed mapping near Lake St. Joseph, was completed by Goodwin (1965) and Clifford (1969). In 1972, the region encompassing the central Uchi Subprovince was examined as part of a helicopter-supported reconnaissance mapping program (Sage and Breaks 1982, which includes Geological Compilation Series Map 2218). In 1986, the Ontario Geological Survey published an airborne electromagnetic and total intensity magnetic survey encompassing most of the greenstone belts within the area of this present report (Ontario Geological Survey 1986). This geophysical survey provides a valuable complement to the geological investigations since numerous electromagnetic and magnetic conductors reveal stratigraphic marker units that extend for many kilometres along strike.

Present Investigations

This report summarizes mapping by the author and his assistants in 1982 and 1984 to 1986. The investigations, initial reports and published maps are listed in the References and summarized here. In 1982, the Meen Lake area was mapped (Stott and LaRocque, 1983a, 1983b; Stott 1982). In 1984, the Muskegsagagen-Bancroft lakes area was mapped at a scale of 1: 50 000 (Stott and Wallace 1984; Stott and Wilson 1986a, 1986b). The Pickle Lake belt, was mapped in 1986 (Stott 1986; Stott and Brown 1986; Stott et al. 1989a and 1989b). Area 3 in the region of Lake St. Joseph was mapped in 1985 (Stott 1985; and Kay and Stott 1985; Stott et al. 1987a, 1987b. Geochronological investigations are reported by Corfu and Stott (1993a, 1993b). A review and interpretation of the Uchi Subprovince geology and its tectonic history is given by Stott and Corfu (1991) from which some sections of this report are reproduced.

The principal objective of this 4 year mapping program was to define on a regional scale the main stratigraphic units, in particular the individual "cycles" of volcanism and to unravel the main elements of the tectonic history of this part of the Uchi Subprovince. This program was intended to provide a regional geological framework for future detailed mapping investigations.

Physiography

Generally low relief, typically ranging through no more than 50 m, characterizes this region. The map area is located on the northern edge of a major drainage divide separating the water systems that flow into Hudson Bay, of which the Meen Lake area is a watershed, and the systems flowing into the Great Lakes. The project area therefore comprises extensive tracts of wetland, including raised bogs and fens and numerous small pond bogs but few marshes. Reedswamps are locally extensive, notably on the lower Dobie River and Obaskaka River where wild rice is harvested by local native people. The lakes and intervening wetlands are shape-controlled to some extent by the structural trends in the bedrock of the volcanic belt.

In Area 1, the bedrock is best exposed on most of the lakeshores and, apart from a well-exposed section south of the Graniteboss stock, and the large exposures of gabbro in the vicinity of Dempster Lake, most outcrops are limited to small "windows" between northeast striking zones of glacial overburden. The presence of large gabbroic and granitoid stocks in the greenstone belt, resistant to glacial erosion, probably enhanced the presence of nearby outcrops of volcanic and sedimentary rocks.

In Area 2, the glacial overburden is typically thin but forms a blanket that limits bedrock exposures to widely scattered, small outcrops in many parts of the greenstone belt. The best exposures, including areas that were mechanically stripped of overburden during gold exploration in the 1980's, are in the vicinity of the former Pickle Crow gold mines east of Pickle Lake.

In Area 3, the level of Lake St. Joseph, a reservoir for hydroelectric power generation, varies dramatically from year to year and extensive bedrock exposures along the shorelines are commonly available, especially late in the summer. Bedrock exposures diminish significantly inland from the lake since this region, like much of the central Uchi Subprovince, is blanketed by a broad Pleistocene till sheet, well illustrated on Ontario Geological Survey Map 2554 (Barnett et al, 1991).

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General Geology

Archean

The report area is underlain by bedrock of Archean age with only minor dikes of Proterozoic age, in particular, the northwest-trending Pickle Crow dike. The area encompasses a mass of greenstone belts forming a continuous chain intruded internally by plutons of various ages and bordered by large batholiths that form the external margins of the belts (Figure 2). This region forms the central part of the Archean Uchi Subprovince, one of several broad, belt-like regions in Ontario dominated by volcanic and felsic plutonic rocks. A general description of this subprovince is given by Stott and Corfu (1991).

The greenstone belts of the map areas are composed of mafic, intermediate and minor felsic metavolcanic rocks; subvolcanic intrusions of gabbro and minor anorthosite and peridotite, quartz and feldspar porphyries; clastic sedimentary rocks dominated by greywacke beds; and chemical sedimentary units of oxide, sulphide and silicate facies iron formation commonly with thin, graphitic schist units, which occur as interbeds in both volcanic and clastic sedimentary sequences. Volcanic units are dominated by tholeiitic basalt flows, typically overlain by tholeiitic to calc-alkalic dacite and rhyolite. Komatiitic units are rare and their scarcity is one of the distinctive features of the central Uchi Subprovince. As will be demonstrated in this report, volcanism occurred episodically over a time span of at least 170 million years. The episodicity of volcanism, the presence of faults and disconformities between packages of volcanic sequences bearing differences in their lithological attributes, and the evidence for stratigraphic younging directions are the principal criteria used to subdivide the greenstone belts into tectonic assemblages as shown on OGS Map 2576 (Ontario Geological Survey 1992).

The plutons in this region include metamorphosed foliated to gneissic tonalite to granodiorite but are mainly composed of typically younger, unmetamorphosed, massive to foliated granodiorite to trondhjemite. Gabbro plutons are locally associated with the late felsic intrusions within the batholiths but some syntectonic gabbro bodies lie within the greenstone belts.

The principal lithologic units are listed in Table 1. The descriptions of the geology of the central Uchi Subprovince are principally summarized in the tables, figures and photographs to follow and are presented within the framework of tectonic assemblages (Table 2) as described by Stott and Corfu (1991) and distributed in central Uchi Subprovince as shown in Figure 3. The tectonostratigraphic framework of the supracrustal rocks of the central Uchi Subprovince, based on tectonic assemblages is an interpretive framework based on integrating the geology, airborne magnetic and electromagnetic patterns, geochronology at selected sites throughout the region, and limited rock geochemistry.

The central Uchi Subprovince is dominated by subvertically dipping volcanic strata of various Archean ages forming the bulk of the greenstone belts, surrounded mainly by massive to foliated plutons of tonalite, granodiorite and monzogranite compositions. Although folding of volcanic and sedimentary strata is locally observed throughout the region, it is most notable on a megascopic scale near the southern margin of the subprovince. By contrast, in the northern half of the subprovince, the greenstone belts are more typically characterized by multi-kilometre-thick strata that face in one direction. The Meen-Dempster belt illustrates this style, with tectonic assemblages stacked subvertically one against the other. Furthermore, within the Confederation assemblage for example, there is geochronologic evidence that basalt to rhyolite cycles of volcanism are in some cases tectonically juxtaposed out of stratigraphic sequence; that is, older strata are found placed above younger strata, implying that thrust faulting was a significant deformation mechanism in the original construction of the greenstone belts. This is illustrated in the Meen-Dempster belt where 2744 Ma dacitic pyroclastic rocks on Caley Lake lie stratigraphically above a sequence containing 2740 Ma dacitic tuff on Dempster Lake. Similar arrangements where strata have been found out of stratigraphic sequence are reported in the Birch-Uchi greenstone belt, further west in this subprovince (Noble et al 1989).

Quaternary

Pleistocene and Recent Surficial Deposits

This region is blanketed by a Pleistocene till sheet that extends east-west over a distance of approximately 120 km (Figure 4 and Barnett et al 1991). The till is typically composed of a sand to silty sand matrix with pebble to cobble-size, rounded clasts of a wide range of rock types. It is transected by southwest-trending glaciofluvial ice-contact eskers of sand and gravel, spaced about 20-40 km apart, and extending from the Agutua Moraine. One of these eskers and accompanying sand aprons covers a substantial part of the Meen Lake area. The morphology of the till sheet is dominated by long northeast-trending drumlinoids standing up to approximately 20 metres above the nearby lake levels. Most of the drumlinoids support the growth of poplar, birch and some jackpine. The map area is notable for irregular patches of open spruce boglands among reasonably open black spruce forests. Long, northeast-trending dry boglands are parallel to the drumlinoids.

This large till sheet with extensive boglands, especially in the Pickle Lake belt, contributes to a generally poor bedrock exposure in this region. Bedrock exposure in the Muskegsagagen-

Bancroft lakes portion of the greenstone belt for example is generally confined to northeast-trending zones between wide (1-5 km) zones of glacially deposited till. Good to fair exposures of rock occur in the southwest (on Lake St. Joseph) and northwest (Meen Lake) corners of the report area.

Area 1

Geology of the Meen Lake - Dempster Lake Area

Archean Rocks

Tectonostratigraphic Assemblages

The Meen-Dempster greenstone belt is dominantly composed of multiple sequences of metamorphosed volcanic rocks (Figure 5) that can be grouped into separate tectonic assemblages characterized by significantly different ages (Figure 6). The older of two assemblages in this belt, as portrayed on the map of Tectonic Assemblages of Ontario (OGS 1992), is the **Woman assemblage**. Two U-Pb zircon age determinations of felsic to intermediate volcanic rocks in this assemblage show that it ranges in age between at least 2842 +5/-2 and 2825 ± 2 Ma (Corfu and Stott 1993b). This is a significant spread of ages and future studies might demonstrate that the Woman assemblage could be subdivided into two assemblages. The hypothetical boundary between the two might be placed approximately as shown on Figure 6 where there is evidence from the pattern of electromagnetic conductors for an oblique discontinuity between the circa 2842 Ma basalt-dacite volcanic cycle and the overlying 2825 Ma cycle. However, these two cycles shall be treated here as parts of a single assemblage for purposes of description. The top of this assemblage is defined here as the top of the intermediate to felsic volcanic sequence extending from Meen Lake to Jacknife Lake; the nature of the boundary (fault or disconformity?) between this assemblage and the overlying Confederation assemblage is not established but there is a substantial age difference of about 80 million years between the intermediate to felsic volcanics of the two assemblages.

The **Confederation assemblage** is younger, with U-Pb zircon ages of dacitic pyroclastic rocks from two sequences of approximately 2740 to 2744 Ma (Corfu and Stott 1993a). These ages correspond closely with the ages of similar volcanic sequences in the Birch-Uchi belt, west of the report area (Noble et al 1989).

Unconformably overlying these two volcanic assemblages is the **Billett assemblage**, composed of clastic sedimentary rocks dominated by wacke beds with minor, intervening beds of banded magnetite iron formation.

The following sections describe the general stratigraphic characteristics of each tectonic assemblage. The field descriptions cover the characteristics of the various rock units. For ease of coverage, the Meen-Dempster belt has been roughly subdivided into 5 general areas: Meen Lake, Muskegsagagen Lake, Kaminiskag Lake, Dempster Lake and Whitmore Lake.

Woman Assemblage
Field Relationships

The lower half to three-quarters of the Woman assemblage is composed principally of massive to pillowed volcanic flows of tholeiitic basalt accompanied by gabbroic intrusions locally, especially close to the Dobie Lake Pluton and by some interlayers of banded, magnetite iron formation. The iron formation is locally interbedded with graphitic pelite and forms an electromagnetic conductor that can be traced discontinuously along strike. Included within this lower section are thin beds of felsic tuff to lapilli tuff located 2 km north of Muskegsagagen Lake and just west of the Dobie River; geophysical evidence indicates the latter unit straddles the Dobie River. Significant gold mineralization (investigated principally by St. Joe Gold Corp. and later Bond Gold Canada Inc.) is spatially associated with these two units, and this includes the Golden Patricia Mine. The lower, mafic-dominated section of the Woman assemblage is overlain by a sequence of intermediate to felsic volcanic rocks, up to 1.4 km thick, that can be traced along strike for over 36 km from Meen Lake to Jacknife Lake. The stratigraphic continuity of this assemblage along strike is evident, not only from the mappable sequence of intermediate to felsic volcanics but also from the continuity of electromagnetic conductors, particularly associated with banded iron formation - graphitic pelite interbeds, within the mafic volcanics and near the top of the major intermediate to felsic volcanic sequence. However, locally significant right-lateral offset on northwest trending, vertical faults is evident locally from maps of an airborne electromagnetic and total intensity magnetic survey (Ontario Geological Survey 1986; e.g. maps 80898 and 80899).

The base of the Woman assemblage is intruded by the Dobie Lake Pluton, and the decrease in thickness of the mafic volcanic base of this assemblage towards the northwest probably reflects an oblique transection of the stratigraphy by this pluton. Thin amphibolite slivers or finger extensions of the assemblage lie within the pluton and locally form a discontinuous screen parallel to the belt margin, which separates a thinner sheet of plagioclase-phyric granodiorite, adjacent to the greenstone belt, from the main mass of the pluton. The northwest end of the greenstone belt terminates at the margins of late to posttectonic plutons, which separate the belt from its apparent continuation on strike in the Birch-Uchi belt to the west.

The nature of the upper contact of the Woman assemblage with the Confederation assemblage to the south is problematic. It is a seemingly conformable contact yet the basal mafic volcanic suite of the Confederation assemblage is marked by a fairly continuous electromagnetically conductive horizon that trends at an oblique angle to the contact with the Woman assemblage and could indicate that the Confederation assemblage, which thins southeastwards, was faulted at its base. The Woman/Confederation contact could therefore mark a tectonic juxtaposition of the two assemblages.

Field Descriptions

Mafic Metavolcanic Rocks

The Woman assemblage is dominantly composed of massive to locally pillowed tholeiitic basalt with bedding and foliation dipping steeply. The pillows are sufficiently deformed or otherwise possess indiscriminate shapes that stratigraphic top determinations are rarely determinable with confidence. In those few cases, the basalt strata consistently face southwards except in the vicinity of Kaminiskag Lake where some regional-scale folding has occurred. Compositional variations are reflected in the rock colour, ranging on the weathered surface from dark grey to light greenish-grey. The rock is typically composed of fine-grained actinolite, chlorite and plagioclase but north of Muskegsagagen, there are local coarse-grained flows. Close to the Dobie Lake Pluton, the basalt is strongly foliated, fine grained and slightly differentiated into colour bands, comprising alternating concentrations of plagioclase and hornblende. The basalt flows generally possess little evidence of significant, primary hydrothermal alteration. However, a bleached zone of calcium carbonate altered, massive basalt lies along the south part of Muskegsagagen Lake, just north of the main felsic pyroclastic unit. This bleached basalt is very fine grained, and on the Obaskaka River, it is locally strongly sheared with iron carbonate-rich bands infilling cleavages. These bands, 4-15 mm wide, comprise approximately 20% of the rock locally. A similar zone of bleached/banded rock occurs on the north shore of Kaminiskag Lake.

In the region just north of Kaminiskag Lake, the strata of basalt flows and iron formation outlines a large Z fold. The basalt is moderately to strongly deformed and notably possesses evidence of hydrothermal alteration in this area; the alteration manifests as extensive bleaching, with epidote-carbonate alteration along the north shore of Kaminiskag Lake, as fracture-filling epidote veins and as chloritized zones. A thinly laminated mafic tuff occurs on the north shore of Kaminiskag Lake and resembles some very distinctively banded tuff units on a chain of lakes, south of Meen Lake, in what was formerly called the Dorothy Lake group (Stott 1982; Stott and LaRocque 1983a, 1983b) is presently interpreted as part of the Confederation assemblage. Close to the northern contact of the belt at Wright Lake, the pillowed basalt flows are strongly to intensely deformed with typically 5:1 length-width ratios of pillow shapes. Part of the southeast striking Bear Head fault zone passes along the southern shore of Wright Lake, locally shearing these basaltic units.

South of Kaminiskag Lake, the basalt flows are only weakly deformed. Pillows are well preserved, bun shaped and ranging in size from about 7x15 cm to 25x34 cm. Fine, primary fractures radiate from pillow centres and are best preserved in the outer margins. Pillows also display extensive fracturing and internal brecciation. They are close-packed with only minor chloritic inter-pillow material. Selvages are typically about 8mm thick. Top determinations in this area are based on two outcrops: one displays a contact between a pillowed mafic flow with interstitial rusty weathered material, grading rapidly to an extensively rusty-weathered flow top breccia, and an overlying massive basalt flow unit; the other outcrop of massive basalt possesses an interbedded unit of magnetite iron formation and wacke with graded bedding. Both outcrops indicate the tops are facing northeast. Regional-scale folding evident further north and the presence of a large gabbroic intrusion nearby make it difficult to infer a regional significance to these top determinations. They may imply more extensive folding or block rotation of strata in the Woman assemblage than is apparent from the regional geophysical evidence.

For much of the length of the Woman assemblage, the contact with the Confederation assemblage is marked by the intermediate pyroclastic unit forming the uppermost formation of the Woman assemblage. However, east of Graniteboss Lake, this pyroclastic unit is not present and the precise position of the Woman/Confederation contact within the thick basaltic sequence is not clear. A very approximate contact is proposed on OGS Map 2507, separating an iron carbonate-amygdular, pillowed basaltic sequence, resembling the base of the Confederation assemblage south of Jacknife Lake, from more massive, very fine-grained basaltic flows further north that are interpreted to be part of the Woman assemblage. Much of the Woman assemblage basalt in this vicinity lies close to the northern margin of the belt and is metamorphosed to amphibolite grade. The rocks become increasingly flattened northward towards the belt margin on Kawinogans River where the rocks are very fissile. The belt margin there is marked by a shear zone that straddles the external granite-greenstone belt contact.

Evidence from the basaltic stratigraphy and geophysical maps (OGS 1986) suggests a low-relief subaqueous paleotopography during basaltic volcanism, consistent with an oceanic mafic plain, which possessed thin inter-flow units of only banded iron formation, associated graphitic black schist, minor siltstone and felsic tuff.

Intermediate to Felsic Metavolcanic Rocks

The intermediate to felsic metavolcanic rocks are dominantly monolithic to locally heterolithic pyroclastic deposits forming thin, discontinuous units interbedded amongst the basaltic flows and forming a thicker continuous sequence comprising the upper part of the Woman assemblage from Meen Lake to Jacknife Lake.

Thin units of intermediate to felsic tuff and lapilli tuff occur as small outcrops within the dominant basaltic base of the Woman assemblage. These units generally cannot be traced along strike very far although associated iron formation revealed by aeromagnetic and electromagnetic conductors, can be traced in the vicinity of Dobie River for over 6 km. There is geophysical evidence of block faulting and rotation of strata in the region of the Golden Patricia Mine; consequently, detailed mapping and ground geophysical surveys are required to establish the relationship of these discontinuous, thin tuffaceous units within the basaltic sequence, notably from west of Dobie River to the area north of Muskegsagagen Lake. One of these felsic tuff units, adjacent to the auriferous quartz vein at the Golden Patricia Mine, is dated from U-Pb zircons at 2842 +5/-2 Ma (Corfu and Stott 1993b). Since the age of the intermediate pyroclastic deposit at the top of the Woman assemblage has been dated on Meen Lake at 2825 ± 1.5 Ma (Corfu and Stott 1993b), there appears to be a significant time break between the deposition of these two pyroclastic units.

The felsic tuff at the Golden Patricia Mine is strongly sheared, very fine grained with micro-quartz eyes. It is the locus for a narrow shear zone that closely follows the strata for several kilometres. Another tuffaceous unit of uncertain relation is observed northeast of Muskegsagagen Lake and, based on one outcrop observation, it is composed of lapilli tuff with clasts ranging up to 3x15 cm in cross section in a fine grained matrix containing medium grained quartz and plagioclase crystals.

The dominant sequence of intermediate to felsic pyroclastic rocks extends from Meen Lake to Jacknife Lake. It forms at or close to the upper contact of the Woman assemblage with the overlying Confederation assemblage. This calc-alkalic sequence (*see* Regional Geochemistry) appears to possess two volcanic centres based on the presence of proximal facies volcanic deposits on Meen Lake and less spectacularly south of Muskegsagagen Lake. These two areas also form the thickest sections of the pyroclastic sequence; they grade along strike into finer grained, tuffaceous units interpreted as distal facies and accompanied by iron formation and graphitic schist, which are best observed southeast of Meen Lake and in the vicinity of Jacknife Lake. The presence of graphitic schist was documented in drill core by geologists of Cominco Ltd. (OGS Assessment Files) and observed by the author on Jacknife Lake. The proximal pyroclastic facies located on Meen Lake is accompanied by local basaltic dikes and a small exposure of a quartz porphyry intrusion at the base of the pyroclastic sequence on the north shore of the eastern arm of Meen Lake. This proximal sequence is dominantly composed of dacitic tuff breccia and pyroclastic breccia with accompanying beds of tuff and lapilli tuff. The outcrops of pyroclastic beds with coarser fragments are restricted to a zone of 3 km strike length at the west end of the greenstone belt. These proximal beds grade into finer deposits of tuff, lapilli tuff and local lapillistone eastwards towards Dobie River. It has been interpreted by Stott and Corfu (1992) that distal deposits of this pyroclastic sequence are also preserved further west of the belt, beyond Zionz Lake in the northern part of the Birch-Uchi greenstone belt.

Minor units of rhyolitic tuff to lapilli tuff occur within this pyroclastic sequence. They are represented by individual, isolated outcrops or as a series of outcrops up to 1 km along strike. One very fine-grained felsic flow occurs approximately 2.5 km southeast of Meen Lake, on the south shore of a small lake along the southern margin of the main pyroclastic sequence (OGS Map P.2619, Stott and LaRocque 1983a). Immediately south of this felsic unit on the shore of the small lake, there are small exposures of marble, comprising laminated granular quartz and calcite, locally accompanied by minor siltstone and mafic tuff breccia. Intermediate to felsic tuffaceous beds occur within massive basalt flow and these units imply a gradational relation with the mafic volcanic units to the south. This limited evidence suggests that the upper contact of the Woman assemblage lies, at least locally, within the southern basaltic sequence.

The main pyroclastic sequence of the Woman assemblage continues south of Muskegsagagen Lake and is geophysically traced by an electromagnetically conductive unit of pyritic graphitic schist, which lies within this sequence and close to its upper stratigraphic (south) contact. The outcrops south of Muskegsagagen Lake range from dacitic, heterolithic tuff breccia to monolithic tuff and minor rhyolitic tuff to lapilli tuff. This sequence continues to Jacknife Lake where outcrops show both dacitic and rhyolitic tuff to lapilli tuff are overlain by shallowly dipping interbeds of chert, ferruginous chert to magnetite to siderite iron formation, quartz arenite, feldspathic arenite, mudstone, and minor quartz-calcite arenite. Although clastic metasedimentary beds are uncommon within this pyroclastic sequence, they are observed in outcrops and drill core intersections at or near the upper stratigraphic contact of the sequence. The best exposed metasedimentary units are found along the north shore of Jacknife Lake.

Clastic and Chemical Metasedimentary Rocks

There are two principal settings in which clastic and chemical metasedimentary rocks are deposited in the Woman assemblage: 1) they mark a hiatus in mafic plain volcanism within the lower sequence of suabaqueous mafic volcanism and 2) they form at or close to the termination of felsic to intermediate volcanism at the top of the Woman assemblage. Clastic metasedimentary rocks are restricted to thin interbeds associated with iron formation and near the upper contact of the main intermediate to felsic sequence described above, usually again in association with chemical metasedimentary beds. The clastic interbeds are typically fine-grained siltstone and mudstone; graphitic pelitic horizons have been observed on the north shore of Jacknife Lake and on a small lake north of the easternmost end of Meen Lake, and reported in drill core (Assessment Files Research Office, OGS, Sudbury) from the intermediate volcanic sequence of the Woman assemblage, east of Meen Lake.

The chemical metasedimentary rocks are dominantly thin units of banded magnetite-chert iron formation. On Jacknife Lake, chert and ferruginous chert beds mark the top of the assemblage and are locally accompanied by siderite iron formation and fine-grained silici-clastic marble. Scarce evidence of carbonate-quartz laminated beds occurs at the top of the felsic volcanics southeast of Meen Lake as noted in the previous section.

Confederation Assemblage

Field Relationships

The Confederation assemblage extends along the centre of the Meen-Dempster greenstone belt from Meen Lake to Kasagiminnis Lake in the southern Pickle Lake belt. It contains two bimodal volcanic cycles of mafic to felsic volcanics labelled the Dempster cycle (Cycle 1) and the overlying Bancroft cycle (Cycle 2) (Figure 5); each is composed of massive to pillowed tholeiitic basalt flows overlain by dacitic pyroclastic rocks with some fine-grained felsic pyroclastic deposits at the top of the Dempster cycle. A basaltic sequence, exposed south of Caley Lake, overlies the Bancroft cycle. These volcanic cycles are intruded east of Dempster Lake by gabbroic to locally anorthositic intrusions, by the Kawashe Gabbro centred on Kawashe Lake, and by gabbro sills southeast of Meen Lake.

Like the Woman assemblage, the Confederation assemblage dips subvertically to steeply northward and since stratigraphic units of the assemblage face generally southward, the assemblage is therefore slightly overturned. The presence of north-facing pillowed units on the shoreline of southern Meen Lake indicates that some folding or juxtaposition of basaltic strata by faulting occurred to produce a back-to back facing within the Confederation assemblage. It overlies the Woman assemblage of the northern half of the belt and is unconformably overlain in turn by the metasedimentary Billett assemblage. The U/Pb zircon age of fine-grained dacitic tuff on Dempster Lake is 2740 ±1 Ma. This unit underlies the Bancroft cycle, the uppermost dacitic pyroclastic unit of which has been dated at 2744 +3/-2 Ma. This sequence of slightly older volcanic units overlying younger implies either a tectonic stacking of different strata out of sequence or a duplication of one original cycle by thrust-stacking to form the Dempster and Bancroft cycles.

Volumetrically significant zones of hydrothermal alteration were not observed in mafic volcanic rocks of the Meen-Dempster belt. Outside of the shear zones, carbonate alteration is locally concentrated on Meen Lake and in the vicinity of Muskegsagagen Lake.

Field Descriptions

Mafic Metavolcanic Rocks

Dempster Cycle (Cycle 1)

Well exposed sections of the mafic volcanic strata southeast of Meen Lake, south of Jacknife Lake and north of Dempster Lake, illustrate that the Confederation assemblage is dominated by massive to pillowed, tholeiitic basaltic flows. Southeast of Meen Lake, massive flows grade upward into pillowed facies which are overlain by flow top breccia containing pillow fragments and a matrix of locally recognizable hyaloclastite. Stratigraphic younging determinations in this area were based on this progressive sequence of massive flow to pillows to pillow breccia in each flow unit. Only one small outcrop of fine- grained ultramafic volcanic rock was observed, located on an island in the south part of Meen Lake. The paucity of ultramafic volcanic rock is characteristic of most of the central Uchi Subprovince, and in particular, the Confederation assemblage. Most of the mafic flow sequence is only moderately to weakly deformed.

West of Muskegsagagen Lake, on the Obaskaka River, the basaltic flows are very fine-grained, strongly deformed, and composed of plagioclase and amphibole. The basalt is iron carbonate-rich. The fabric and amphibolitic nature of the rocks may be related to the thermal and strain aureole imposed by the nearby Obaskaka Pluton. South of Muskegsagagen Lake, the massive mafic volcanic rocks are dark green grey on the fresh and weathered surfaces and composed of plagioclase, amphibole and minor carbonate. The pillowed volcanic rocks are light green grey weathered and medium-dark green grey on the fresh surface and composed of very fine to fine-grained amphibole and plagioclase. Pillows are elliptical on the outcrop surface and range in size from typically 40x8 cm to 100x60 cm. Selvages are dark grey, 0.5 - 1 cm wide and more schistose. A pod of quartz + tourmaline, 25x15 cm in size, occurs interstitial to the pillows at one outcrop 1200m south of Muskegsagagen Lake. Fine grained black tourmaline needles comprise 40% of the pod. The presence of tourmaline has also been observed locally in a major shear zone, south of Mousetrap Lake.

South of Jacknife Lake, the basaltic stratigraphic section is composed of weakly to moderately deformed pillowed flows, which become more intensely deformed further southwest in a major shear zone (see OGS Map 2507). The pillows are rimmed with calcium carbonate amygdules, etched as pits on the weathered surfaces. These etch pits accent the pillow outlines and also characterize weathered amygdules in the 3.5 km thick section of pillowed basalt north of Dempster Lake. The marked similarity between the pillowed sections south of Jacknife Lake and north of Dempster Lake implies a stratigraphic correlation of this basaltic sequence extending over 11 km of strike length and underlying the intermediate to felsic volcanic unit that forms the uppermost part of a bimodal volcanic sequence, the Dempster cycle.

A stratigraphic section, greater than 1 km thick, of pillowed basalt flows is characterized by carbonate amygdules that form a zone around the inside of pillow rims. The amygdules are more typically iron carbonate-rich in the upper half of the pillowed section and calcite-rich in the lower half. The pillows are well preserved, though moderately deformed and demonstrate a southward younging of the sequence. Further north, the pillows are underlain by more highly deformed mafic flows, interpreted to be part of the Woman assemblage. The pillowed sequence shows a typically very fine-grained texture, with a medium green grey weathered surface and medium grey fresh surface. Pillows vary in size from 1.5 m x 35 cm in some outcrops to section of smaller pillows 45 x 15 cm. The pillows are typically elliptical on surface, but two outcrops provide good consistent cusp orientations among pillows to indicate southward younging. Selvages are 0.5 to 1 cm wide. The grade of metamorphism changes north of Dempster Lake from greenschist with chlorite selvages in the pillowed Confederation assemblage to amphibolite grade within 1 km of the northern boundary of the greenstone belt.

Bancroft Cycle (Cycle 2)

Minor outcrops on Duffell, Jarrow and Bancroft lakes show massive to pillowed mafic flows with insufficient information obtained in this survey to provide a general characterization of this sequence of basalt. Only limited carbonate is associated with these dominantly massive flows. They do not appear to possess the well-preserved primary textural features of the basalts of the Dempster cycle and furthermore they possess evidence of a stronger, penetrative flattening strain with local shear zones. There is an apparent third cycle of mafic volcanism interpreted to stratigraphically overlie the upper intermediate to felsic volcanic unit of the Bancroft cycle, based on limited outcrops on Jarrow Lake for example.

Intermediate to Felsic Metavolcanic Rocks

Dempster Cycle (Cycle 1)

Intermediate to felsic volcanic rocks are dominantly concentrated in two sequences forming the upper units of the Dempster and Bancroft cycles. These sequences form steeply north-dipping lenses up to 1 to 2 km wide, with their thickest parts from Dempster to Whitmore lakes (Dempster cycle) and on Caley Lake (Bancroft cycle).

The upper sequence of the Dempster cycle is dominantly composed of massive felsic volcanics from south of Jacknife Lake to Dempster Lake and thick intermediate tuff beds east of Dempster Lake. The sequence bears some features of a resedimented tuff and clastic sediment on Whitmore Lake, including the local presence of alumina-rich beds containing garnet and staurolite. This stratigraphic unit may correlate with an intermediate volcanic unit, dominated by tuff to tuff breccia further east in the Kasagiminnis Lake area (Stott et al 1989a). Further west, the sequence may correlate, on the basis of a discontinuous electromagnetically conductive horizon, with a very thin dacitic tuff horizon 2 km northeast of Dorothy Lake along strike with a set of small elongate lakes that lie northwest of Dobie River.

Bancroft Cycle (Cycle 2)

The upper volcanic unit of the Bancroft cycle is mainly composed of dacitic tuff with some local beds of mafic tuff, on southern Caley Lake for example. A unit of magnetite iron formation extends from east of Bancroft Lake to south and west of Sky and Caley lakes. Its strike is oblique to the northern and southern contacts between the dacitic tuff unit and basalt. This obliquity (OGS 1986, Maps 80914, 80915, 80921), implies that the northern and southern dacite/basalt contacts of the upper Bancroft cycle are probably tectonic and not conformable, stratigraphic contacts. Consistent with this interpretation is the presence of a 2744±2 Ma age of dacitic tuff breccia on Caley Lake which apparently overlies the 2740±1 Ma felsic tuff on Dempster Lake (Corfu and Stott 1993a) and implies that the slightly older Bancroft cycle is out-of-stratigraphic-sequence and tectonically overlies the Dempster cycle. However, younging directions within the Bancroft cycle are not recorded (apart from southward facing pillow top directions west of Bancroft Lake reported by a prospector, R. Seyler; personal communication, 1984) and therefore an interpretation of consistent southward facing remains open to question.

Two small quartz and quartz-feldspar porphyry intrusions are located within the upper dacitic sequence of the Bancroft cycle. One occurs on Sky Lake and the other, better exposed, lies just east of Kasagiminnis Lake. Both show metamorphic and deformation fabrics comparable to the surrounding volcanic rocks, which indicate the stocks are probably synvolcanic. However, coarser pyroclastic units are not spatially associated with them.

Clastic and Chemical Metasedimentary Rocks

Units of magnetite iron formation can be traced mainly from aeromagnetic and electromagnetic maps (OGS 1986), which were published subsequent to the production of the geological maps (Stott and Wilson 1986a,b). Consequently, some changes to the general stratigraphy and the traces of iron formation units are shown in Figure 5, which reflect the new interpretation of the above geophysical maps. Some local metachert units and epidote or amphibole-bearing silicate facies iron formation are observed on Whitmore Lake, interbedded with dacitic tuff and minor clastic metasedimentary beds.

Billett Assemblage
Field Relationships

The clastic metasedimentary Billett assemblage partially wraps around the Obaskaka Pluton, and extends eastwards along the southern flank of the Meen-Dempster greenstone belt. Remnants of this assemblage also occur within the Osnaburgh Pluton along the southern margin of the belt. The disposition of this assemblage in map plan, with its contacts trending obliquely to the strike of adjacent Confederation and Woman assemblages, implies that the Billett assemblage unconformably ovelies the volcanic assemblages and represents a synorogenic basin-fill.

Field Descriptions
Clastic Metasedimentary Rocks

The assemblage is characterized principally by monotonous beds of brownish grey feldspathic wacke coupled with thinner shale. The wacke-shale couplets vary in thickness but are generally less than 40 cm. Mafic minerals (biotite and chlorite) comprise about 15% of the wacke, which is otherwise composed of fine sand-size quartz and feldspar grains with scattered medium-size grains. Some quartz grains are up to 2 mm in diameter. The sediment appears to be mainly derived from an intermediate to felsic source.

In contrast to the predominant wacke in this assemblage, the vicinity of Billett Lake is characterized principally by polymictic conglomerate with mainly trondhjemitic cobbles and pebbles. However, the north margin of the Billett Lake basin is composed of very thinly bedded and thickly laminated wacke derived from a felsic source. The rock is composed of very fine sand size grains with some local graded bedding younging to the northeast. The younging direction is oppositely facing the southwest-facing Confederation volcanics and the contact, which is also a major late-tectonic shear zone, could mark an unconformity with the adjacent Confederation assemblage volcanic rocks. Some minor small pebbles occur in the wacke. These clasts are flattened, disk shaped and vary in size from 4 x 15 mm up to 5 x 8 cm in cross section. They are composed of quartz porphyritic felsic volcanics. Smaller clasts of light grey chert, approximately 1 cm x 4 mm, are also observed.

This sedimentary suite is very narrow and rapidly yields westward to a thick conglomerate section centred on Billett Lake. This is a dominantly matrix supported, polymictic conglomerate with 30% clasts of quartz porphyritic felsic volcanics, trondhjemite with lesser and smaller clasts of mafic volcanics, light grey chert and rare dark grey, weakly magnetic chert of the type seen on the north shore of Jacknife Lake. Sandstone interbeds, locally graded, are immature, poorly sorted with subangular to subrounded grains of material derived dominantly from felsic igneous sources. In the conglomerate beds, the felsic volcanic clasts are dominant, followed by trondhjemitic clasts and these rock types comprise the larger clasts. Clast sizes of the principal representative rock types are as follows:

mafic volcanic:	35x8 mm; range - 6x2mm up to 8x1cm
felsic volcanic:	4x2.5cm; range - 5x2mm up to 7x3.5 cm
trondhjemite:	2.5x2cm up to 14x3.5cm

Clasts are generally ellipsoidal, with trondhjemite more typically subspherical, and vary from subangular to subrounded. The matrix is fine to medium sand with some coarse to very coarse bluish quartz grains. Granule size felsic volcanic, mafic volcanic and chert occur scattered in the matrix. These small clasts tend to be subangular. In some outcrops on Billett Lake, wacke beds up to 20 cm occur. Bedding is otherwise characterized by marked differences in clast sizes; some beds contain only small pebbles whereas others are characterized by the presence of cobbles among various sized pebbles. Bedding varies from 45 cm to greater than 75 cm in thickness.

Interpreted Environment of Deposition

All of the clasts appear to be derived from proximal sources to the north. The quartz porphyry felsic volcanic clasts are similar to volcanic rocks observed south of Muskegsagagen Lake. The cobbles of trondhjemite resemble the lithologic character of much of the Dobie Lake Pluton to the north of the Meen-Dempster belt. In addition, an age determination of 2748 +5/-4 Ma from one of the trondhjemite clasts on Billett Lake compares closely with the age of the Dobie Lake Pluton of 2750±3 Ma (Corfu and Stott 1993b). The conglomerates southwest of Kawashe Lake appears to reflect a late tectonic exhumation, subaerially exposing mainly the northern volcanic assemblages and the Dobie Lake Pluton. The Billett assemblage could represent a tectonically telescoped basin-fill of conglomerates with sandstone interbeds possibly formed in the upper channelway of a submarine fan, with more distal turbidite wacke further south.

Intrusive Rocks

Mafic Intrusive Rocks

Gabbro Sills

In the Meen Lake - Dorothy Lake region, three significant sill-like gabbro intrusions are observed. Two of these, north and east of Meen Lake, are irregular in form but generally intrude subparallel to the planar fabric of the host rocks. The third intrusion is a much narrower sill (<200m wide) that forms the prominent southern margin of a straight line of small lakes, 3 km south of Meen Lake. None of these gabbroic sills shows significant differentiation. They are composed principally of medium to fine grained hornblende and plagioclase. The intrusion east of Meen Lake is characterized by a major linear aeromagnetic anomaly, which is outlined on OGS Maps P.2619 and P.2620 (Stott and LaRocque, 1983a,b). This anomaly extends south of Meen Lake beyond the observed outcrops and implies a probable westward extension of the gabbro sill. This intrusion is centred on the upper, intermediate to felsic volcanic sequence of the Woman assemblage and contains numerous inclusions of these host rocks. Locally, fissile gabbro marks zones of shearing that continue into the adjacent volcanic rocks where, for example, fissile basalt was observed but mapped as isolated outcrops of "mafic tuff" amongst the basalt flows on OGS Maps P. 2619 and P. 2620.

Kawashe Gabbro

South of Kaminiskag Lake, the Kawashe Gabbro is a subcircular intrusion with a homogeneous, fine to medium-grained fabric of hornblende and plagioclase that is only subtly different from the surrounding, finer grained basalt. The stubby to tabular hornblende grains average 1mm across in a typically finer white weathered plagioclase matrix. The texture is generally massive to moderately mineral aligned. Although the pluton's fabric ranges from equigranular to ophitic with large hornblende crystals or aggregates in a finer grained matrix, it is typically equigranular, moderately to weakly foliated, with a strong schistosity developed only in narrow shear zones, particularly around the outer margins of the body. A single ultramafic outcrop was observed on the southeastern margin of the intrusion near a stream draining from Jacknife Lake. This phase is a massive metamorphosed pyroxenite with pyroxene altered to stubby hornblende crystals 1 mm in diameter. No penetrative tectonic fabric is evident.

In general, the Kawashe Gabbro appears to have resisted significant regional tectonic strain and acted like a large, weakly to only moderately strained "tectonic pebble" in contrast to the slightly more schistose, enveloping basalts. The gabbro body is laced with vertical dikes of fine-grained felsite that are probably derived from the trondhjemitic Kawashe Lake stock, which invaded the core of the Kawashe Gabbro at 2722 +6/-4 Ma (Corfu and Stott 1993b). Yet the gabbro crosscuts the boundary between the upper Woman assemblage and the 2740 Ma Confederation assemblage to the south. It therefore postdates the time of juxtaposition of these two volcanic assemblages, effectively stitching them and providing a potential minimum age marker of assemblage accretion. The age of the Kawashe Gabbro is yet to be determined although the above relationships show that it intruded between 2740 and 2722 Ma. This body has been the subject of a paleomagnetic investigation by Hale and Lloyd (1989, 1990).

Kawinogans Gabbro

The Kawinogans Gabbro is semiconcordant with the volcanic strata and is well exposed on Kawinogans Lake, north of the Knupp Lake Stock. This gabbro intrusion has a range of grain sizes but is generally medium grained, and dark green to black on the fresh and weathered surfaces. It shows a prominent knobby weathering surface arising from differential weathering of the amphibole and plagioclase, which produces a moderately well developed "salt and pepper" texture. The medium grained hornblende laths vary in size, but are commonly 3-5 mm long and accentuate the planar tectonic fabric in a matrix of finer grained white weathered plagioclase. On some surfaces very narrow bands of alternating mafic and felsic minerals are evident.

The gabbro body is crossed by numerous northeast-trending shear zones that are related to the regional (D_1) deformation, characterized by southwest-plunging stretching and mineral lineations (*see* Structural Geology). These shear zones strike parallel to the regional foliation, which strikes slightly clockwise to the major axis of the pluton. These shear zones grade internally from zones of chloritic schist to local lithons of less intensely deformed rock. The most prominent shear zone occupies a long, southwest trending narrow channel off the eastern arm of Kawinogans Lake. These shear zones are carbonatized and contain numerous quartz-calcite pods and veins that trend parallel to the foliation. They also locally contain pyritic gossan zones. Some of these zones, located on the shoreline, west of Knupp Lake, have been the subject of exploration drilling.

The aeromagnetic and electromagnetic patterns in this body (OGS Map 80913) are unusual; although the aeromagnetic pattern shows a varied range of intensities, part of the body shows an anomalously low magnetic intensity with a clear outline and implies the presence within the gabbro body of a small felsic pluton that lies just north of the Knupp Lake Stock. The numerous, strong electromagnetic conductors resemble the patterns of stratigraphic marker horizons elsewhere but are observed in some cases to coincide with intense shear zones within the gabbro. Nevertheless, thin volcanic zones are observed within this intrusion and the intrusion could alternatively consist of a series of thick sills separated by much thinner volcanic slivers. Observations made during 1984 were mainly limited to the shorelines and could not discriminate between these alternatives; drill core from this area would provide additional insight. The intrusion is evidently host to an anomalous occurrence of chalcopyrite, sphalerite, pyrrhotite, and graphite drilled by UMEX Inc. just east of Kawinogans Lake (OGS Map 2507 and Assessment Files).

Dempster Lake Gabbro

The Dempster Gabbro is an irregularly shaped body that is regionally metamorphosed and deformed; its long axis is parallel to the regional stratigraphic layering. The intrusion is typically composed of medium-grained, dark green-black gabbro. A narrow phase of anorthosite, grading sharply through leucogabbro, occurs on the northwest margin of the body. The anorthosite is exposed on a small peninsula and some islands on the east side of Dempster Lake. This phase is massive, white weathered and homogeneous. It is medium-grained and composed of inequigranular (1-5 mm) saussuritized plagioclase. Along the southern margin of the intrusion, south of the powerline, quartz-bearing light coloured diorite is locally observed. This white-grey weathered rock contains 20% biotite and chlorite and the presence of quartz and the low mafic mineral content of the rock may be related to the assimilation of sedimentary country rock.

Deformation in the intrusion is variable; a weak fracture cleavage is typical in the northern half and reflects the weakly penetrative response by this more massive pluton to the regional deformation. Local more intense zones of schistosity are prevalent in the southern half of the intrusion and especially in the vicinity of a major northwest-striking shear zone, south of Mousetrap Lake where a narrow tail of the gabbro separates the Billett assemblage from felsic volcanics of the Confederation assemblage. There, the gabbro is variably reduced across the shear zone to a chloritic schist with fine-grained plagioclase porphyroclasts. The intensity of deformation varies across the shear zone so that mylonitic zones may be juxtaposed with zones of less intensely deformed gabbro that contain narrow shear bands. Even in the most intensely deformed parts of the gabbro, there is a recognizable fabric division into narrow lithons of mylonite enveloped by very fine-grained schistose ultramylonite.

The Dempster Gabbro intruded the Confederation volcanics and contains inclusions of basalt and partly assimilated banded magnetite iron formation near its southern margin. This southern part of the intrusion is characterized by high magnetic susceptibility and is particularly magnetite-rich near iron formation inclusions.

As noted above, this gabbro body also intruded the Billet assemblage and locally contains sedimentary xenoliths. Since the Billett assemblage unconformably overlies the volcanic sequences of the Confederation assemblage, the Dempster Gabbro is clearly a late intrusion, but predates the regional D_1 deformation (*see* Structural Geology). This undated gabbro therefore provides a potentially valuable time marker in the magmatic-tectonic history of this greenstone belt.

Felsic Intrusive Rocks - Stocks within the belt

Kawashe Lake Stock

The Kawashe Lake Stock is a small, elliptical body that intruded the Kawashe Gabbro at 2722 +6/-4 Ma (Corfu and Stott 1993b). It is an early to pre-orogenic body composed of medium to fine-grained biotite trondhjemite to granodiorite. The rock is generally massive and homogeneous with a weak cleavage that strikes obliquely clockwise to the long axis of this elliptical intrusion and is parallel to the regional schistosity in the greenstone belt. This parallel fabric implies that the stock intruded during or before the main period of regional flattening. Spatially associated with this body is a set of quartz porphyry and fine-grained trondhjemitic sills that intrude the surrounding Kawashe Gabbro. Some of the porphyry dikes contain minor pyrite and tourmaline.

Graniteboss Stock

The Graniteboss Stock is a late to posttectonic body that contains a primary igneous fabric; the stock deflects the surrounding greenstone belt strata to the north but its contact is markedly discordant with volcanic-sedimentary strata to the west near Jacknife Lake. The rock is composed of homogeneous K-feldspar megacrystic granodiorite to tonalite. It is massive, medium-grained (1-3 mm) with K-feldspar megacrysts, 4-8 mm and up to 1 cm across, and comprising 5% of the rock. Biotite exceeds hornblende as fine-grained mafic minerals in the rock. In places the K-feldspar megacrysts are moderately aligned. Locally coarser pink granite dikes and fracture fillings occur. Some fine-grained, dark green mafic clots and lenses up to 10 cm long are variously assimilated by the granodiorite host. Apart from these scattered mafic blemishes, the intrusion is notably homogeneous with widely spaced joints.

The pluton is massive with a steeply dipping, weak planar alignment of minerals that is slightly more pronounced near the pluton margins. A steeply plunging mineral lineation, notably accentuated by the hornblende, can be observed throughout the body, reflecting the late stage extensional strain induced during subvertical magmatic emplacement.

Knupp Lake Stock

A late tectonic felsic intrusion is centred on Knupp Lake. The lake covers a flat pluton peneplain wherein very large white weathered blocks of granodiorite were glacially plucked and now stand up prominently in the lake. Most of the exposed rock in the pluton comprises large angular blocks. Outcrops on the shoreline are few and several form shoals in the lake.

This northeastward elliptical intrusion is composed of massive, homogeneous granodiorite. The northern two-thirds of the body contains medium to coarse-grained (2-8 mm) rounded quartz phenocrysts and less prominent K-feldspar megacrysts 5-13 mm in diameter. The southern one-third of the pluton is finer grained, equigranular to slightly inequigranular. The northern, quartz porphyritic part of the pluton contains bluish-grey quartz phenocrysts - 25%; K-feldspar - 10%; mafic minerals (biotite in book crystals) 2% with the rest comprising plagioclase 1-3 mm in diameter. Only rare aplitic dikes are noted. The finer grained southern part is of the same homogeneous modal composition. It is the least exposed part of the pluton and is only evident from the large rubbled blocks in the lake.

There is no evident contact strain aureole around this intrusion. The regional lineation is still preserved in the adjacent intermediate volcanic unit to the west although the fabric in the Whitmore Lake volcaniclastic rocks suggests significant overturning of strata, induced by the pluton emplacement.

Felsic Intrusive Rocks - Plutons external to the belt

Dobie Lake Pluton

Regional Relationships

The Dobie Lake Pluton is a foliated hornblende-biotite tonalite body, 40 km long with a shallowly dipping domical core. It is readily distinguished on the 1:1 000 000 scale total field magnetic map (Gupta 1991) by a broad, low intensity magnetic field that contrasts with the significantly higher intensity of the surrounding greenstone and granitoid terrains. Its age (2747 Ma) is comparable with that of a felsic volcanic unit (2749 Ma) in the southern part of the adjacent Lang Lake greenstone belt to the northwest (Corfu and Stott 1993b). The pluton transects the strata of the adjacent Meen-Dempster greenstone belt at an oblique angle; there is local evidence for thin, discontinuous slivers of amphibolite within the pluton, which trend parallel to the belt. The amphibolite and a sliver of tonalite gneiss found locally on "Hour Lake", just north of the Golden Patricia Mine, appear to separate the main phase of the pluton from a plagioclase-porphyritic tonalite phase approximately 1.5 km wide lying adjacent to the greenstone belt. In general, outcrops of this pluton are typically homogeneous; xenolithic material and felsic dikes are rare.

Although the pluton is comparable in age to volcanism in the adjacent Lang Lake belt, it imposed a narrow contact metamorphic aureole upon the adjacent greenstone belts. Structural and paleomagnetic evidence show that it has been treated to subsequent regional orogenic shortening and rotation (Stott and Wilson 1986b; Hale and Lloyd 1989). The pluton is weakly metamorphosed and carries a strain fabric with a stretch lineation near its margins, which is attributed to regional orogenic shortening.

Age

From a location on the western shore of Dobie Lake, zircons from a tonalitic sample of the Dobie Lake pluton provide a crystallization age of 2750±3 Ma (Corfu and Stott 1993b). There is no evidence of older zircons or the presence of inherited Pb. A titanite analysis apparently reflects a metamorphic overprint at 2734±3 Ma.

Lithologic Descriptions

The Dobie Lake pluton possesses a plagioclase porphyritic tonalite phase adjacent to the Meen-Dempster greenstone belt but most of the body is characterized by a medium-grained (1-2 mm) inequigranular fabric. It is slightly quartz phyric in the south on the Kaminiskag River for example, and although biotite is the predominant mafic mineral, there is local heterogeneity where hornblende + epidote are included in the mafic assemblage. Hornblende may vary in relative proportion and locally forms the dominant mafic mineral where it forms medium-grained clusters and ellipsoidal aggregates. Mafic minerals generally comprise up to 10% of the rock. Slightly coarser plagioclase crystals enhance the inequigranular nature of the rock. Leucotonalite to granodiorite sills occur locally concentrated in some outcrops to produce a banded fabric. The plagioclase porphyritic tonalite is typified by medium grain (1-3 mm) sizes with plagioclase phenocrysts, 2-5 mm across and up to 8mm, showing clear primary albite twinning. Biotite and hornblende comprise up to 10% of the rock with 2-4 mm hornblende crystals, and minor hornblende-rich lensic inclusions up to 5 cm long. Plagioclase phenocrysts occupy approximately 5% of the rock.

A moderate mineral foliation and lineation occurs throughout the pluton. The fabric in part could be related to pluton emplacement; near the southwest contact with the Meen-Dempster greenstone belt in the plagioclase-porphyritic phase, more intense fabrics and accompanying metamorphism are associated with a major right-handed transcurrent shear zone - the Bear Head Fault (*see* Structural Geology). Within the Bear Head Fault zone, the rock becomes increasingly flattened towards a mylonite zone that varies up to 300 m wide locally and displays reduced grain sizes in locally anastomosing shear planes. Quartz varies from being moderately ribboned to forming interstitial grains around plagioclase. Quartz in the mylonite is finely ribboned and plagioclase is augen-shaped, 3-6 mm long in a fine-grained matrix. The finely ribboned foliation is slightly undulating. The width and intensity of the fault zone varies significantly along strike. The fault zone is shown generalized on OGS map 2507 (Stott and Wilson 1986a) and is identified on OGS map P.2619 and P.2620 (Stott and LaRocque 1983a, 1983b) by individual mylonitic outcrops.

Tonalite Gneiss

A narrow 500 m wide zone of fine-grained tonalite gneiss extends across Wright Lake (OGS Map 2507) northwestwards to the Obaskaka River (OGS Map P.2620), just north of the Golden Patricia Mine. This zone separates the plagioclase phyric tonalite phase described above from the main body of the Dobie Lake Pluton. This tonalite gneiss appears to be a remnant of an older tonalitic terrain and lies on strike with a narrow amphibolite sliver northwest of Dobie River (OGS Map P.2620). It is locally intruded by the plagioclase porphyritic tonalite phase. The gneiss is equigranular (0.5 mm grain sizes) and is strongly foliated with thin bands, lenses and foliae of darker grey, biotite-rich tonalite, comprising 10% of the rock and resembling nebulous, partly assimilated and biotitized mafic volcanic inclusions. In addition, pinkish granodiorite layers and lenses make up 30% of the rock and could represent either partial melts of the tonalite or melt injected from depth. Since granodiorite dikes occur, though sparsely, in the main phase of the Dobie Lake Pluton, it is probable that the tonalite gneiss provided a locus for narrow granodiorite injections during the late stage of pluton emplacement. The dikes and sills are subparallel to the flattening fabric of the tonalite and all components of the rock have been strongly deformed.

Stoughton Creek - Hammerton Lake Granodiorite

A late tectonic pluton lies west of the Meen-Dempster belt and centred in the vicinity of Hammerton Lake. This intrusion is composed of massive, locally quartz porphyritic granodiorite to monzogranite with a separate K-feldspar-phyric phase west of Hammerton Lake and north of the greenstone belt in the vicinity of Stoughton Creek. These two phases may constitute separate intrusions. A K-feldspar-phyric outcrop on a lake north of the belt has been sampled and dated at 2732 +11/-7 Ma (Corfu and Stott 1993b).

Southern Pluton

On the southern flank of the western end of the Meen-Dempster belt, there is a late tectonic pluton of homogeneous, equigranular biotite trondhjemite to granodiorite that sharply contacts the greenstone belt. The intrusion contains no dikes or volcanic and sedimentary inclusions; however, minor inclusions of an apparently older fine-grained tonalite are locally evident. The pluton within 5 km of the northern contact, possesses a moderately northward dipping planar alignment of minerals; this foliation and accompanying mineral lineation orientation, interpreted to be related to the pluton emplacement, can be traced into the greenstone belt for approximately 3 km (*see* Structural Geology). This correspondent fabric in the belt is inferred to be a contact strain imposed by the Southern pluton.

Structural Geology

Regional Setting

The Meen Lake map area is part of the Uchi Subprovince, one of several granite-greenstone subprovinces in the Superior Province; it comprises an east-west trending region of curvilinear supracrustal belts infolded between and enveloping large granitoid batholiths. This subprovince is one of several in the Superior Province.

The Meen-Dempster belt is in the northwesternmost part of a continuous supracrustal assemblage that extends eastward to Pickle Lake and southward to margin the English River Subprovince in the vicinity of Lake St. Joseph. The belt is 7 km wide and extends over 31 km in length. The regional tectonostratigraphy and structural domains are summarized in Figures 7 to 9.

Megascopic Structures

The stratigraphy and tectonic cleavage north of Meen Lake dips vertically to steeply southward, whereas the southern three-fourths of the belt dips moderately northwards. As a consequence, a megascopic fanning of cleavages occurs in this belt, centred on Meen Lake. The few observed mesoscopic folds, bedding/cleavage intersections and widely observed mineral lineations indicate that the folds plunge approximately 35°-50° to the east and southeast.

A qualitative assessment of the tectonic strain fabric across the greenstone belt suggests the following: the centre of the belt is characterized by a prolate strain fabric with tectonic stretching (as defined by mineral lineations) of the rock that is more prominent than flattening (as defined by cleavage). Flattening of the fabric becomes somewhat more predominant over stretching further north towards the belt margin. To the south, the rock fabric becomes markedly fissile with a strong cleavage development close to the Southern Pluton. Not only the oblateness or flattening nature of the rock fabric increases southward, but the intensity of that fabric also increases. Quantitative confirmation of some of these observations was made by E. Jennings (1983), using varioles as strain gauges in mafic metavolcanics. Her results clearly illustrate the more pronounced tectonic stretching of the rock fabric in the central part of the belt.

Cleavage trajectories within the granitic masses around the greenstone belt are conformable to the belt margins. The Southern Pluton possesses a planar fabric with dips that progressively shallow from 70° to 30° north- and northeastward toward the belt. The internal structural pattern of the pluton is therefore consistent with that of a large singular dome, the major part of which lies to the south of the map area. The pluton also possesses primary, northwesterly plunging mineral lineations within the map area (Figure 7). The significance of this fabric element is discussed later.

The megascopic structures of the other two intrusions are less clearly defined. The Hammerton Lake Pluton is extensively covered with overburden and its relation to the Southern Pluton is unknown. However its emplacement may have uplifted and rotated the westernmost extensions of the greenstone belt clockwise (See Figures 7 and 8). There, the major easterly plunges of the mineral lineations in the belt change to westerly plunges further west. The hinge of this megascopic flexure trends from the east end of Simard Lake northeastward across the metavolcanic tail of the belt just northwest of Meen Lake.

The Dobie Lake Pluton is poorly exposed but the moderate dips to the cleavage in the rocks and local small slivers of supracrustal rocks suggest that the batholith may comprise several small domes partially enveloped by intervening supracrustal remnants. The best observed candidate for such a parasitic dome is 1.2 km wide and lies just north of Dobie River between the greenstone belt and a 3 km long metavolcanic sliver that parallels the belt. The change in dip of the planar fabric across this portion of the batholith resembles that of a ridge-like dome. It is evident from Figure 7 that the easterly plunging stretching directions in the tectonic fabric across the greenstone belt also continues into the adjacent Dobie Lake Pluton.

Mylonitic shear zones lie close to the northern margin of the belt. Granitoid rocks of both the Dobie Lake Pluton and the Hammerton Lake Pluton exhibit quartz ribboning and grain size reduction across widths of several metres to tens of metres, close to the metavolcanics. The mylonitic outcrops do not appear to be part of a continuous singular mylonitic band but comprise a set of bands. The mylonitization is discontinuous along strike in places. North of Meen Lake there appear to be several discrete mylonitic bands across a 0.6 km wide zone within the Dobie Lake Pluton. The mineral lineations parallel the direction of movement along these shears and they plunge shallowly to the east. At least some of the shear zones have right-handed sense of movement with dominantly transcurrent displacements.

There is some evidence of shear zones within the greenstone belt, close to its northern margin, on lakes just east and north of Meen Lake. The extent of these shear zones and their spatial relation to the mylonitic bands to the north is not clear.

Faults in this area are not prominent owing to the extensive overburden. One northeast-trending fault, on a lake just east of Meen Lake, produces a sinistral offset of the margin of the upper intermediate to felsic volcanics of the Woman assemblage. Other fault(?) lineaments are found in the granitoid terrains including a prominent northeast-trending lineament along Dobie River that crosses, but does not appear to offset, the margin of the metavolcanic belt.

Minor Structures

Foliation and Gneissosity

The rocks throughout the Meen Lake belt have been tectonically deformed and possess a continuous penetrative foliation defined by a pervasive planar alignment of mineral grains and accentuated by a planar alignment of distorted pillows, varioles, breccia fragments and sedimentary clasts. The intensity of foliation development is qualitatively observed in the metavolcanic flows to be weak to moderate across most of the belt. However, progressively more intense fissility occurs within approximately 2 km of the southern margin, owing to the additional strain imposed on the belt margin by the late tectonic Southern Pluton.

Very local, narrow zones of shear are marked by a pronounced fissility of the rock. One example is a fine grained fissile zone within the gabbro exposed along the southern shore of a lake just northeast of Meen Lake. Such zones, locally observed, may bear a relation to the discontinuous mylonite zone within the granitoid rocks along the northern margin of the belt.

Metasediments and tuffs possess a moderate to strong schistosity parallel to the bedding. Intersections of bedding and oblique cleavage are not commonly seen. However the cleavage on Meen Lake is locally observed as a spaced cleavage with narrow, more intense cleavage domains approximately 2-10 cm apart.

Crenulation cleavages are uncommon in this belt. Several outcrops of intermediate tuff display such cleavage development, deforming earlier bedding-parallel foliation, north of Dobie River within the intermediate to felsic volcanics. The axes of these crenulations plunge southeastward, parallel to the axes of minor folds.

The granitoid rocks typically possess a weak to moderate foliation defined by planar alignment of minerals. In places this developed into a planar differentiation of minerals. Gneissosity is only well developed in two locations in the map area: a prominent zone of recrystallized, tonalitic gneiss (up to just over 1 km from the volcanic belt, in the southeast corner of the area on Obaskaka River and on the lake to the south), which may represent an older, locally preserved granitoid suite or a complex portion of the Dobie Lake Batholith; and, two small areas comprising older granitoid relicts northwest of Hammerton Lake, and enclosed by the Hammerton Lake Pluton.

Lineations

Lineations are prominently observed on foliation planes throughout the area. There is generally only one lineation set observed in a given outcrop and it is consistent with the regional pattern of lineations across the belt. These fabric elements are defined by linear-preferred alignment of minerals plus stretched sedimentary and volcanic clasts, volcanic pillows, amygdules and varioles. Similarly the intersections of bedding and cleavage define lineations that are parallel to the stretched fabric in the rock. The lineations are consistently aligned locally. On a regional scale there is a mappable pattern to the lineation orientations as outlined in the section on Megascopic Structures and shown in Figures 7 and 8. The regional set of lineations are parallel to the axes of minor folds and indicate the general orientation of megascopic tectonic stretching.

There is a later superimposed lineation observed at several outcrops on a lake south of Meen Lake, labelled "B" Lake on map P.2619 (Stott and LaRocque 1983a). This later set becomes dominant southwards towards the Southern Pluton, to the exclusion of the regional easterly plunging set. The lineations of this later set thereby record the areal extent of the strain imposed by the Southern Pluton upon the supracrustal rocks (Figure 7). The lineations accordingly provide us with a tool for establishing the relative history of events as outlined in Figure 10.

Minor Folds

Minor folds are not widely observed in this area. Observations of these structures are restricted to iron formation and tuff units. Folded iron formation on the north shore of Meen Lake is consistent in its orientation with other structural evidence of the D_2 strain extending throughout the west half of the Meen-Dempster belt. Other minor folds have been observed locally within the Meen Lake area and especially near the southern margin of the belt, near the Southern Pluton. In each case, the folds correspond to a very simple geometry of easterly to southeasterly plunging folds. Larger scale folding of strata is also evident north and south of Kaminiskag Lake. It should be noted that the initial interpretation of regional folds within the felsic volcanic sequence on Meen Lake, shown on OGS Preliminary map P.2619 (Stott and Laroque 1983a), is incorrect; subsequent work showed that the dominant younging direction of bedding across the core of the belt is to the southwest.

Magmatic and Structural Sequence of Events

The tectonostratigraphic framework of the Meen-Dempster belt is summarized by cross-sections in Figure 9; the timing constraints and the overall sequence of structural and magmatic events are summarized in Figure 10.

The Meen-Dempster greenstone belt, composed of 2 volcanic assemblages that face dominantly southward, has been subdivided by Stott and LaRocque (1983a, 1983b) and Stott and Wilson (1984) into 2 broad structural domains, which are locally overprinted by younger, contact strain aureoles bordering late granitic plutons and locally by the Bear Head fault. The 2 domains (*see* Figure 8) both display steeply northward-dipping schistosity that closely parallels the overturned volcanic bedding. This belt is, however, locally folded close to external batholiths (Stott and LaRocque 1983a; Rodd and Hutchinson 1991), but there is otherwise little observable evidence of folding. There is a moderate state of strain across most of the belt with intense, apparently irrotational flattening strain in some narrow deformation zones and rotational shear strain in other zones that could be related to the Bear Head fault zone along the northern margin of the belt.

A common schistosity across these 2 domains inhibits their distinction, but one can recognize these domains from the orientations of stretching lineations (e.g., of varioles, clasts and mineral aggregates) that differ in each domain. These stretching lineations are accompanied by parallel mineral lineations that are more widely distributed and readily observed. Prismatic amphibole crystals, quartz and feldspar grains and phyllosilicates reveal this fabric.

The oldest recognizable strain fabric occupies the D1 domain and is characterized by westward-plunging lineations on the plane of schistosity in rocks to the east and south of the Graniteboss Stock. The western half of the belt is marked by eastward-plunging lineations, with a typically 30° to 40° plunge. This fabric, which typifies the D_2 domain, can also be traced into the southern part of the Dobie Lake pluton and can be traced into a 1.5 km wide shear zone that defines part of the domain's southern boundary east of Obaskaka pluton in Figure 8. The size and location of the D_2 domain is notably coincident with the size and presence of the Dobie Lake pluton north of the belt. In addition, this domain is bounded by 2 high-strain deformation zones and appears from paleomagnetic evidence (Hale and Lloyd 1990) to have rotated, as a block, clockwise. These considerations coupled with the consistent eastward plunge of mineral lineations in the slightly metamorphosed Dobie Lake Pluton lead one to postulate the following: the D_2 domain is a broad zone of stain produced by the Dobie Lake Pluton as the pluton was translated and rotated south and southeastward during *circa* 2700 million-year-old regional orogenic shortening; the pluton deflected that part of the belt southward and induced a clockwise block rotation. The overall mechanics can be likened to squeezing a pebble in a muddy matrix with the enveloping martrix (D_2-part of the greenstone belt) absorbing more than its share of the bulk strain against a comparatively rigid pluton. The orogenic shortening produced a tectonic schistosity in the 2722 Ma Kawashe Lake Stock and the Billett assemblage, but predated the emplacement of the posttectonic 2700 Ma Graniteboss Stock (Corfu and Stott 1993a, 1993b).

The subsequent strain effects of younger plutons upon the greenstone belt vary; for example, the geometric pattern of flattened strata in the greenstone envelope around the Obaskaka pluton implies that the pluton may have expanded during emplacement. The Billett assemblage, for example, is thickened where it strikes toward the east side of the pluton and becomes attenuated as it bifurcates around it to the north and south (Sage and Breaks, 1982). The tabular and crescent-shaped intrusions (e.g., the Osnaburgh pluton) have narrow contact strain and metamorphic aureoles; one can recognize the strain aureoles by the change in orientation of stretching directions in the greenstone envelope, from a regional-scale trend and plunge to a more local orientation, adjacent to the pluton, which conforms to the stretch lineations produced within the pluton during its emplacement. One example of the strain effects can be observed at the west end of the Meen-Dempster greenstone belt where detailed lineation measurements show a progression in lineation orientations as one approaches the late to posttectonic external pluton (the Southern pluton in Figure 7). This strain envelope, labelled D3 on Figure 8, is imprinted upon the existing regional D2 foliation in the belt. With few exceptions, only a single lineation is preserved on or parallel to a foliation surface so that we see a progression of orientations of prismatic amphiboles, micaceous streaks, mineral aggregates, vesicles and clasts.

This D_3 deformation has produced a pronounced flattening and westerly plunging stretching fabric within the southwesternmost part of the belt. This is a contact strain aureole superimposed by the Southern pluton upon the pre-existing easterly plunging regional strain fabric. The westerly plunging mineral lineations of the Southern Pluton parallel the stretching direction in the contact strain aureole in the enveloping supracrustal rocks. This contact aureole extends for a width of 1.6 to 2 km north and east of the pluton and is clearly seen in outcrop to deform the older easterly plunging fabric. A progressive change in the plunge azimuth of mineral lineations can be seen in Figure 7. Within a zone 0.4 to 1.2 km wide adjacent to the pluton, mineral lineations within the belt reflect a fabric stretching direction plunging to the northwest, parallel to the stretching direction within the pluton itself. This rotates to a more northerly plunge direction further away from the pluton in an outer zone of the contact strain aureole shown as a separate domain in Figure 7. Within this outer zone on "B" Lake, north-northwesterly trending mineral lineations are superimposed on weak, locally preserve lineations plunging eastward, related to the earlier regionally developed D_2 strain fabric.

The Hammerton Lake Pluton is also a late to posttectonic intrusion and, like the Southern Pluton, it possesses a locally developed narrow contact strain aureole (D_3) that postdates the D_2 deformation event in the western half of the Meen-Dempster belt. This intrusion has deflected the stratigraphy close to its contact.

A right-handed transcurrent shear zone, part of the Bear Head fault zone, follows the length of the belt along its northern margin. It is well expressed within the margin of the Dobie Lake pluton, with a shallow southeastward-plunging direction of shear, and varying from parallel sets of narrow mylonite zones to a broader zone 1.5 km wide of high to moderate shear strain.

This fault zone follows the boundary between the Berens River and Sachigo subprovinces and can be traced discontinuously as part of a fault system that extends from Lake Winnipeg in Manitoba; its main branch continues into the North Spirit Lake greenstone belt (Stone 1990), but it is also interpreted to continue, through a horsetail-like splay, southeastward towards the Meen-Dempster greenstone belt. It can be traced as a zone, typically 1 km wide along the northern margin of the Meen-Dempster greenstone belt, increasing to 3 km wide in the vicinity of MacDowell Lake in the Berens River Subprovince (Osmani and Stott 1988). In the Uchi Subprovince, this fault crosses plutons of hornblende-bearing potassium-feldspar megacrystic granite; it appears on the aeromagnetic maps as a narrow line of high magnetic intensity crossing the plutons, and owes its expression to shear-induced alteration of hornblende to form magnetite, chlorite and epidote. The rocks within the fault zone have been deformed to protomylonites, which enclose very fine-grained mylonite bands. Mineral lineations and the long axes of mineral aggregates typically plunge 5° to 30° to the southeast. Various shear-sense criteria - progressive clockwise rotation of the schistosity plane towards the shear plane, ductile shear bands, and asymmetric pressure shadows of porphyroclastic potassic feldspar megacrysts - demonstrate a right-handed sense of shear on the horizontal plane.

The Bear Head fault zone is typical of numerous curviplanar faults in northwestern Ontario, following close to greenstone belt margins. Since these faults transect 2.7 billion-year-old plutons, they represent late displacements during and subsequent to the main period of the 2.7

Ga Kenoran orogenesis. The fault zone probably has a long episodic history, initially as a zone conveying ductile shear during the late stage of cratonization of the northern Superior Province (the "Uchian phase" of the Kenoran Orogeny; *see* Summary of Events in the Central Uchi Subprovince), and more speculatively, later as one of a number of reactivated zones of brittle relief in the interior of the Archean craton during creation of the 1800 million-year-old Trans-Hudson Orogen, which adjoins the Superior Province to the northwest.

Area 2

Geology of the Pickle Lake Area

Archean Rocks

Tectonostratigraphic Assemblages

The Pickle Lake greenstone belt is dominantly composed of basaltic flows with some intermediate to felsic volcanic units concentrated in the southeastern part of the belt (Figure 11). Contrasts in U-Pb zircon ages from two felsic volcanic sequences and the geophysical evidence of a major fault boundary within the belt permits us to subdivide the Pickle Lake greenstone belt into three tectonic assemblages shown in Figure 12.

The northern half of the belt, north of an aeromagnetic and electromagnetic discontinuity (Figure 12), has been labelled the Northern Pickle assemblage and might be correlatable in future with similar supracrustal rocks of the North Caribou greenstone belt in the Sachigo Subprovince. Basaltic strata in this portion of the Pickle Lake belt appear to continue northeastward to form aeromagnetic extensions or "tails" of the belt into and conforming with the structural grain of enveloping tonalite gneisses.

The southern half of the belt has been subdivided into two tectonic assemblages. The Pickle Crow assemblage of basalt, iron formation and local quartz porphyry units bears a U-Pb zircon age of 2860±2 Ma for a quartz porphyry (Corfu and Stott 1993b). This assemblage is in apparent structural conformity with a sequence of mafic and felsic volcanic rocks to the southeast that contains an ash-flow tuff with a U-Pb zircon age of 2836±3 Ma (Corfu and Stott 1993b). This age is between the ages of two felsic volcanic sequences (2842 and 2825 Ma) in the Woman assemblage of the Meen-Dempster belt. The Woman assemblage strata continue eastward to form a tail or extension of the belt, which compares in rock types with undated volcanic units that lie on strike further east in the northern Miminiska-Fort Hope greenstone belt, separated by a granitoid terrain.

Northern Pickle Assemblage

Field Relationships

The northern half of the Pickle Lake belt is dominantly composed of massive and pillowed tholeiitic basalt flows, accompanied by magnetite-banded iron formation interbeds, sill-like mafic to ultramafic intrusive sheets and very limited evidence (mainly in drill core) of dacitic to rhyolitic tuff beds (Stott et al. 1989a, 1989b). This association of rock units resembles a typical assemblage of Archean oceanic mafic plain sequences, as described by Thurston and Chivers (1990), and can be compared closely with similar units in the North Caribou greenstone belt of the Sachigo Subprovince (see Thurston et al. 1991). Most volcanic units of this area are moderately deformed with only local zones of pervasive hydrothermal alteration. Several long, linear aeromagnetic anomalies and electromagnetically conductive graphitic schist beds and other marker beds continue for many kilometres in this area; these together with other correlated stratgraphic units indicate that the northern Pickle Lake region is typically composed of tabular volcanic and minor sedimentary strata that extend along almost the full length of the northern half of the Pickle Lake greenstone belt. However, there is no clear determination of the general sense of stratigraphic younging in these rocks. The age of the rocks in this northern unnamed assemblage of the Pickle Lake belt is not determined but is interpreted, from aeromagnetic extensions of the belt into the northern granitoid gneisses, to be correlatable with the circa 3 Ga volcanic rocks of the McGruer assemblage in the North Caribou belt, Sachigo Subprovince.

This assemblage is bounded to the south by the Pickle Crow assemblage. The boundary is determined from the juxtaposition of the different structural trends, both stratigraphic and geophysical, observed in these two assemblages; the northeastward strike of the northern Pickle Lake basalts, iron formation marker beds, and other electromagnetic conductors is at a 15° to 30° angle counterclockwise to the more easterly striking units of the Pickle Crow assemblage (Figure 12). Based on this juxtaposition of contrasting stratigraphic trends, the author infers that the boundary between these trends represents a tectonic juxtaposition of separate assemblages. If this interpretation is validated, such an angular convergence of two stratigraphic packages at a geophysically definable boundary probably characterizes the presence of cryptic boundaries between tectonic assemblages in other greenstone belts.

Field Descriptions
Mafic Metavolcanic Rocks

Based on widely scattered outcrops, most of the unnamed northern volcanic assemblage in the Pickle Lake belt is probably composed of massive to pillowed tholeiitic basalt flows. However, extensive boglands occupy this region and the bedrock exposures are limited. The observed mafic flows are fine-grained and typically weakly to moderately deformed. A northeast-trending zone of pervasive iron carbonate alteration occurs just east of Highway 808; the Mitchell gold occurrence (Stott and Brown 1986) lies in this zone and illustrates the alteration intensity. Pillowed volcanic units have not provided reliable top directions in this region. There is some evidence of either coarse mafic flows or intrusive gabbro east of Tarp Lake associated with iron formation.

Metasedimentary Rocks

Clastic metasedimentary rocks in this northern region were not observed. Some graphitic schist units and fine-grained wacke units are recorded locally in drill core north of Central Patricia as shown on OGS Map P.3056 (Stott et al. 1989a). The mafic volcanic units are accompanied by several major iron formation sequences east of Highway 808 and observed in the vicinity of Kawinogans River. The easternmost iron formation of this assemblage can be traced geophysically for many kilometres; it is composed of weakly deformed banded magnetite-chert with local sulphidic beds. The aeromagnetic features of the western iron formation, east of Highway 808, imply several fault offsets that have not been confirmed on the ground owing to a scarcity of outcrop.

Pickle Crow Assemblage
Field Relationships

The Pickle Crow assemblage consists of a folded sequence of subaqueous massive to pillowed basaltic flows, dacitic to rhyolitic pyroclastic flows, synvolcanic quartz porphyry intrusions, and magnetite-banded iron formation with thin interbeds of graphitic schist. A suite of lenticular, quartz porphyry sills intruded the basaltic base of this assemblage and one sill has been dated at 2860±2 Ma (Corfu and Stott 1993b). This sill also contains inherited zircons with an age of 2892 +5/-2 Ma, comparable with the age of rhyolitic tuff in the Bruce Channel assemblage of Red Lake and with the age of the Pembina Tonalite Gneiss in the Lake St. Joseph batholith (Stott and Corfu 1991). The Pickle Crow assemblage is the locus of extensive hydrothermal alteration, folding and zones of ductile deformation trending subparallel to the strata and associated with the Central Patricia and Pickle Crow gold deposits. The units of oxide facies banded iron formation provide markers that permit tracing the folded stratigraphy in this assemblage. The greater evidence of folding in this assemblage is in contrast to the comparatively straight-layered, unnamed northern assemblage.

There is no evidence of angular discordance between the Pickle Crow and Woman assemblages. The contrast in ages (Figure 13) and the greater abundance of folded iron formation in the Pickle Crow assemblage are the principal features used to separate the local volcanic strata into these two assemblages. The presence of the younger Woman assemblage to the south of the Pickle Crow implies that there may be an overall younging of tectonic assemblages southward within this belt.

Field Descriptions
Mafic Metavolcanic Rocks

The Pickle Crow assemblage is dominated by massive to pillowed tholeiitic basalt. On Kapkichi Lake, the basalt flows are massive and fine-grained with a dark grey fresh surface. The rock is amphibolitized and composed of acicular hornblende and plagioclase. A basalt zone on the southeast shore of the lake contains pods and veinlets of epidote-quartz, with almandine garnet and associated minor pyrite and chalcopyrite. The basalt units around the granitic stocks are strongly deformed, with a pronounced flattening fabric accentuated by colour banding.

In the Skebo Lake area, pillowed basalt flows are predominant. The pillows, comprising, acicular amphibole, plagioclase and chlorite, show mottled dark to light green colouring with epidote-rich patches, interpreted as a product of seawater-rock interaction at the time of deposition. Average pillow dimensions on the rock surface are 70cm by 25 cm. Pillow selvages, containing chlorite and quartz, are 1-2 cm wide but the pillows are strongly flattened and no top determinations can be made. Scarcity of reliable top determinations amongst pillowed basalts of this assemblage is typical of the Pickle Lake belt as a whole.

The Pickle Crow area is dominated by extensive carbonatization of strongly deformed, typically pillowed, basaltic flows. These basaltic rocks vary widely from intensely sheared, chloritic schist to locally carbonatized to silicified massive flows (e.g., Table 4, Pickle Crow sample 3210), which occur north of the Hooker-Burkoski stock and are spatially associated with a suite of lens-like, quartz-feldspar porphyry sills. This suite of sills includes the sheared and carbonatized Pickle Lake Porphyry northeast of the Number 1 (Howell) vein of the Pickle Crow mine (Ferguson 1966). A broad northeast-trending zone, from Central Patricia and beyond Pickle Crow, contains numerous shear zones and areas of extensive carbonatization that characterize this part of the Pickle Crow assemblage. Much of the gold mineralization in this vicinity is associated with individual shear zones.

Intermediate to Felsic Metavolcanic Rocks

A unit of intermediate tuff, lapilli tuff to tuff breccia occurs southeast of the Pickle Crow gold deposits. This lenticular, 2.6 km wide dacitic to rhyodacitic unit appears to be separate from a thinner (800 m) unit of massive to tuffaceous dacite observed 2.5 km east of the Dona Lake mine. The units are separated by massive to pillowed basalt. The thicker unit contains lapilli tuff and lapillistone that are typically heterolithic in fragment textures and composition with local evidence of clasts more felsic than the matrix. Some outcrops are weakly to moderately iron carbonatized. The strike extent of these units is not known.

Quartz-Feldspar Porphyry

Within the Pickle Crow assemblage, lenticular sills of quartz-feldspar porphyry are buff weathered with a light grey fresh surface. They are composed of a fine to medium-grained matrix with quartz and feldspar phenocrysts 3-5 mm in size. These sills conform to the schistosity and contain a strong planar tectonic fabric, locally intensely developed in shear zones. Their intrusive character is locally evident where inclusions of mafic volcanics are observed.

Clastic and Chemical Metasedimentary Rocks

Long, continuous marker units of magnetite-chert iron formation, interbedded with greenish mudstone, occur within the mafic volcanics. The interbeds of mudstone and local graphitic schist associated with the iron formation are extensively ferroan dolomitized in the vicinity of the village of Central Patricia and the former settlement of Pickle Crow. This alteration is spatially associated with pervasive carbonatization of the volcanic rocks. A long continuous unit of banded iron formation to ferruginous chert can be traced to First Loon Lake where the unit outlines a large `S' fold close to the external granite contact. Apart from thin clastic units spatially associated with iron formation, very few clastic metasediments are observed in this belt and this probably reflects a distal oceanic environment that characterizes most of the rock associations in the belt. However, there is limited evidence in the First Loon Lake area (OGS Map P.3057, Stott et al. 1989b) of sedimentary carbonate layers, spatially associated with the iron formation (D. Mullen, Umex Incorporated, personal communication, 1988), which may reflect local deposition on a shallow-water platform.

Woman Assemblage

Field Relationships

The Woman assemblage is composed of an approximately 2200 m wide sequence of tholeiitic basaltic flows and thinner dacitic to rhyolitic ash flows. Quartz-phyric, felsic pyroclastic rocks locally contain thin, massive sulphide lenses, which are dominated by massive pyrrhotite and overlain by thin chert beds as evident from the diamond drilling by Minnova Inc. (MNDM assessment files office); the stratigraphic relationships suggest a southward-younging direction. A quartz-phyric tuff from this unit has provided a U-Pb zircon age of 2836±3 Ma (Corfu and Stott 1993b). A possible stratigraphic correlation can be postulated between these felsic volcanic rocks of the Woman assemblage and a coarser, thicker suite of dacitic pyroclastic rocks with quartz porphyry intrusion, inferred to lie close to a vent, in an unnamed tectonic assemblage in the Keezhik Lake area of the northern Miminiska-Fort Hope greenstone belt (Stott and Corfu 1991). The pyroclastic rocks of the Woman assemblage are associated with banded iron formation, and this suite appears to be on strike with a similar rock association in the Keezhik Lake area. The Woman assemblage is interpreted, from aeromagnetic and electromagnetic conductors, to continue southwards from the Pickle Lake belt to skirt the south margin of Kagami Pluton (Stott and Corfu 1991, figure 6.3).

Exposures of this assemblage are limited; the best exposures occur in the vicinity of Second Loon Lake. Stratigraphy in the rest of the assemblage is based on drill core documented by Minnova Inc. (MNDM assessment files office) and on aeromagnetic and electromagnetic maps (OGS Maps 80912, 80928, 80932-80934 inclusive). An arbitrary boundary has been drawn to separate the felsic to intermediate volcanic rocks of the Pickle Crow and Woman assemblages. The boundary lies within the basaltic sequence that underlies the 2836 Ma felsic volcanics of the Woman assemblage.

Field Descriptions
Mafic Metavolcanic Rocks

The basalt in the Second Loon Lake area is massive amphibolite with a strong schistosity. Only minor ultramafic volcanic rocks have been noted in this greenstone belt, as intersected in drill core by Power Explorations Inc., northeast of Keating Lake (OGS Map P.3056, Stott et al. 1989a). The metamorphic grade and strong flattening fabric are typical of narrow greenstone belt tails protruding into the granitoid terrains. North-dipping schistosity and northwest-plunging mineral lineations conform to the igneous fabrics of the adjacent Second Loon pluton, which is interpreted to have imposed a contact strain aureole and amphibolite facies metamorphism on the greenstone belt in this vicinity.

Intermediate to Felsic Metavolcanic Rocks

The main unit of dacitic tuff, which is locally quartz porphyritic, has been drilled by Minnova Inc. in exploration for base metals. This unit of massive tuff, can be traced for up to 8 km along strike in northeastern McCullagh Township. Several apparently lenticular dacitic tuff units occur in the vicinity of Second Loon Lake. These thin units of tuff in the Woman assemblage generally lack pyroclastic fragments and might represent distal volcanogenic deposits.

Clastic and Chemical Metasedimentary Rocks

Little is known of the banded magnetite iron formation interbedded with basalt apart from descriptions in drill core logs. These iron formation units can be traced geophysically for many kilometres and strike subparallel to the southeast margin of the greenstone belt. Fine-grained clastic volcanogenic sediments are known, from drill core of Minnova Inc., to occur interbedded with the tuff in McCullagh Township (MNDM Assessment Files Research Office, Toronto; Resident Geologist's Office, Sioux Lookout).

Intrusive Rocks

Mafic Intrusive Rocks
July Falls Mafic Stock

On the northern margin of the Pickle Lake belt, at July Falls, there is a composite mafic stock consisting of phases ranging from quartz diorite to gabbro, pegmatitic gabbro and hornblendite. The elongate shape of the stock is parallel to the regional northeast strike of foliation. On Highway 808, near July Falls, quartz diorite with a dark grey weathered surface, is composed of medium-grained, equigranular quartz, plagioclase, and hornblende. This homogeneous rock fabric breaks down to a heterogeneous shear fabric, containing zones of mylonite and ultramylonite that may be mistaken for tuff. The shear zone strikes eastward with evidence of right-handed sense of transcurrent displacement.

Other exposures of this stock east of Highway 808 show knobby-weathered gabbro with intrusive contacts against the volcanic rocks. Local rafts of mafic volcanic rocks are observed in the gabbro and gabbro dikes are observed locally intruding the volcanic envelope.

Ultramafic Sills - Thierry Mine Area

A suite of ultramafic to mafic sills occur in the vicinity of the Thierry Mine and comprise the main ultramafic magmatism in the northern half of the greenstone belt. They could be synvolcanic intrusions and form a characteristic part of the unnamed northern assemblage. These sills have been mapped by Umex Corporation (Verbeek et al. 1972) and described by Sage and Breaks (1982) and Patterson and Watkinson (1984a, 1984b) in the vicinity of the former Cu-Ni mine.

Felsic Intrusive Rocks - Stocks within the belt

The Ochig Lake Pluton, Pickle Lake Stock and Hooker-Burkoski Stock have been described by Sage and Breaks (1982) and the following is intended to complement these descriptions.

Ochig Lake Pluton

The Ochig Lake Pluton is semicircular in plan with a domical internal structure, defined by outward-dipping foliation, and with a smaller domical lobe at its east margin, just south of the Hooker-Burkoski Stock (Figure 14). The pluton was observed at a few outcrops mainly near roadways and in the vicinity of Dona Lake and Wimbabika Lake. Most of the intrusion is composed of a homogeneous, medium to fine-grained granodiorite to trondhjemite. It is more typically trondhjemitic near a lenticular tonalite gneiss unit on Wimbabika Lake. The rock in most parts of the pluton is slightly inequigranular and is notably quartz-phyric in some outcrops, especially in the semicircular lobe at the east end of the pluton, near the Dona Lake Mine. This lobe compares closely, in its sodic composition (Sage and Breaks 1982) and quartz-phyric texture, with observed rocks of the Hooker-Burkoski Stock; this lobe and the H-B Stock are probably related as domical exposures of a common intrusive mass at depth.

The Ochig Lake Pluton possesses a mineral foliation that dips moderately to steeply (50° to 80°) outward and conforms in strike with the curvature of the pluton's margin. A mineral lineation is typically observed within the foliation plane and plunges almost down-dip, towards the pluton's nearest perimeter. This fabric is consistent with a domical structure for the Ochig Lake Pluton, which is typical of a diapir. In addition, the surrounding greenstone belt displays both a contact strain aureole (forming part of structural domain 2 of Figure 13) and contact thermal aureole around the pluton. The pluton is obliquely discordant to the surrounding greenstone strata, which nevertheless display planar and linear mineral fabrics that parallel the internal fabrics of the pluton (Figure 14). This contact strain aureole can be mapped up to 3 km from the pluton on its eastern margin for example. Much of the supracrustal rocks of the Pickle Lake belt are metamorphosed to greenschist facies but an aureole of amphibolite facies is observed around the Ochig Lake Pluton; within this thermal aureole, which varies greatly in width around the pluton from 100's of m to 2.5 km, the metamorphic mineralogy carries the fabric of the broader, contact strain aureole.

No subsequent regional scale deformation is recorded in or around this pluton; consequently, the emplacement of this pluton and its associate bodies, the Hooker-Burkoski Stock and Pickle Lake Stock, postdates the regional, penetrative deformation (See Structural Geology).

Wimbabika Tonalite

A narrow remnant of biotite tonalite over 5 km long occurs within the northwest corner of the Ochig Lake Pluton on Wimbabika Lake. This plagioclase-porphyritic tonalite unit is a 500 m wide sheet-like inclusion within the pluton; the tonalite is recrystallized and contains metamorphic epidote and thin, tabular inclusions of amphibolite and garnet-bearing feldspathic wacke. This tonalite unit dips moderately (40°) towards the outer margin of the enveloping Ochig Lake Pluton, and contains trondhjemite dikes probably derived from the pluton. The Ochig Lake Pluton in this vicinity by contrast is more leucocratic with strongly flattened, disk-like quartz phenocrysts, typical of the pluton's more intensely foliated outer margin and probably produced during its emplacement.

Pickle Lake Stock

The Pickle Lake Stock is poorly exposed and centred on Pickle Lake. It is at least locally composed of K-feldspar megacrystic granodiorite with quartz phenocrysts. The pluton has imposed a contact thermal aureole and a broader strain aureole on the surrounding greenstones that can be observed on its northern flank in the open pit of the former Thierry Mine copper-nickel deposit. The outward dipping schistosity and pronounced down-dip mineral lineations in the enveloping greenstone rocks imply that the Pickle Lake Stock probably intruded as a forceful diapir.

Hooker-Burkoski Stock

The Hooker-Burkoski Stock is a quartz-phyric, biotite, sodic trondhjemite with a small satellite intrusion on its north side, separated from the main body by a very thin screen of mafic volcanic rock. The pluton shows marked discordance along its margins which contain disrupted angular inclusions of amphibolitic wall rock. Although the pluton is poorly exposed, its marginal contacts locally show significant flattening strain, which is interpreted to have formed during pluton emplacement. The contact strain aureole is rather narrow; north of the pluton, the volcanic envelope with its older strain fabric is deflected by the pluton and indicates that the regional strain fabric that principally hosts the Pickle Crow gold deposits (domain 1 of Figure 13) pre-dates the emplacement of this intrusion; that is, the Hooker-Burkoski Stock as a member of the 2740 Ma Ochig Lake plutonic suite, has deflected the strata containing gold deposits that bear a pre-2740 Ma strain fabric.

Age Determinations and Implications

U-Pb zircon age determinations of the Ochig Lake Pluton at 2741±2 Ma and the Pickle Lake Stock at 2740±2 Ma (Corfu and Stott 1993a) confirm that these three lithologically comparable intrusions are members of a common plutonic suite. The field evidence shows that there are similarities among these three intrusions in mineralogic composition, fabric and structural relationship to surrounding rocks. In particular, the evidence in the surrounding 2.8. Ga greenstone envelope of each of these plutons shows that the plutons intruded subsequent to any regional penetrative deformation event. Yet these bodies are similar in age to the felsic extrusive rocks of the Confederation assemblage in the Meen-Dempster greenstone belt nearby. The synvolcanic relationship, however, is not obvious for 2 reasons: 1) the plutons do not intrude volcanic rocks of the same age, but are emplaced farther to the north into older crust and are not deformed by any regional shortening; 2) they are subcircular intrusions that produced contact strain and thermal aureoles upon their supracrustal host. For example, the Ochig Lake pluton (Figure 14), which postdates the regional deformation in the Pickle Lake greenstone belt and is, on a local scale, a posttectonic intrusion, nevertheless is synvolcanic with respect to the Confederation assemblage and pre-tectonic with respect to the main deformational expression of the Kenoran Orogeny recorded in the southern half of the belt (*see* Area 3 below).

Felsic Intrusive Rocks - Plutons external to the belt

Seach-Achapi Batholith

Southeast of the Pickle Lake greenstone belt, the Seach-Achapi batholith is a complex of early sodic plutons and gneiss terrains, with some inclusions of amphibolite, and younger, more potassic plutons (Figure 12). This batholith is a large oval mass that separates the greenstone belts of central Uchi from the Miminiska-Fort Hope greenstone belt further east. The western part of the Seach-Achapi batholith consists of several lithologic components (Stott et al. 1989b) as shown in Figure 11). Field evidence of intrusive and deformational relationships between different plutonic units, produced by the emplacement of the younger bodies, are observed (and described below) in excellent exposures along the principal waterways within this batholith, notably along Coucheemoskog Lake, Quarrier Lake, and the Etowamami River system, which includes Seach and Penhale lakes. In its complexity of old and young intrusions, it resembles the Lake St. Joseph batholith (see its description in Area 3 below) but it also shows evidence that plutonism in the northern Uchi Subprovince is locally synchronous with volcanism in the southern Uchi Subprovince. For example, the central tonalitic core (Quarrier tonalite gneiss at 1 locality is dated at 2821 +3/-2 Ma (Corfu and Stott 1993b), comparable to the age of Woman assemblage volcanism on Meen Lake (2825 Ma). The Second Loon Pluton, lying adjacent to the Pickle Lake belt, appears to have imposed a contact strain aureole upon the Pickle Lake greenstone belt and is late to posttectonic in relation to events recorded in the belt. Yet, the Second Loon Pluton is dated at 2711±2 Ma (Corfu and Stott 1993b) and corresponds in age to the youngest volcanism of the St. Joseph assemblage (2713 +3/-2 Ma) forming the southern edge of the Uchi Subprovince (see description in Area 3 below).

Gneissic Rocks

Quarrier Tonalite Gneiss

The Quarrier tonalite gneiss domain is generally characterized by fine-grained, recrystallized and locally folded biotite tonalite with widely distributed banding of different tonalite - diorite phases and amphibolite inclusions. The rock is cut by tonalite dikes, which largely postdate the local deformation, and younger pegmatite dikes. The amphibolite inclusions and banding are most prominent in an arcuate zone, characterized by higher magnetic susceptibility, and extending from the greenstone belt at McCullagh township to Rouble Lake and separating the Seach-Croshaw pluton from the Quarrier tonalite gneiss exposed on Weiberg Lake. Supracrustal rock units in this arcuate zone show textures indicative of some assimilation by intervening layers of granodiorite.

Near the boundary with the Kagami Pluton, the Quarrier tonalite gneiss possesses contact strain fabrics of planar and linear aligned minerals that parallel the magmatic fabrics within the younger pluton. The width of the contact aureole is approximately 4 km with most pronounced transposition of early S1 foliation of the Quarrier gneiss within 2 to 5 km of the pluton contact. Minor tonalite inclusions occur within the margin of the Kagami Pluton. The gneiss/pluton contact corresponds approximately to the 60,800 gamma aeromagnetic contour line on ODM-GSC Map 923G. Similarly, the Quarrier gneiss occurs as inclusions within the margin of the Seach-Croshaw pluton to the northeast on the Etowamami River.

Plutons

Seach-Croshaw Pluton

The Seach-Croshaw pluton is a broad area of medium to fine-grained trondhjemite to tonalite that is characterized by quartz phenocrysts and a variably weak solid state recrystallization fabric that could imply that it was subjected to a subsequent thermal and deformational overprint. A titanite age on Croshaw Lake of 2710±5 Ma probably reflects a thermal effect of the emplacement of the adjacent 2711±2 Ma Second Loon Pluton.

Kagami Pluton

Numerous late plutons have been found in recent years to have intruded along greenstone-granite boundaries and formed curved sheet-like crescents or broader wing-shaped bodies in plan view (Schwerdtner et al. 1983). Such plutons have been identified within the external batholiths. Two examples are the Kagami Pluton and the Second Loon Pluton.

The Kagami Pluton is a crescent-shaped intrusion; it is slightly arcuate in plan, or "boot-shaped" and appears to have invaded a pre-existing boundary between the greenstone belt and the Quarrier tonalite gneiss, and deformed the adjacent rocks during its emplacement. The following is based on a B.Sc. thesis study by Green (1987). This pluton is dominated by a single, homogeneous phase of granodiorite with quartz aggregates 2 to 20 mm in length, and a finer-grained, plagioclase porphyritic border phase, which is similar in modal composition. Dikes are generally absent. Mapping of the planar and linear alignment of minerals, especially quartz aggregates, within the pluton indicates that the strain fabrics were produced by the emplacement of the pluton and not by a regional deformation event. The fabric pattern within the pluton plus the pluton shape and its location at a greenstone-gneiss contact are features comparable to crescentic plutons observed elsewhere in the Superior Province (Schwerdtner et al. 1983). In particular, the Kagami Pluton is similar to the Jackfish Lake-Weller Lake pluton in Wabigoon Subprovince, a crescentic pluton described by Schwerdtner et al. (1983) as characterized by: 1) discordant relationships with adjacent rock units; 2) a prolate fabric with subhorizontal extension lineations converging towards the hinge line or plane of symmetry of the crescent; 3) at least 1 parasitic lobe showing increased flattening strain, with the Kagami Pluton displaying a more evolved parasitic dome centred on its northern arm and probably developed at a late stage of pluton emplacement; 4) schistosity attitudes at the margins of the pluton that are consistent with the shape of true synformal sheets except locally where the pluton margin probably mushroomed and now dips inward like a funnel.

Second Loon Pluton

The Second Loon Pluton is composed of medium-grained, amphibole-biotite granodiorite to trondhjemite with minor granodiorite dikes. The mineral lineations, within the steeply northward dipping foliation plane, plunge moderately (45° to 60°) westward and this orientation of fabric elements can be traced as a contact strain aureole in the adjacent greenstone terrain. The strain aureole is 3 - 4 km wide and is further described in Structural Geology. This pluton is crescent-shaped and lies between the greenstone belt and the Seach-Croshaw Pluton, which displays a strain fabric on Croshaw Lake that conforms with the internal fabric of the Second Loon Pluton.

Structural Geology

In the northwestern half of the Pickle Lake belt, reliable stratigraphic top indicators are not widespread. However, limited stratigraphic younging evidence in the southeastern half of the belt, outside of the tightly folded rocks in the Pickle Crow area, suggests that the regional younging direction in the southeastern part of the belt is southeastward towards the Seach-Achapi batholith.

Mapping by Pye (1975) and earlier workers has defined large folds of the stratigraphy in the Pickle Crow area, and local younging evidence from pillowed basalts confirm the anticlines and synclines previously defined there. However, much of this style of tight folding is restricted to the vicinity of the Central Patricia - Pickle Crow - First Loon Lake zone and megascopic folding is concentrated locally; for example, south of Ochig Lake Pluton. Elsewhere, in other parts of the belt, the continuity of electromagnetic conductors and stratigraphic units, such as magnetite-banded iron formation and intermediate tuff, suggests a simple stratigraphy on the regional scale (*see* e.g., OGS Maps 80923-80933).

A planar alignment of minerals defines a foliation that lies at a small angle to or parallel to the bedding in most areas of the belt. There are regional variations in the intensity of development of this schistosity. A weak flattening fabric is typical of the northwesternmost part of the belt along Highway 808. A moderate deformation appears to be most typical of other parts of the belt with notable exceptions. These exceptions include:

1. discrete deformation zones of strong to intense schistosity in the Pickle Crow area
2. a triangular area of the belt, south of Ochig Lake Pluton, squeezed between several late plutons and bearing a highly constrictive strain where rocks in many places are almost purely lineated
3. strong flattening fabrics in the supracrustal rocks enveloping the late to posttectonic plutons within the belt.

This latter exception is well illustrated, on the road leading to the Thierry Mine, by the strongly flattened and banded amphibolite that forms the northern margin of the Pickle Lake Stock.

Other zones of shear have been observed locally (Figure 15) but in each case the full extent of these zones has not been established. One example is an east-trending zone of right-handed transcurrent shear, several tens of metres wide, within quartz diorite at July Falls on Highway 808 at the northernmost end of the belt. The narrow ductile deformation zones within the supracrustal wedge between the Ochig Lake Pluton and the Hooker-Burkoski Stock are another example.

Apart from a late transcurrent shear zone seen at July Falls, where the stretching lineation is subhorizontal, most zones of strong to intense deformation show moderate to steeply plunging lineations, which are parallel to the stretching lineations in the surrounding moderately deformed rocks. In spite of the generally poor bedrock exposure which characterizes large parts of the Pickle Lake belt, there are regional patterns of total strain in the rocks which allow for the subdivision of the belt into structural domains (Figure 13). These domains are defined mainly by orientations of stretching lineations and fold axes.

The Pickle Lake greenstone belt has been subdivided into 3 structural domains (see Figure 13). The oldest deformational fabric occurs in Domain 1 and comprises a steeply northwestward-dipping foliation (Stott et al. 1989a, 1989b) that typifies the generally northward-dipping foliation prominent in most of the major belts of the Uchi Subprovince. The domain is characterized by a steep, northeasterly plunging lineation of amphibole and other mineral grains and shaped ellipsoids of varioles, clasts and mineral aggregates. Domain 1 includes most of the mineralized deformation zones of the Pickle Crow gold deposits, which comprise steeply north-northeast-plunging ore shoots of folded gold-quartz veins. Domain 2 comprises a grouping of spatially restricted contact strain aureoles surrounding, or adjacent to, late felsic plutons such as the Pickle Lake Stock and the Ochig Lake Pluton. Features of pluton-induced strain aueoles are summarized later. Domain 3 is characterized by a foliation that dips moderately to the northwest (Stott et al. 1989a, 1989b), away from the adjacent 2711 million-year-old Second Loon Pluton in the Seach-Achapi batholith. The westward-plunging lineations of this domain are parallel to the lineations of the Second Loon Pluton. One could infer that the fabric of Domain 3 represents a wide contact strain aureole related to the emplacement of the Second Loon Pluton. This strain aureole appears to have affected a once broader Domain 1 so that the eastern half of the Pickle Crow gold deposits, probably formerly part of the original Domain 1, are re-aligned from the NNE plunge direction and instead plunge westward, conforming to this younger Domain 3 fabric.

Interpreted Sequence of Magmatic and Structural Events

The Pickle Lake belt reveals a history that encompasses an age range exceeding 150 million years (Figure 16). The oldest dated magmatism at 2860 Ma in the Pickle Crow assemblage brought with it older zircons dated at 2892 Ma, apparently inherited from a preceding magmatic event preserved in the underlying crust. It is also possible that an even earlier period of volcanism is preserved in the northern half of the Pickle Lake belt where tholeiitic basalt, ultramafic sills and iron formation comprise a rock association that can be interpretively correlated with a similar rock association of the McGruer assemblage in the North Caribou belt of the Sachigo Subprovince.

A significant 90 million-years hiatus occurs between the youngest volcanism in the Pickle Lake belt, the Woman assemblage at 2836 Ma, and the oldest internal plutons at 2741 Ma, the Ochig Lake pluton and its associated stocks. During that interval, a major period of deformation is recorded as the D_1 event, preserved as the foliation and lineation fabric of Domain 1 (Figure 13). This could have coincided with or postdated the tectonic juxtaposition of assemblages. The domainal structural subdivision of the Pickle Lake greenstone belt distinguishes areas containing older structures of the D_1 event from parts of the belt, Domains 2 and 3, that are dominated by the deformational effects of external and internal pluton emplacements. The fact that the older D_1 deformation is preserved indicates that subsequent regional deformation, affecting the younger volcanic sequences of the Confederation and St. Joseph assemblages in the Meen-Dempster and Lake St. Joseph belts, did not produce a penetrative fabric as far north as the Pickle Lake belt. Therefore, the tectonic record of the Pickle Lake belt preserves a history in the northern part of the Uchi Subprovince that escaped the penetrative effects of the circa 2710-2700 Ma Kenoran Orogeny so prominently recorded in the southern half of the subprovince, e.g., the Lake St. Joseph belt.

Area 3

Geology of the Lake St. Joseph Area

Archean Rocks

Tectonostratigraphic Assemblages

The Lake St. Joseph greenstone belt (Figure 17), is best exposed in the western part of Lake St. Joseph where there are 4 volcanic cycles (Figure 18). These cycles were originally mapped and described by Clifford (1969; Clifford and McNutt 1971) who recognized sequences of Upper and Lower Volcanics and an overlying sequence of Upper Clastic Rocks. Berger (1981) recognized additional top determinations which permitted subdividing this region into 3 volcanic cycles. An additional, younger volcanic Cycle 4 was traced by Stott et al. (1987a, 1987b) along the length of Lake St. Joseph and it can also be partly inferred from the original mapping by Clifford (1969).

The volcanic cycles are each composed of tholeiitic basaltic flows and overlying dacitic to rhyolitic pyroclastic rocks. However, cycles 1 and 3 compare closely in age (2733 +3/-2 Ma and 2730±1 Ma respectively; Corfu and Stott 1993b) and in geochemical signatures (Clifford and McNutt 1971; and this report - see Geochemistry). Cycles 1 and 3 are part of the **Confederation assemblage** (Figure 19), which extends the length of the Uchi Subprovince, as described by Stott and Corfu (1991). These two cycles represent volcanism that is slightly younger than the eastern half of the Birch-Uchi greenstone belt, yet similar in age to the Bidou Lake Subgroup of the Rice lake greenstone belt in Manitoba (Turek et al. 1989). Cycle 1 of this belt is physically continuous with strata along the southern flank of the Birch-Uchi greenstone belt.

Cycle 2 is a basalt-rhyolite cycle with a U-Pb zircon age of 2724±2 Ma (Corfu and Stott 1993b) determined from the rhyolitic sequence. Cycle 4, which is dominated by a thick sequence of pyroclastic rocks of intermediate composition, has an age of 2713 +3/-2 Ma (Corfu and Stott 1993b). Cycles 2 and 4 are grouped as members of the **St. Joseph assemblage**, which can be traced along the southern part of the Uchi Subprovince into the Miminiska-Fort Hope greenstone belt as described by Stott and Corfu (1991) and Corfu and Stott (1993b).

The first 3 volcanic cycles were unconformably overlain in western Lake St. Joseph by a suite of clastic and chemical sedimentary rocks that form the **Eagle Island assemblage**.

Confederation Assemblage
Field Relationships

The volcanic cycles 1 and 3 are physically separated by cycle 2 of the St. Joseph assemblage. These three mafic to felsic volcanic cycles define an eastward-facing, steeply plunging anticline (*see* Figure 19) that is overturned and verging steeply southward (*see* Structural Geology). This stratigraphic-structural framework plus the closely similar ages of upper felsic units in both cycles 1 and 3 and the similar geochemical character of the basalts of cycles 1 and 3 imply that the volcanic cycles had been tectonically shuffled out of sequence. That is, cycles 1 and 3 are interpreted to represent the same basalt-dacite-rhyolite cycle of volcanism; the portion now referred to as cycle 3 evidently was tectonically separated and thrust-stacked on top of cycle 2.

The boundary of the Confederation assemblage with the St. Joseph assemblage (i.e., at the cycle 1-cycle 2 contact in Figure 19) is a disconformity; each assemblage shares the same major volcanic vent, the felsic flows and explosive products of which are well exposed among the islands on western Lake St. Joseph. The west boundary of cycle 1 is at a posttectonic granitic pluton (Blackstone Pluton) that imposed contact strain and metamorphic aureoles upon the Confederation assemblage; substantial erosion of the cycle 1 edifice apparently occurred before reactivation of the vent during St. Joseph volcanism (cycle 2); the west boundary of cycle 3 with cycle 2 is not clear and lies mainly within the lake, but is interpreted to be a fault on the basis of age determinations, with cycle 3 slightly but significantly older than the structurally underlying cycle 2. The relationship between cycles 3 and 4 is not clearly exposed; cycle 4 is much younger and could have been deposited either before or after thrust-interleaving of the other cycles.

The volcanic paleotopography in western Lake St. Joseph appears to have been partly preserved in cross section; the edifice of the shield volcano, now tilted on its side and composed of cycle 1 and a disconformable cycle 2 representing ractivation of the volcano, is centred with its proximal and vent facies in the nose of the anticline, the positioning of the anticline having been governed by the shape of the volcano.

Western Lake St. Joseph displays some of the best-preserved proximal and vent facies stratigraphy to be seen anywhere in the Superior Province. The dacitic-rhyolitic edifice of the Confederation and St. Joseph assemblages is built in each case upon a tholeiitic basalt base and shows evidence in each assemblage of erosion products in the flanking basins as expected for a volcano that emerged above the water surface. Clifford and McNutt (1971) interpreted this feature as a composite stratovolcano.

Field Descriptions
Mafic Metavolcanic Rocks

The lower unit of the Confederation tholeiitic basalt flows is over 2000 m thick. Individual flows in the lower half of the basaltic suite show an eastward progression from massive to pillowed phases but the individual pillow shapes do not generally provide reliable indications of stratigraphic top directions. Only local evidence of carbonate alteration occurs in the pillowed units. However, upwards through the basaltic strata, along the major anticlinal hinge line (the axis of the main volcanic vent), there is an increase in the presence of very small iron carbonate amygdules. This has produced an intensely pitted weathered surface which, along with locally abundant iron carbonate-quartz veins, characterizes the hinge zone of this anticline.

Intermediate to Felsic Metavolcanic Rocks

The upper unit, 500 m thick, is composed of local rhyolitic flows near vents on the flanks of the main vent, but is dominated by rhyolitic to dacitic pyroclastic deposits of proximal vent facies, which grade to more distal, finer-grained deposits on the flanks of this volcano (Clifford 1969; Stott et al. 1987a, 1987b). The proximal facies pyroclastic deposits, in the anticlinal hinge and locally along its southern limb, include clast-supported volcanic breccias, and tuff deposits with coarse lithic clasts. The vent zone is also marked by pervasive iron carbonate-filled vesicles in all rock types, local intense calcium carbonate alteration of basalt, silicification, abundant basaltic dikes and diatreme breccia pipes, and local massive sulphide clasts in the coarser pyroclastic deposits. The carbonatized basaltic dikes transect the stratigraphy through units of all 3 cycles.

St. Joseph Assemblage
Field Relationships

The St. Joseph assemblage is composed of volcanic cycles of tholeiitic basalt and calc-alkalic dacite and rhyolite. Its most extensive exposure is in the vicinity of Lake St. Joseph and the southern half of the Miminiska-Fort Hope greenstone belt. This is the youngest assemblage with ages of volcanism ranging from 2723 to 2713 Ma (Corfu and Stott 1993b). The assemblage represents an episode of volcanism that postdates the 2750 to 2730 million-year-old Confederation assemblage. The St. Joseph assemblage is the last episode of volcanism prior to the regional deformation that dominates the southern half of the subprovince. This assemblage locally strikes at a 30° angle to the southern boundary of the subprovince where the assemblage is terminated by the Sydney Lake - Lake St. Joseph Fault. The boundary of this assemblage with the Confederation assemblage marks a disconformable hiatus in volcanic activity preserved in western Lake St. Joseph.

Field Descriptions
Mafic Metavolcanic Rocks

The basal basalt member of cycle 2 is comparatively thin (<0.5 km), composed entirely of pillows, which are intensely iron carbonatized, with numerous basaltic dikes and local diatreme breccia dikes. Pervasive white weathering of the basalt flows increases in intensity eastwards (stratigraphically upwards) through the strata in the hinge zone of the anticline where pods and veins contain quartz and quartz+iron carbonate with stringers of pyrite in the carbonate. The quartz forms narrow "ladder" fracture fillings in the massive carbonate pods.

Intermediate to Felsic Metavolcanic Rocks

The basaltic base of this assemblage in western Lake St. Joseph is overlain by a thick mantle (over 2.5 km wide at the anticlinal hinge) of rhyolitic to dacitic pyroclastic deposits. The base of the rhyolitic suite is marked by a massive quartz-feldspar porphyritic flow, which progresses stratigraphically upward into an unstratified autoclastic breccia of angular to subrounded clasts of the underlying flow. Overlying this is a series of pyroclastic deposits. This pyroclastic sequence is typified in the anticline on Lake St. Joseph by rhyolitic, lithic tuff breccia and massive quartz porphyritic flow with minor dacitic tuff breccia to crystal tuff, especially near the top of the cycle.

Clast sizes diminish along the limbs of the anticline. In Johnston Bay, the upper member of cycle 2 is dominated by dacitic to andesitic tuff and associated volcaniclastic sediments, including argillaceous beds, graphitic schist and amphibole-rich iron formation. The units of both cycle 1 and cycle 2 are interpreted as the finer-grained volcanic and sedimentary deposits on a distal slope of an eroded volcanic edifice.

At the top of cycle 4, the coarsest pyroclastic deposits are to be found in the eastern part of Lake St. Joseph with tuff deposited into the westernmost part of this lake and similar deposits observed further east beyond Pashkokogan Lake. The pyroclastic sequence is typified by an upward progression towards the north from dacitic, lithic tuff breccia, to highly vesicular tuff breccia, to an increasingly mafic-rich dacitic to andesitic or basaltic lapilli tuff. The coarsest pyroclastic deposits are to be found north and northeast of Soules Bay. Further west, the sequence is represented by tuff beds that display a characteristic progression northwards from dacitic tuff to basaltic or andesitic tuff with locally abundant mafic lapilli clasts. This compositional change through the pyroclastic suite and the textural features are consistent with eruption, in part as an ash flow, from a compositionally zoned magma chamber. The volume of preserved pyroclastic effusion in this final, 2713 Ma episode of Uchi volcanism is greater than similar deposits in nearby sequences of the Confederation assemblage. Although the strata of upper cycle 4 show similarities to an eruption from a zoned magma chamber, the reconnaissance-scale of mapping in this project did not identify any evidence of resurgence which terminates a complete caldera cycle described by Smith and Bailey (1968). This upper part of cycle 4 is overlain by basaltic rocks exposed along the southern margin of the Lake St. Joseph batholith. The basalt could be the base of a fifth volcanic cycle.

The inter-relationships among the major stratigraphic components in the Pashkokogan Lake area and in the area south and west of Doran Lake have not yet been resolved. The intermediate volcanic rocks that outline a large fold on Pashkokogan Lake (Goodwin 1965) are similar to the dacitic to basaltic tuffs of cycle 4 on Lake St. Joseph. The inference is that cycle 4 (the St. Joseph assemblage) probably extends across the Pashkokogan Lake area; this is indirectly supported by the extension of this stratigraphy along strike, across the Seach-Achapi batholith, into the southern half of the Miminiska-Fort Hope belt, where the ages of volcanic strata (Corfu and Stott 1993b) are comparable to the St. Joseph assemblage.

Eagle Island Assemblage

Field Relationships

In the vicinity of Eagle Island in western Lake St. Joseph, Clifford (1969) identified an assemblage of clastic and chemical sedimentary rocks that he called the Upper Clastic Rocks, which from the map pattern and younging directions, unconformably overlie the volcanic rocks of the Confederation and St. Joseph assemblages. This sedimentary sequence was subsequently mapped by Berger (1981), and described as a product of a submarine fan environment by Meyn and Palonen (1980). At the base of this assemblage, deposits of eroded dacitic pyroclastic material lie upon the St. Joseph assemblage, the source of the detritus (Meyn and Palonen 1980; Berger 1981), and are succeeded upward by arenite- and wacke-sandstone beds, interbeds of mudstone, conglomerate and banded magnetite iron formation. Pebble clasts in the conglomerate have been successfully scavenged from arenite and iron formation beds, presumably deposited earlier in this submarine basin. An impressive range of sedimentary structures is preserved in this sequence. Meyn and Palonen (1980), using various sedimentary facies criteria, favour an interpretation of this sedimentary assemblage as the product of a submarine fan environment.

Field Descriptions

Clastic and Chemical Metasedimentary Rocks

The Eagle Island assemblage outlines a sedimentary basin-infill developed on top of the tilted volcanic cycles and described in some detail by Clifford (1969), Meyn and Palonen (1980) and Berger (1981). A basal sequence in this assemblage is composed of volcaniclastic material, which appears to have been derived mainly from the upper felsic volcanics of cycle 2. This was followed by a largely quiescent period during which much of the iron formation was deposited with intervening wacke beds. The Eagle Island assemblage possesses volumetrically significant banded magnetite iron formation interbedded with the wacke and arkose sandstone. Tight folding of the iron formation created sufficient enrichment of iron that Lake St. Joseph Iron Incorporated was encouraged to conduct detailed investigations in the 1970's for the possible economic potential of this iron resource.

This stage of chemical sedimentation was blanketed by a major submarine fan deposit (Meyn and Palonen 1980) that prograded southward away from the volcanic pile and included decreasing thicknesses of iron formation deposition. There is evidence (Berger 1981) that a major proportion of the epiclastic suite was derived from a felsic source, most likely from the felsic volcanic rocks that dominate the stratigraphy immediately north and west of these metasediments. The Sydney Lake-Lake St. Joseph Fault separates these rocks from higher grade biotite-bearing wacke to the south in the English River Subprovince.

There is sufficient evidence of slumping and dewatering in the clastic sediments of this assemblage to permit one to speculate that the earliest folds in the sedimentary rocks, first described by Clifford (1969) and which possess no associated cleavage, may be products of large-scale subsidence of the original depositional sequence. The subsidence could have been encouraged by the substantial thickness and density of iron formation beds in this unstable, clastic host, resulting in an abundance of dewatering features, sandstone diking, slump balls and slump folds. Subsequent regional folding would have tightened these folds and made their primary origin less obvious, creating the complexity of lineation orientations and refolded folds that was documented by Clifford (1969).

Other Metasedimentary Rocks

Major metasedimentary suites were originally mapped by Goodwin (1965) and Clifford (1969) and only modest revisions have been made to the original mapping of these units during this survey.

A major anticline plunging steeply to the east lies along the central axis of the Soules Bay metasedimentary sequence. The metasediments thus structurally underlie the upper dacitic part of cycle 4 of the St. Joseph assemblage. This sequence of sediments is composed of staurolite- and locally andalusite-bearing wacke-pelite couplets interbedded with magnetite iron formation.

Garnet is concentrated at the wacke-iron formation interface in most places, where iron was scavenged from the adjacent iron formation beds during prograde metamorphism. This sedimentary suite widens to the west and partially wraps around the posttectonic Doran Lake stock.

It is unclear as to whether or not this Soules Bay sequence stratigraphically underlies cycle 4 of the St. Joseph assemblage or has been tectonically interleaved with the volcanic units. If the latter has occurred, the sedimentary rocks could be younger than the volcanics and physically related to metasediments of the English River Subprovince or coeval with the Eagle Island assemblage.

Intrusive Rocks

Mafic Intrusive Rocks

Thick gabbroic sills and substratiform dikes have injected the upper part of volcanic cycle 4, cycle 3 and the Soules Bay metasediments. A large tabular gabbroic intrusion underlies part of central Lake St. Joseph; it is outlined by numerous gabbroic islands northeast of Brodribb Bay. There is some modest evidence of compositional zoning observed on the largest gabbroic island north of Brodribb Bay.

On the peninsula north of Pedlarpath Bay in eastern Lake St. Joseph, 3 mafic intrusions have been mapped, two of which contain an outer peridotite margin exposed along the shoreline. There are long tabular gabbroic sheets which have intruded the margin of the Soules Bay metasediments. One of these intrusions is mylonitized and trends along the southern shore of Doran Lake and into Thelma Lake. In general, all gabbroic intrusions acquired a tectonic fabric that corresponds to the regional strain fabric in the volcanic rocks.

A differentiated sill of peridotite to gabbro and local granophyre is intruded into volcanic cycle 4 in western Lake St. Joseph. A large gabbroic intrusion and several sills occur in proximity to this differentiated sill and may constitute a co-magmatic suite. The sill is a slightly discordant intrusion up to 500 m thick and extends about 11 km along strike with the volcanic strata. It transects the uppermost exposure of the Confederation assemblage and, according to Smith (1977) and Berger (1981), its magmatic layering and top direction conform with the northward-facing strata of cycle 3 of the Confederation assemblage and the basal part of cycle 4 of the St. Joseph assemblage. The sill complex appears to crosscut the boundary between the Confederation and St. Joseph assemblages. This sill, studied in detail by Smith (1977), is composed of 4 principal phases observed across strike:

1) medium-grained equigranular gabbro
2) quartz-bearing, locally glomeroporphyritic gabbro
3) magnetite-bearing leuco-gabbro or anorthosite
4) pegmatitic gabbro

The medium-grained gabbro phase is massive and homogeneous and contains stubby, euhedral hornblende crystals.

A quartz-bearing, dioritic phase is chracterized by medium-grained, stubby euhedral hornblende crystals, locally glomeroporphyritic; and by 2% fine-grained, rounded, white to blue quartz eyes.

The magnetite-bearing leucogabbro or anorthosite is composed of 3-5% white to blue, rounded to ribboned quartz eyes set in a plagioclase-rich groundmass. Hornblende is present as fine-grained, stubby, euhedral crystals. It is intimately grown with fine-grained magnetite.

The pegmatitic gabbro, locally in contact with anorthosite, is composed of large pods of epidote+plagioclase+quartz and pods of chlorite+magnetite in a fine to medium-grained groundmass of stubby hornblende and fine-grained interstitial plagioclase.

Local gabbro dikes intruding the surrounding volcanic envelope locally contain small, rounded ultramafic to gabbroic inclusions.

Differentiation in this complex sill is also displayed by minor dunite metamorphosed to an olivine pseudomorph assemblage (serpentine-magnetite-calcite-chlorite), succeeded by more voluminous pyroxenite and gabbro with abundant pegmatitic clots. The stratigraphic top direction was determined by Smith (1977) from several features including upward-decreasing anorthosite content of the plagioclase and increasing quartz content, cross-stratification, and greater concentrations of less dense felsic minerals in the upper parts of the pegmatite clots.

Felsic Intrusive Rocks - Stocks within the belt

Doran Lake Stock

The Doran Lake stock is a posttectonic intrusion of potassic feldspar-megacrystic, hornblende granite to local syenite. It intruded into a pre-existing anticline, the hinge of which trends through Soules Bay on Lake St. Joseph. The stock displays a medium-grained, inequigranular and unmetamorphosed lithology with little evidence of dikes; inclusions of gabbro occur within the core of the pluton and on the northern margin. Such plutons like the Doran Lake stock show petrographic similarities to hornblende diorite-monzonite-granodiorite of the Shebandowan greenstone belt near Thunder Bay; this suite is postulated by Stern et al. (1989) to be associated with a mantle-derived sanukitoid suite. A number of these plutons appear to be aligned along the southern margin of the Uchi Subprovince (OGS Map 2542).

Riach Lake Stock, Benmeen Lake Stock and the Pashkokogan Lake Stocks

Several late plutons are composed of homogeneous, quartz-phyric, biotite granodiorite to monzogranite. Each pluton possesses a weak to moderate foliation that conforms near its margin to the shape of the pluton perimeter. The medium-grained quartz phenocrysts define a very steep shape-lineation which contrasts with the regional stretching lineation of the tectonic fabric in the surrounding greenstone belt and can therefore be inferred to have formed during magmatic emplacement. These small stocks are unmetamorphosed and postdate the main period of regional deformation and metamorphism that affected the surrounding volcanic rocks. Riach Lake stock possesses fine-grained epidote in association with biotite. Petrographic descriptions of these stocks are given by Goodwin (1962, p.34) and Sage et al. (1982, pp.184, 192).

Felsic Intrusive Rocks - Plutons external to the belt

Lake St. Joseph Batholith

The Lake St. Joseph batholith can be subdivided into its plutonic components as shown on Figure 17 (from Stott et al. 1987a, 1987b). This batholith is an example of the structural and lithological complexity of batholiths and an example of the long history of thermal and structural reactivation of its components. This batholith illustrates some basic features observed in several of the larger batholiths common to granite-greenstone terranes (cf., Schwerdtner et al. (1979) who described these features in batholiths of the Wabigoon Subprovince).

1. The Lake St. Joseph batholith is subdivided into areas of older, metamorphosed and tectonized tonalite to granodiorite (the multi-phase **Pembina Tonalite Gneiss** and the homogeneous foliated **Searson Tonalite**) and younger plutons of granodiorite to monzogranite that contain strain fabrics formed during plutonic emplacement. The younger plutons (**Osnaburgh Pluton, Carling Pluton and Twiname Stock**) display little or no evidence of metamorphism.

2. The older tonalite phases listed above comprise the central core of the batholith. The oldest tonalite phase in the Pembina Tonalite Gneiss (2887±3 Ma; Corfu and Stott 1993b) occurs with other tonalitic phases, cut by several sets of tonalite and granite dikes. The structural complexity and the record of multiple intrusive phases contrast markedly with the younger plutons, which contain fewer rock types and very weak planar fabrics attributed to their original emplacement. The large elliptical gneiss terrain dips consistently southward and resembles a tilted dome. It is bordered to the north, through Pembina Bay, by an amphibolite belt-remnant, which is associated with hornblende-rich tonalite to quartz diorite. This narrow supracrustal remnant forms a thin magnetic expression that arcs and trends westward towards Honderich Lake. Southeastward towards Carling Island, it largely manifests as a hornblende-rich tonalite to quartz diorite. The fine-grained tonalite gneiss has been dated, as noted above, where it is banded with thin foliation-parallel medium-grained granodiorite to monzogranite layers. The gneissosity is formed in part by leucotonalite bands and by these granitic layers.

This domical gneissic area may be the exposed portion of a buoyant tonalitic mass underlying at least part of the greenstone belt. It may be related to rock underlying the Pickle Lake belt; it compares in age with inherited zircons in the Pickle Crow assemblage of the Pickle Lake belt, dated at 2892 +5/-2 Ma (Corfu and Stott 1993b).

3. Long slivers of volcanic and clastic sedimentary rocks form narrow screens that subdivide parts of the tonalitic core. Other supracrustal slivers form discontinuous screens between the tonalite and the younger plutons. Such features are similar to those described by Schwerdtner et al. (1985) in the Wabigoon Subprovince and commonly occur in many other large granitoid batholiths of the Superior Province.

4. The younger granodiorite-monzogranite plutons are tabular to crescent-shaped and separate the tonalitic core from the surrounding volcanic belts. Field relations indicate that they have been injected along the interface between an older tonalitic terrane and the surrounding greenstone belt, and resemble sheet intrusions, comparable to those described by Schwerdtner et al. (1983) in the central part of the Wabigoon Subprovince. The Osnaburgh Pluton has been dated at 2694±1 Ma (Corfu and Stott 1993b) and the Carling Pluton so closely resembles this intrusion in its lithologic characteristics that they are probably temporally and co-magmatically related. These biotite-bearing, fine to medium-grained plutons (e.g., the Osnaburgh and Carling plutons) are petrographically similar and possess varying proportions of potassium feldspar megacrysts. In places, the tabular megacrysts are sufficiently abundant to form clear primary flow textures. These plutons ar generally free of supracrustal inclusions. They are unmetamorphosed and contain inclusions of tonalite and minor amphibolite near the pluton margins. The Osnaburgh Pluton imposed a narrow contact strain aureole along its northern margin, for example on Caley Lake. The eastern margin is a highly constrictive zone of supracrustal rocks squeezed between this pluton and the batholith to the east. The Carling Pluton is strongly deformed along its southern margin with the greenstone belt. This is a magmatic fabric since the fabric is overgrown by late poikilitic megacrysts of K-feldspar.

5. The young, posttectonic, peraluminous **Twiname Stock** is a comparatively large example (10-13 km wide) of a suite of typically small pegmatite stocks and dikes that occur in the southern half of the Uchi Subprovince. This stock probably bears a temporal and genetic relation to the peraluminous granite plutons in and adjacent to the English River Subprovince. The Twiname Stock is a massive body of muscovite-granite pegmatite with well distributed garnet and tourmaline. This body is interpreted to be related to the muscovitic to two-mica pegmatite dikes widely observed to the southeast . It may also be co-magmatic with the lithium pegmatite occurrence on East Pashkokogan Lake (Figure 20).

6. The late to posttectonic plutons imposed contact strain aureoles on both the surrounding volcanic belt and the tonalitic core. The imposed strain is recognized most particularly in adjacent volcanic rocks by steeply plunging lineations of prismatic amphibole crystals and mineral aggregates within the aureole; these lineations are parallel to the magmatic stretching lineations in the pluton, and are accompanied by a contact thermal aureole imposed on the supracrustal envelope.

Bamaji-Blackstone Batholith

The large homogeneous Blackstone Pluton, within the Bamaji-Blackstone batholith, is composed of granite to granodiorite. It is unmetamorphosed and appears to have postdated the main record of regional penetrative deformation. It imposed a contact strain aureole upon the adjacent Confederation assemblage basalts in westernmost Lake St. Joseph, as illustrated by highly flattened and amphibolitized pillows immediately adjacent to the intrusion (Clifford 1969). This pluton, dated at 2702±1 Ma, was transected by a branch of the Sydney Lake - Lake St. Joseph Fault (Stott and Corfu 1991) and thereby provides a maximum age for at least part of the transcurrent movement along the fault system. The map pattern and the postmetamorphic timing of the pluton show that it postdates, and thereby provides a minimum age to, the large scale folding of the volcanic and sedimentary assemblages in western Lake St. Joseph.

Structural Geology

The principal structural elements, bedding, stratigraphic top directions, plus tectonic foliations, lineations and folds are shown on OGS Maps P.3550-3551 (Stott et al. 1987a, 1987b).

Bedding

Stratigraphic layering in volcanic rocks is recognized particularly by the contacts between pyroclastic and resedimentation units of contrasting composition or grain size. This layering in many areas is parallel or subparallel to the planar-preferred alignment of minerals, i.e., the foliation. Elsewhere, particularly in the vicinity of fold hinges, differences in bedding and foliation strikes are recorded and provide the principal means (apart from bedding top indicators) of defining the existence of some folds, such as the anticline along Soules Bay.

Owing to the generally higher levels of strain in eastern Lake St. Joseph and Pashkokogan Lake, compared to western Lake St. Joseph, few bedding top directions were determined in the volcanic rocks. North of Soules Bay, a pyroclastic ash flow sequence has been mapped within the upper intermediate volcanic unit of cycle 4 and well preserved bedding units can be traced amongst the islands and headlands on the lake.

In western Lake St. Joseph, the bedding is much better preserved and top direction indicators are more abundant amongst sedimentary and pyroclastic units with minor reliable pillow top determinations. The top directions generally face north and eastward, defining a large fold hinge centred on a volcanic edifice near the southern margin of the belt and best represented in cycles 1 and 2. However, some local southward top directions within cycle 4 imply more complex local folding is present. Top indicators critically show that the Eagle Island assemblage is a synclinal sedimentary sequence, sitting unconformably upon an eastward facing stack of volcanic cycles.

Foliations and Folds

In general, a planar preferred alignment of minerals is recorded in all rock types and this preserves at least a partial record of either local or regional flattening strain as well as a component of simple shear close to the faulted southern boundary of the Uchi Subprovince. Some late to posttectonic plutons preserve an internal foliation that conforms to the shape of the pluton and can be shown, principally from the lineation orientations, to be related to pluton emplacement.

Otherwise, the planar fabrics reflect tectonic flattening. The foliation generally strikes subparallel to the trend of the subprovince and its southern boundary; it dips to form a fan or flower structure with foliation dipping northwards in the southern half of the belt and southwards in the northern half of the belt.

The anticline along Soules Bay is based on bedding-cleavage relationships and top directions. Since the layering dips generally southward, the fold is overturned, verging to the northwest.

In western Lake St. Joseph, the dominant foliation parallels the bedding outlining the large east-closing anticline in that area, which likely corresponds with the Soules Bay anticline on strike. An east-striking foliation parallel to the axial plane of this western anticline is observed particularly in the hinge of this fold. Details of the structural sequence have been documented by Clifford (1969).

Lineations

Lineations are defined by mineral shapes and linear, dimension-preferred alignment of features such as varioles, clasts, grains and vesicles. In general, a single dominant lineation is observed on a foliation plane and in the southern half of the belt, these lineations plunge northward, down the foliation dip. In the northern half of the belt, closer to the Lake St. Joseph batholith, the lineations plunge southward (down dip) or eastward. A record of different generations of lineations has been documented by Clifford (1969) in the vicinity of Eagle Island, where the sedimentary assemblage has been infolded to form a syncline that was subsequently refolded on the main east-striking anticline.

Interpreted Sequence of Magmatic and Structural Events

The Lake St. Joseph greenstone belt records a critical part of the structural history of the Uchi Subprovince in that the events postdating 2713 Ma volcanism include thrust stacking of volcanic assemblages, crustal exhumation and erosion followed by orogen-parallel folding, plutonism and later transcurrent faulting. The basic features of this sequence of events are given here and summarized in Figure 21.

Observations by Clifford (1969, 1972), Berger (1981) and Stott et al. (1987a, 1987b) are combined with the age determinations (Corfu and Stott, 1993a, 1993b) to postulate a sequence of events as summarized below and in Figure 21. The assembly of the Lake St. Joseph greenstone belt involved tectonic repetition (*see* Figure 19) of 2 assemblages: the Confederation assemblage, comprising high-magnesium tholeiitic basalt flows and an overlying 2734 Ma cap of rhyolite; and the St. Joseph assemblage comprising at least 2 cycles of volcanism, one of tholeiitic basalt capped by a 2723 Ma dacite to rhyolite pyroclastic edifice and the second of basalt and 2713 Ma dacite. In the western part of Lake St. Joseph, these 2 assemblages, separated by a hiatus, formed the core of a stratovolcano (Clifford and McNutt 1971). The evidence from age determinations

(Corfu and Stott 1993b) of volcanic cycles in this area plus trace element and rare earth element geochemistry (Clifford and McNutt 1971; this report, *see* Geochemistry) show that the 2 assemblages were repeated by fault imbrication so that in Figure 19, cycle 1 (Confederation assemblage), which shares the same volcanic vent system as the younger and overlying cycle 2 (St. Joseph assemblage), recurs as cycle 3, overlain by cycle 4, the St. Joseph assemblage. The volcanic units in all cycles show dominant way-up directions towards the north and east. This tectonic stacking of strata was rapidly followed by erosive exhumation of continental crust exposed from the north, debris from which forms the unconformably overlying sedimentary Eagle Island assemblage. This assemblage includes deposits of both clastic detritus and thick iron formation beds (a submarine channel fan?; Meyn and Palonen 1980) adjacent to turbidite of the English River assemblage (fore-arc basin?; Langford and Morin 1976; Williams 1987). Deposition of the Eagle Island assemblage is speculated to have been accompanied by soft-sediment slumping, subsidence, dewatering and folding of the proximal basin. This period of sedimentation was followed by collision between the Uchi-Sachigo and the Winnipeg-Wabigoon superterranes (Stott and Corfu 1991) across a suture zone (the tectonic expression of a collision zone; Howell 1989) underlying what might have been a chain of English River basins to form an accretionary prism. The collision stage is characterized by the presence of orogen-parallel folds, including the anticline that folds the Eagle Island and older assemblages; the abundance of elongate, orogen-parallel granitic plutons near the subprovince boundary; the prevalence of eastward-striking schistosity and bedding in the southern half of the subprovince; and the Sydney Lake-Lake St. Joseph Fault, which appears to have initiated as a thrust fault (judging from the volume of St. Joseph assemblage strata removed by the fault near Pashkokogan Lake), and terminated as a transcurrent fault. This postulated sequence of events culminated in the emplacement of late to posttectonic granodiorite plutons, including the Blackstone Pluton at 2702±1 Ma, which was cut by a branch of the Sydney Lake-Lake St. Joseph Fault and shows kinematic evidence of limited dextral, transcurrent displacement. The evidence for sense of shear along this fault includes numerous Z-folds of layers of banded magnetite-iron formation and wacke-sandstone in the fault zone; duplex stacking of sandstone and iron formation by transcurrent thrusting; sygmoidal C/S shape fabrics; extensional shear bands within mylonitized metasedimentary and tuffaceous rock; and abundant S-kink folds in schistose, magnetite-iron formation and sandstone. Some of these features are illustrated by Stott and Corfu (1991, their Fig. 6.22).

The Lake St. Joseph fault has now been shown by reconnaissance mapping (e.g., Williams 1988) to be continuous with the Sydney Lake fault south of Red Lake. The features of this fault have been documented by Stone (Stone 1977, 1981), Breaks et al. (1978) and Schwerdtner et al. (1979). The east-striking Sydney Lake-Lake St. Joseph fault zone is steeply dipping and can be traced along the Uchi-English River subprovince boundary for at least 440 km from Lake Winnipeg in Manitoba to Pashkokogan Lake where the fault joins 2 other fault zones (the Miniss River and Pashkokogan Lake-Kenoji Lake faults) that cross the English River Subprovince. The Sydney Lake-Lake St. Joseph fault zone, typically 1 to 2 km wide, is generally a continuous structure south of Lake St. Joseph but in places (e.g., south of the Red Lake greenstone belt) it contains a braided network of narrow shear zones. Kinematic indicators and evidence of transcurrent displacement across this fault show a consistent right-handed sense of movement. If the direction of regional compression was constant at the time of transcurrent faulting, then dextral transcurrent movement across northeast-striking splays of this fault require that the maximum compressive stress must have been along a northwest-trending (approx. 300°) axis (Stone 1977).

Regional Metamorphism

The regional pattern of metamorphism in the central Uchi Subprovince is shown in Figure 22. Zones of low and high grade metamorphism in the greenstone belts reflect a complex history of metamorphic events that arose from episodes of burial, crustal thickening, thrusting, baking by felsic intrusions of all sizes and ages, and late hydrothermal alterations focussed along shear zones. The greenstone belts have been subjected to low pressure Abukuma-type metamorphism ranging from very low to high temperature grades. Greenschist facies (low grade) metamorphism is prevalent within the core of the greenstone belts and retrograde chloritic schist is most evident in sheared basaltic sequences; e.g., in the Central Patricia - Pickle Crow region and east of Highway 808 (Figure 15). Acicular actinolite-plagioclase-chlorite-epidote, actinolite-plagioclase, and chlorite-biotite-plagioclase are commonly observed mineral assemblages in the basaltic rocks.

Amphibolite facies is evident as metamorphic aureoles in the volcanic envelopes surrounding the internal plutons, e.g., Ochig Lake pluton, and adjacent to the external granitoid batholiths as generalized on Figure 22. Hornblende-plagioclase, hornblende-plagioclase-epidote-diopside, and hornblende-plagioclase-epidote-diopside-garnet are typical mineral assemblages in these amphibolitic domains. The medium grade metamorphism is evident in some areas close to the English River Subprovince boundary, e.g., eastern Lake St. Joseph belt where a broad domain of amphibolite facies rocks occurs. In western Lake St. Joseph, Clifford (1969) identified a typical basaltic assemblage of hornblende-almandine-quartz-plagioclase±epidote within the thermal aureole of the Blackstone Pluton. This contrasts with the regional greenschist facies metamorphism of most of the belt and the broader, high to medium-grade thermal metamorphism and higher pressure conditions present in the adjacent English River Subprovince (Thurston and Breaks 1978; Breaks 1991).

Conditions of low pressure metamorphism in eastern Lake St. Joseph (Goodwin 1965; Thurston and Breaks 1978) are evident from medium-grade assemblages in wacke-pelite turbidites bearing staurolite + andalusite. These are exceptionally well displayed in the Soules Bay area of Lake St. Joseph. Chipera (1985) summarized the conditions of metamorphism in the Lake St. Joseph area. The presence of andalusite limits the pressure conditions of metamorphism to less than 4 kbars (Holdaway 1971). The common assemblage of chlorite-muscovite-biotite in sedimentary rocks shows that the temperature was greater than 400°C but this assemblage would also break down where temperatures exceed 500° to 550°C. In addition, since cordierite has not been observed, this limits the conditions of metamorphism to less than about 550°C (Winkler 1979). Staurolite however, is widespread in pelitic rocks at Soules Bay (Lake St. Joseph) and at Whitmore Lake (Meen-Dempster belt) and locally coexists with almandine garnet. The presence of staurolite indicates that temperature conditions probably reached 525° to 550°C at least locally (Hoschek 1969). Therefore, the typical conditions of metamorphism in the greenstone belts, outside of thermal aureoles adjacent to the plutons, are constrained to pressures of less than 4 kbars and temperatures less than 550°C.

Isotopic age determinations on several plutons, internal and external to the greenstone belts, provide general constraints on the timing of contact metamorphism and earlier regional metamorphism. In general, the most notable thermal aureoles around the late granitic plutons were imposed at approximately 2700 Ma, during and subsequent to the main episodes of regional, penetrative deformation across the southern half of the subprovince; yet they postdate the *circa* 2740 Ma period of contact metamorphic aureoles produced around the Ochig Lake pluton and its associates in the Pickle Lake belt.

Geophysical Patterns

Aeromagnetic and Electromagnetic Patterns

Owing to the general sparcity of Proterozoic diabase dikes in the Uchi Subprovince, in distinct contrast to the Abitibi belt for example, it is possible to extract meaningful patterns from the aeromagnetic maps of this region. There is a close correlation between regional magnetic anomalies and major geological units; electromagnetic conductors in the greenstone belts provide valuable constraints on the stratigraphic framework in the absence of bedrock exposures.

There are several features worthy of general comment.

1) There is a close correspondence between major geological units and the aeromagnetic patterns. The lowest magnetic susceptibility within the subprovince is recorded generally within the greenstone belts, apart from the banded magnetite ironstone units and within some trondhjemitic plutons. The younger, granitic plutons and some tonalite gneiss terrains generally show a higher magnetic susceptibility.

2) Some of the late to posttectonic granite plutons are prominently displayed on aeromagnetic maps by virtue of their high magnetite content. Examples of the latter are found among the *circa* 2700 Ma, magnetite-rich, Williams granite-granodiorite suite (Stott and Corfu 1991); *compare* the Williams suite on OGS Map 2576 (OGS 1991) with the corresponding aeromagnetic signature on OGS Map 2585 (Gupta 1991); this suite dominates the Berens River Subprovince.

3) One can integrate, with regional geological mapping, a qualitative analysis of the aeromagnetic patterns and susceptibility variations within granitoid batholiths to distinguish bodies of foliated tonalite and gneiss from bodies of more massive, younger granite and granodiorite. This has permitted us to subdivide most of the batholithic complexes into their component parts to varying degrees of confidence depending upon the available geological control. As a typical example, the aeromagnetic patterns of the Seach-Achapi granitoid complex, east of Pickle Lake belt (OGS Map

2585, Gupta 1991), closely correspond to the separate granitoid units shown in Figure 11. The tonalite gneiss in the central core of the batholiths displays the most complex pattern of higher susceptibilities, contrasting with the susceptibility patterns in the adjacent granodiorite plutons.
4) Identification of faults, and sense of displacement across them can be inferred from aeromagnetic maps, and can be confirmed on the ground from local sense-of-shear criteria. Most prominent are the Bear Head and Sydney Lake-Lake St. Joseph fault zones (Figures 8 and 19) described by Osmani and Stott (1988).
5) Aeromagnetic trends within the greenstone belts, notably from iron formation units, have been used in conjunction with stratigraphic markers and electromagnetic conductors to interpret the presence of obliquely juxtaposed tectonic assemblages and their suspected fault boundaries, especially in terrains covered by extensive overburden. For example, in the Pickle Lake belt the combined geophysical features show that the unnamed volcanic domain to the north appears to be tectonically transected by the Pickle Crow assemblage, implying a juxtaposition of two assemblages along a fault (Figure 12). A similar feature occurs in the northern part of the Miminiska-Fort Hope belt (Stott and Corfu 1991).

Paleomagnetic Patterns

Paleomagnetic studies have only recently been ventured in the Uchi Subprovince, (Hale and Lloyd (1989, 1990; Costanzo-Alvarez and Dunlop 1990). From selected granitic and gabbroic plutons in both areas, these workers obtained stable magnetizations that are inconsistent with the Archean Aparent Polar Wander (APW) Path for the Superior Province (Irving 1979). Both sets of workers have advocated a revision to the APW Path (eg. Hale and Lloyd 1990, Hale 1991). As additional stable magnetizations become available from late Archean plutons in different subprovinces, one can anticipate that a new APW Path will provide useful constraints on the timing and nature of post-2700 Ma intra-cratonic crustal movement. However, determinations on late-tectonic plutons (2.7 Ga) in both Uchi and Abitibi subprovinces show that the plutons bear very similar paleomagnetic poles and accordingly indicate that the amount of intracratonic movement across the Superior Province after about 2.7 Ga was rather limited (Hale 1991).

Block rotation of crust between late, parallel faults has been proposed on a regional scale, especially in the Sachigo Subprovince, where clockwise rotations are evident from a qualitative analysis of asymmetric, sygmoidal aeromagnetic patterns (Osmani and Stott 1988). Such clockwise rotation on a local scale has been suggested independently by Hale and Lloyd (1989, 1990) in the central part of Uchi Subprovince by comparing the orientations of stable remanent magnetizations of plutons within and outside of the rotated block. With available age determinations of plutons (Corfu and Stott 1993 a, 1993b), Hale and Lloyd concluded that, at some stage in the interval between 2747 and 2722 Ma, a block of the Meen-Dempster belt, containing the Kawashe Gabbro, rotated clockwise relative to the Dobie Lake Pluton, north of the belt. This block rotation compares closely with the conclusions derived from geological and structural arguments as presented for the Meen-Dempster greenstone belt under Interpreted Magmatic and Structural Sequence of Events.

Proterozoic Rocks

Diabase Dikes

Proterozoic magmatism is represented by a single northwest-trending diabase dike passing through the Pickle Lake belt. It is a quartz diabase with a paleomagnetic pole position that places it at about 2.0 Ga in age on the Proterozoic apparent polar wander path (C. Hale, University of Toronto, personal communication, 1990). The dike is approximately 460 km long and about 90 m wide (Osmani, 1991). It is well exposed in various parts of the Pickle Lake belt, for example in the midst of the Hooker-Burkoski stock. Other small diabase dike segments have been observed during this project in other belts nearby, notably two small exposures of a westward trending Proterozoic diabase dike northeast of Brodribb Bay on Lake St. Joseph. One of these was previously mapped by Goodwin (1965).

Regional Geochemistry

From the greenstone belts and several felsic and mafic plutons, 328 samples were obtained for whole rock geochemical analysis. The geochemical analyses of the volcanic samples are grouped by tectonic assemblage and subdivided between mafic and felsic compositions in Tables 4 -1 and 4-2. The geochemistry of samples from selected mafic and felsic intrusions is given in Tables 4-3 and 4-4.

Whole rock geochemistry of major oxides, selected trace elements and rare earth elements was provided by the Geoscience Laboratories of the Ministry of Northern Development and Mines. Analytical techniques used include: XRF for the major oxides, Atomic Absorption and Inductively Coupled Plasma/Optical Emission Spectroscopy for trace elements and ICP/Mass Spectrometry for the rare earth elements. Information regarding the detection limits and analytical precision for each element is available at the MNDM Geoscience Laboratories. The following discussion mainly reviews the basalt geochemistry of each of the tectonic assemblages as illustrated in Figures 23-1 to 5. Owing to the reconnaissance scale of this project, the geochemical character of each tectonic assemblage is described in general terms only. The geochemical data is displayed without excluding samples that display hydrothermal alteration. Limited or uneven sampling distribution does not permit detailed descriptions of possible group- and formation-scale stratigraphic subdivisions within these assemblages; indeed, most samples were taken along transects across each tectonic assemblage and this must be recognized in any interpretation of the results. Nevertheless, the results provide some insight and a basis for future investigations; not surprisingly, the central Uchi Subprovince is dominantly characterized geochemically by thick, subvertically dipping plains of tholeiitic basaltic flows and intervening calc-alkalic dacitic to rhyolitic pyroclastic and flow deposits. The reader should also note that general subdivision of volcanic samples into felsic and mafic compositional subtables in Table 4 is based on the original field names; some of the samples labelled as intermediate pyroclastics in the field, particularly in the Confederation and St. Joseph assemblages, possess more mafic compositions but are grouped here with the more intermediate compositions since they form parts of mappable intermediate pyroclastic units (e.g., Tables 4-2h and 4-2k).

Discussions on tectonic settings are tentative owing to the limitations of the available trace element geochemistry and the limited precision of analyses made in the mid 1980's. More substantial discussions on the environment of deposition of the volcanic suites requires a re-analysis of the geochemical samples for additional trace elements and radiogenic isotopic ratios using more modern analytical equipment.

Alteration - General Observations

Most samples are taken from relatively fresh and less altered sites. The most extensive carbonate alteration observed in the central Uchi subprovince occurs in three areas:
1) Two zones in the Pickle Lake belt (Figure 15), with Ca-carbonatization and local silicification in the vicinity of the Pickle Crow gold deposits and Fe-carbonatization and chloritization in a northeast-trending zone parallel to and east of Highway 808 in the northern half of the belt; both zones have been subjected to extensive gold exploration;
2) In western Lake St. Joseph, along the axis of the large fold centred on a volcanic edifice, there is extensive Ca-carbonatization, Fe-carbonatization and spilitization (bleaching) of basaltic flows and dikes.
3) Outside of this report area, in the Fry Lake - Bamaji Lake greenstone belt, south of the Meen-Dempster belt, there is extensive carbonatization of sheared supracrustal rocks. Apart from these areas, most penetrative alteration is restricted to discrete shear zones.

Virtually all mafic volcanic rocks in the area are subalkaline (Figure 23-1 a to e) but slight alkaline enrichment alteration is apparent in some mafic volcanic samples.. The more silica or alkali-enriched compositions of some basaltic units, apparent on the Jensen plots (Figure 23-2a-e), reflect alteration, particularly within the Pickle Crow assemblage in the Pickle Lake area. The alteration index ($MgO + K_2O$)/($MgO + K_2O + CaO + Na_2O$) (Date et al. 1983) from all mafic volcanic samples reveals generally normal values (0.30 to 0.50 typically); widespread spilitization, especially in western Lake St Joseph, is evident from Na_2O enrichment values (<0.30) but hydrothermal alteration where alteration index values exceed 0.60 is rare, occurring only in the sample set taken from the Pickle Crow assemblage (e.g., 0.81 from sample 86GRS-3203) within and along strike with the strongly carbonatized volcanic rocks that host the Pickle Crow gold deposits.

Mafic to Intermediate Volcanic Rocks

General Observations:

Mafic volcanic rocks in the central part of the Uchi Subprovince are dominantly tholeiitic with some calc-alkaline suites in the Pickle Crow, Woman and Confederation assemblages. Ultramafic volcanic rocks are rare in this region. Chondrite-normalized rare earth element patterns are generally flat, ranging up to 10X chondrite values and typical of most Archean tholeiitic suites. Jensen AFM diagrams (Figures 23-2) reflect a range of tholeiitic to calc-alkalic compositions and the tectonomagmatic diagrams of Mullen (1983) (Figures 23-4) and Pearce and Cann (1973) (Figures 23-5) show broad scatters that probably reflect the predominant island arc setting of the volcanic rocks in most of the assemblages. The assemblages are not simply defined geochemically and as the Woman assemblage illustrates, there is probably a spectrum of island arc and ocean floor volcanic strata tectonically interleaved within these assemblages.

The Northern Pickle Assemblage

A single sample of basalt, from a location just west of Kawinogans River, is taken from a basaltic unit that is interbedded with a magnetite-chert iron formation. Rocks in the area of this sample are well preserved and not strongly deformed. The sample shows major element features (Figure 23-1a) of iron-rich tholeiitic basalt (16.2% total Fe, 1.55% TiO_2) yet with low SiO_2 (45.1%) and Na_2O (0.79%).

Tectonic Setting:
The flat pattern of rare earth elements (REE) and the tectonomagmatic plots of Figures 23-4a and 23-5a, are typical of modern mid-ocean ridge basalts (MORBs); the single sample is therefore interpreted as part of a basaltic suite deposited initially on an ocean floor.

The Pickle Crow Assemblage

A selection of 47 mafic volcanic samples of the Pickle Crow assemblage is taken mainly from the area east of Pickle Lake, between the Hooker-Burkoski stock and Kawinogans River. There is more evidence of iron-rich tholeiitic basalt amongst these samples than in the Woman assemblage (compare Figures 23-2b and 2c) but this might reflect the limited sample set of the latter assemblage. In addition, the most intensely silicified and/or carbonatized basalts are widely observed in the field in the region surrounding the former Pickle Crow mines. North of the Hooker-Burkoski stock, there are parts of the basaltic sequence that show progressively greater silicification across the stratigraphic section. The variable alteration in this region is exemplified by several samples ranging from the most intense silicification of basalt (65.2% SiO_2 in sample 86GRS-1181) to calcite carbonatized basalt of sample 86GRS-1189 and generally by the scatter of analyses across the calc-alkaline field of the Jensen-AFM diagram (Figure 23-2b). The volume of hydrothermally altered rock is greater here than in other tectonic assemblages with the possible exception of those parts of the Confederation and St. Joseph assemblages forming a volcanic vent and proximal stratigraphy in western Lake St. Joseph.

Tectonic Setting:
The chondrite-normalized patterns of rare-earth element analyses shows a predominance of flat MORB-like signatures, with up to 10x chondrite values. One sample (86-4169) of calc-alkaline basalt shows light-REE enrichment. For samples (Table 4-1e and f) with approx. 8% MgO, the TiO_2% is about 0.6-0.7, with Al_2O_3/TiO_2 ranging from 14 to 23 and Zr/Y values ranging from 4.4 to 2.7. These characteristics are generally typical of N-type (normal) MORB ocean floor basalts (Le Roex 1987). The spread of values in the major element diagram of Mullen (1983), Figure 23-4b, reflects relative alteration depletion of MnO and is inconsistent with the above and the typical character of ocean floor basalts in Figure 23-5b.

The Woman Assemblage

The mafic to intermediate volcanics of the Woman assemblage were sampled mainly in the western half of the Meen-Dempster belt. High magnesium tholeiitic basalt along the northern margin of the belt and calc-alkaline basalt in the vicinity of Kaminiskag Lake (Figure 5), as shown by the two clusters in the Jensen-AFM diagram (Figure 23-2c), indicate that significant diversity exisits within this assemblage. Values of MgO generally range from 5 to 9 wt%.

Three basaltic samples from the vicinity of Kaminiskag Lake display generally flat REE patterns (Figure 23-3c). A slightly enriched light-REE trend is from a sample east of Pickle Lake, north of the Second Loon pluton (Figure 11).

Tectonic Setting:
Characteristics of samples (Tables 4-1h and i) with approx. 8% MgO include: TiO_2% ranging 0.6 to 1.1, Al_2O_3/TiO_2 ranging from 14 to 25, and Zr/Y ranging from 4 to 6, are generally consistent with N-type MORB oceanic basalts. The distribution of analyses in the tectonomagmatic diagrams (Figures 23-4c and 23-5c) reflect a spectrum of possible settings from island arc calc-alkaline to tholeiitic sequences and ocean floor tholeiites. This complex spectrum will require additional sampling, with greater analytical precision, to subdivide the Woman assemblage into its component depositional environments.

The Confederation Assemblage

There is a broad diversity of major element compositions of the mafic volcanic rocks in the Confederation assemblage. This assemblage hosts a range of high-iron to high-magnesium tholeiitic basalts with a rare, thin unit of basaltic komatiite on western Meen Lake. The diverse analyses in the Jensen AFM diagram (Figure 23-2d) are mainly from intensely sheared and hydrothermally altered rocks south of Kaminiskag Lake and north and south of Dempster Lake.

Tectonic Setting:
The REE plots of Figure 23-3d show flat to slightly convex, approx. 10x chondrite patterns, typical of tholeiitic sequences. The interlayering of the basalt with intermediate to felsic volcanics reflects the island arc character of the assemblage. Two samples, 84-0032 and 84-1184, just above and below the main dacitic tuff unit in the Meen-Dempster belt, show slightly enriched light-REE patterns. In western Lake St. Joseph, the Confederation assemblage displays slight enrichment of light REEs, similar to samples from the same area in the St. Joseph assemblage, close to a vent facies of a large volcano that was episodically active during the times of deposition of both the Confederation and St. Joseph assemblages. For samples with approx. 8% MgO, TiO_2% at ranges from 0.6 to 1, Al_2O_3/TiO_2 ranges from 11 to 22, and Zr/Y ranges from 1 to 3.6., reflecting a mix of island arc to N-type MORB characteristics (Le Roex 1987).

The St. Joseph Assemblage

The St. Joseph assemblage is dominated by tholeiitic basalt with some tholeiitic andesite, overlain by a thick dacitic to locally andesitic pyroclastic deposit that is well exposed on the shores of eastern Lake St. Joseph and in the vicinity of Pashkokogan Lake. Geochemical evidence of basaltic komatiite flows is obtained from the vicinity of a layered ultramafic intrusion at Pedlarpath Bay in eastern Lake St. Joseph (Stott et al. 1987b).

Tectonic Setting:
A few samples with MgO at approx. 8% give TiO_2 values of .4 to 1, Al_2O_3/TiO_2 of 16 to 28, and Zr/Y of 2 to 4, which typify the range of values encompassing island arc and N-MORB basalts.

Felsic Volcanic Rocks

Felsic volcanic rocks are dominantly dacitic with local rhyolitic sequences. All chondrite-normative REE plots (Figures 23-6) show the steep light-REE enrichment (up to 100x chondrite) typical of calc-alkaline intermediate to felsic volcanics. There is also no evidence of a Eu anomaly from these few samples taken from the Pickle Crow, Confederation and St. Joseph assemblages.

Mafic Intrusions

The mafic intrusive rocks, generally fine to medium gabbroic bodies sampled within the Meen-Dempster belt, display similar geochemical characteristics to the tholeiitic basalts with approximately 8% MgO (Table 4-3a to c). A sample of peridotite (82-0386) with MgO of 26.5%, is obtained from a small ultramafic intrusion just within the southwest margin of the western Meen-Dempster belt, near the Southern pluton. Such intrusions are rare in the central Uchi Subprovince, with the most notable occurring at the former Cu-Ni Thierry Mine near Pickle Lake. South of Dempster Lake, sample 84-1238 is a quartz-bearing diorite within a shear zone transecting the Dempster Lake gabbro body. The diorite composition is reflected in the higher SiO_2 (71%) and higher Zr (230 ppm). Sample 86-0027 is from the NW-trending Proterozoic Pickle Crow diabase dike which contains high Al_2O_3 and low MgO.

Felsic Intrusions

General Observations and Tectonic Setting:
Samples from several major plutonic bodies and smaller intrusions from the central Uchi region are classified modally on the QAP diagram of Strekeisen (1976) as illustrated in Figures 23-7a to e. The reconnaissance sampling of various plutons and local felsite dikes (Table 4-4a) permits only a general observations of the geochemical character of this intrusions. All samples are sub-alkaline and as Figure 23-8 (Maniar and Piccoli 1989) illustrates, the synvolcanic porphyry (QFP) intrusions tend to be metaluminous in contrast to the late tectonic plutons which are slightly more peraluminous. The trondhjemite-tonalitic-granodioritic (TTG) synvolcanic intrusions (samples 84-241, 84-1038, and 86-164) possess low K_2O (< 2.3%) but the major elements otherwise

provide limited discrimination from other suites of granitoid rocks that are more typical of late tectonic plutons. Figure 23-9 (Pearce et al 1984) suggests that the Rb - Y+Nb geochemistry for most of the sampled intrusions is consistent with a volcanic arc setting, within a continental margin. The late tectonic Osnaburgh pluton plots in the syn-collision granite field and the older 2887 Ma Pembina tonalite on Lake St. Joseph plots just in the within-plate granitic field. The rare earth element profiles (Figure 23-10) are somewhat more helpful. Of the seven of intrusions represented, all but one (86-164) are late tectonic intrusions; each displays light REE enrichment but only the older Pembina tonalite gneiss (sample 86-164) displays a slight Eu depletion, which is typical of synvolcanic TTG (trondhjemite-tonalite-granodiorite) series granitic rocks (e.g., Sage et al., 1996). The other, late tectonic intrusion profiles are steeper with heavy REE values significantly less than 10x chondrite, and are similar to intrusions of the late tectonic syenite-monzonite-granodiorite (SMG) suite, near the Michipicoten greenstone belt, Wawa Subprovince (Sage et al., 1996). This is also evident in comparisons of Rb with both SiO_2 and Sr. Overall, the modal and geochemical character of felsic intrusions within the central part of Uchi Subprovince are typical of synvolcanic and late tectonic plutons elsewhere in the Superior Province. A modern petrogenetic analysis of the granitoid rocks in this region requires a comprehensive geochemical study in future.

Summary of Events in the Central Uchi Subprovince

Each of the greenstone belts has recorded a sequence of magmatic and structural events, the highlights of which are described above. This section reviews these events and summarizes patterns that developed across time and space in the creation of the central Uchi Subprovince.

Patterns of Secular and Spatial Progressions

a) There are secular and spatial progressions in rock types across the subprovince. The older assemblages, including the northern Pickle Lake domain, dominantly comprise subaqueous tholeiitic basalt flows with rare clastic sedimentary units. These contrast with younger assemblages, bearing an increasing volume and successful preservation of intermediate to felsic volcanism, with more voluminous rhyolite in some assemblages and greater dacitic and basaltic pyroclastic deposits in others. This change is observed southward and eastward across the subprovince, culminating in the more voluminous calc-alkalic deposits of the 2723-2713 Ma St. Joseph assemblage.

Clastic sedimentary rocks, such as the Eagle Island and Billett assemblages, lie unconformably upon the volcanic Confederation and St. Joseph assemblages and in some cases overlap the volcanic assemblage boundaries. These sedimentary sequences developed in late-forming basins and record an episode of exhumation and erosion of continental crust during the Kenoran orogeny.

A secular progression in plutonic compositions is evident since older tonalitic gneisses (e.g., Pembina Tonalite Gneiss of the Lake St. Joseph batholith) and syn-volcanic trondhjemitic plutons and stocks (e.g., plutons such as the Dobie Lake Pluton and the Ochig Lake Pluton) are followed by more potassic plutonism with increasing granite to granodiorite compositions amongst the younger 2713 - 2693 Ma plutons. Although there is no general progression in the ages of plutonic rocks across the subprovince, ages of felsic volcanism in the southern half of the subprovince, in some cases, correspond with comparable ages of plutonism in the northern half. This secular correspondence of volcanism and plutonism in different parts of the subprovince is a critical feature that sets limits to the probable way in which the subprovince was constructed as discussed later.

b) There are secular and spatial progressions in structural style across the subprovince. The "homofacing" panels of strata in the northern half of the subprovince are in some cases repeated by stacking, as in the Confederation assemblage within the Meen-Dempster belt; in other cases, they are stacked out of normal stratigraphic order, as in western Lake St. Joseph. This out-of-stratigraphic-sequence style is inferred to be a product of thrusting and is superseded by orogen-parallel folding, especially near some assemblage boundaries and near the southern margin of the belt. Moderately plunging, stretching-lineations in the wider belts (viewed here as orogen-parallel lineations) are superseded by down-dip lineations associated with folding and thrusting near the southern margin of the belt (comparable to fabrics observed along the southern margin of the Wabigoon Subprovince by Williams (1987)) and within the strain aureoles of plutons. The penetrative fabrics were succeeded by transcurrent faults that strike eastward and southeastward. The Sydney Lake-Lake St. Joseph fault initiated as a thrust fault, transecting volcanic strata, and terminated as a ductile to brittle-ductile transcurrent fault, reflecting the final stage of NNW-directed, regional shortening and telescoping of the subprovince.

There is a close comparison between the regional east-northeastward structural grain observed in the Uchi Subprovince and an anisotropic upper mantle mineral fabric that has been interpreted by Silver and Chan (1988) under the Red Lake teleseismic station and along a subsequent north-south teleseismic survey (Silver 1992). This mantle anisotropy is coincident with the orogen-parallel extension direction and compares favourably with the regional trend of greenstone belts and the long axis of elliptical plutons. Such a linear, belt-like trend is similar to the form of Proterozoic and Phanerozoic orogens (e.g. Howell 1989) and corresponding upper mantle anisotropy (Silver and Chan 1988).

Sequence of Post-2740 Ma Events

Pre-2740 Ma deformation is recorded in structural domain 1 of the Pickle Lake belt (Figure 13) and is described under Area 2. Evidence for a pre-Kenoran orogeny is to be found in this belt and in the North Caribou terrane to the north of the Uchi Subprovince (Thurston et al. 1991). (Probably older orogenic deformation is in part preserved in the tonalite gneisses - Pembina Tonalite Gneiss for example - but this has not been demonstrated.) Athough older, pre-2740 Ma deformation is recorded locally, the most readily documented sequence of deformation events occurred subsequently. This sequence of deformation events has been ascertained in the greenstone belts (Figures 10, 16 and 21) and details were summarized earlier to illustrate the local structural style as well as the sequence of events. From these features, a general sequence of structural events can be proposed that postdates *circa* 2740-2730 Ma Confederation assemblage volcanism, beginning with the formation of assemblage boundaries in the southern part of the Lake St. Joseph belt, which predates the main phase of the Kenoran orogeny following 2713 Ma volcanism. The sequence involves overlapping episodes of volcanism, thrust stacking and compression of strata, and tectonic juxtaposition of assemblages, crustal exhumation, erosion, folding and wrench faulting.

Thrusting and Compression

As Stott and Corfu (1991) illustrate, pre-2718 Ma tectonic transport and juxtapositioning of assemblages is evident in the Red Lake belt by the formation of the tectonic boundary between the Balmer and Confederation assemblages; this boundary predates an episode of plutonism; e.g., the 2718 Ma Dome stock (Corfu and Wallace 1986), synchronous with 2723-2713 Ma volcanism of the St. Joseph assemblage (Corfu and Stott 1993b). Yet such tectonic activity may have included thrusting of strata within the assemblages and thrust-imbrication of strata may have been a dominant process for a prolonged period from before 2722 to after 2713 Ma in the central part of Uchi Subprovince. For example, in the Meen-Dempster belt, the 2722 Ma Kawashe Lake stock intrudes the Kawashe Gabbro which stitches the boundary between the Woman assemblage and the tectonically imbricated 2740 Ma volcanic cycles of the Confederation assemblage. Yet in western Lake St. Joseph, thrust-repetition of the Confederation and St. Joseph assemblages appears to have occurred subsequent to the youngest volcanism of the St. Joseph assemblage, i.e., post-2713 Ma.

This northward thrusting of strata formed stacks of volcanic and sedimentary sequences, as illustrated in the eastern half of the Birch-Uchi belt where age determinations (Noble et al. 1989) show that the Confederation assemblage units are inversely stacked: younger strata lie under and to the southeast of older Confederation assemblage strata. A lobe of tectonically interleaved volcanic and sedimentary units, closing to the north, appears to characterize the eastern half of the belt. This lobe is part of the postulated "South Uchi parautochthon" in Figure 24. The evidence of truncated volcanic strata, southeast of Lake St. Joseph in the vicinity of Pashkokogan Lake (Goodwin 1965), indirectly confirms a stage of northward thrusting along the Uchi-English River boundary, which removed a portion of the St. Joseph assemblage from the southern margin of the subprovince. This style of regional deformation is comparable to "thin-skin" tectonic processes in Phanerozoic orogens (Howell 1989).

Exhumation

Greenstone belts and synvolcanic plutons were exhumed subsequent to at least the initial stages of thrust-stacking of the volcanic strata. The eroded detritus from these rocks collected in syntectonic basins to form sedimentary sequences that were subsequently folded. These younger sequences lie unconformably upon the volcanic rocks, as in the Meen-Dempster belt where the sedimentary Billett assemblage, containing trondhjemitic clasts evidently eroded from the nearby

Dobie Lake Pluton, forms an overlapping sequence upon the Woman-Confederation assemblages boundary and is itself folded during northward-directed regional shortening. Another example is the Eagle Island assemblage in the Lake St. Joseph belt wherein a basal conglomerate contains clasts of dacite similar to the underlying St. Joseph assemblage and pink arkose is presumed to be derived from the erosion of a granitic pluton (Berger 1981). This folded assemblage unconformably overlies the fault-boundary separating St. Joseph and Confederation assemblages stacked out of stratigraphic sequence.

Folding

The above processes of thrusting and exhumation are accompanied and followed by folding locally concentrated close to the southern boundary, as in the Lake St. Joseph belt and in the syntectonic sedimentary sequences; folding in the Lake St. Joseph area postdates 2713 Ma volcanism and predates the emplacement of the Blackstone Pluton at 2702 Ma. The folding encompasses a crustal segment, involving a thrust-interleaved sequence of assemblages in the Lake St. Joseph area for example, which reflects a regional progression in the style of deformation, from "thin-skin" thrusting to "thick-skin" folding processes in the sense described by various workers for Phanerozoic orogens (Howell 1989). Folding in the Lake St. Joseph area occurred after both the 2713 Ma volcanism of the St. Joseph assemblage and the thrust-stacking of two assemblages, and before the emplacement of the 2702 Ma Blackstone Pluton, which crosscuts the folded sequence.

Wrench Faulting

Wrench faulting characterizes the terminating stage of the Kenoran Orogeny across the Superior Province (Schwerdtner et al. 1979) and features of this stage are evident in the Uchi Subprovince. During the orogeny, shortening and thickening of the crust probably occurred as a consequence of convergence and collision of the superterranes directed along a northwestward principal axis, oblique to the westward striking superterrane boundaries. The structural styles in different parts of the greenstone belts demonstrate that this deformation was partitioned into crustal thickening (thrusting and folding) and wrenching components. Evidence in the northern part of the subprovince for penetrative, ductile, transpressive deformation can be found in areas, such as the Meen-Dempster belt, showing block rotation (Hale and Lloyd 1990) and associated orogen-subparallel stretching lineations (Stott and Wilson 1986b). However, the evidence is mainly based on the orientation of late-stage, regional-scale wrench (transcurrent) faults (e.g., Schwerdtner et al 1979; Osmani and Stott 1988) and features near the Uchi-English River boundary where deformation was partitioned into 1) shortening and tightening of east- and northeast-striking folds with moderately east-plunging axes and stretching lineations in a narrow domain close to the boundary (Clifford, 1969; Stott et al. 1987a), comparable to similar domains along the north margin of the Wabigoon Subprovince (Blackburn et al. 1991) and the north margin of the Shebandowan belt, Wawa Subprovince (Williams et al. 1991); and 2) transcurrent, simple shear in the Sydney Lake-Lake St. Joseph fault zone and in local, subparallel shear zones nearby within the greenstone belts (e.g., D_2 shear zones of the southern Birch-Uchi belt). This transcurrent shear continued after the 2702 Ma crystallization of the Blackstone Pluton. This late phase of deformation, concentrated in narrow zones of brittle-ductile shear, is also expressed in the 3 km-wide Bear Head fault and marks the terminating stage of orogenesis.

It is estimated that the main phase of Kenoran orogenesis in the Uchi Subprovince (labelled the "Uchian phase" (Stott et al. 1989c)) occurred between 2713 and 2701 Ma and predates the culmination of the orogenesis in the southern part of the Superior Province, during about 2689-2684 Ma (the "Shebandowanian phase"), recorded by Corfu and Stott (1986) in the Shebandowan belt and Davis et al. (1989) in the southern Wabigoon Subprovince (see Williams et al. 1991). Most of the granitic plutons in Uchi Subprovince intruded after the culmination of the orogeny, from about 2704 to 2693 Ma. The terminating stage of the Uchian phase is schematically summarized for features in the Lake St. Joseph area (Figure 24). These orogenic phases, which could be viewed as separate micro-orogenies following rapidly one after another, each culminate as one of a series of major transpressive collision events in the construction of the Superior Province, arising from oblique-convergence of superterranes (Stott et al. 1987c).

Tectonic Interpretation

The view that the Superior Province was constructed of distinct tectonic entities called subprovinces begins to break down in the vicinity of the Uchi, Berens River and Sachigo subprovinces (as defined by Card and Ciesielski (1986)). It is becoming evident that 1) there are stratigraphic, aeromagnetic and age correlations between parts of the Uchi and Sachigo subprovinces that comprise the North Caribou terrane (Figure 24) (Thurston et al. 1991); and that 2) the Berens River Subprovince represents a deeper section of the North Caribou terrane (Thurston et al. 1991), exposed during the Kenoran orogeny and dominated by late-tectonic plutons. The northern part of the Uchi Subprovince and the Red Lake belt contain pre-2740 Ma crust that has been subjected to a pre-Kenoran orogenic history; only a small window on this history is evident in the Pickle Lake belt for example. An early history of accretionary growth in the northern part of the Uchi Subprovince is proposed to represent Stage 1 in a three stage history of crustal growth and deformation in the Uchi Subprovince (Stott and Corfu 1991). It precedes a better preserved record of crustal growth and deformation that dominates the southern half of the subprovince involving Stage 2: magmatism along a convergent continental margin; and Stage 3: continental collision.

Stage 1: Accreting Terranes To Form A Microcontinent

There is a growing enthusiasm amongst Archean researchers for postulating that accretionary tectonic processes, as observed in modern crustal settings, were also involved in producing the similar patterns of tectonic assemblages, structures, ages, and sequences of events in Archean terranes. However, the evidence of growth of the Uchi Subprovince by accretion of terranes (in the sense of Howell, 1989) is not presently compelling, owing in part to limited detailed studies of potential terrane boundaries in this region, but also to observations that are more consistent with another scenario. The northern portions of the subprovince, including the northern part of the

Pickle Lake and Miminiska-Fort Hope belts, and much of the Red Lake belt and its slivers extending into the Berens River Subprovince, are interpreted as part of the North Caribou terrane (Figure 24) (Stott and Corfu 1991; Thurston et al. 1991). This terrane is flanked on the south by the Pickle Crow assemblage and its possible extension into the Miminiska-Fort Hope belt, and tectonically underlain by the Bruce Channel assemblage in the Red Lake belt (Stott and Corfu 1991). The structures in the Pickle Crow assemblage strike at an oblique angle to structures in the northern half of the Pickle Lake belt and similar discordance is evident in the northern Miminiska-Fort Hope belt. One could, therefore, postulate that the Pickle Crow assemblage and its synchronous counterpart, the Bruce Channel assemblage, in the Red Lake belt are remnants of a *circa* 2890-2860 Ma terrane, referred here as the Pickle terrane, which accreted to the North Caribou terrane. The timing of such accretion is not clear but it precedes the disconformable juxtaposition of the circa 2840 Ma, Woman assemblage with the Pickle Crow assemblage in Pickle Lake (Figure 12). The development of the Woman assemblage represents the beginning of Stage 2.

Stage 2: A Convergent Continental Margin

It is apparent in this scenario that the Woman assemblage has an autochthonous origin. This assemblage is spatially associated with tonalite in the Trout Lake batholith, which has intruded rocks of the Balmer assemblage in the Birch-Uchi belt (based on relationships reported by Noble et al. 1985, p.76); this spatial relationship implies that the Woman assemblage more likely developed as an arc-marginal basin complex upon the edge of an older continent (a North Caribou-Pickle composite terrane?) and was not an intra-oceanic terrane transported and accreted upon a "North Caribou proto-continent". Consistent with this scenario is the presence, south of the Woman assemblage rocks, of older, 2887 Ma tonalite gneiss in the Lake St. Joseph batholith which conceivably formed part of the North Caribou-Pickle composite terrane but separated from the main mass of this terrane when the Woman arc complex formed. The Woman assemblage is proposed to have developed along the margin of the North Caribou-Pickle composite terrane as shown in Figure 24, although its present distribution may reflect some telescoping by compression during subsequent deformation events.

A similar argument can be made regarding the Confederation and St. Joseph assemblages. A volcanic vent in western Lake St. Joseph (Clifford and McNutt 1971) was active during Confederation assemblage deposition at about 2734 Ma and later reactivated at about 2723 Ma to deposit the St. Joseph assemblage. Plutonic bodies of similar age to these assemblages (e.g., Hammerton Lake Pluton and Kawashe Lake Stock) intruded older volcanic rocks in the northern part of the subprovince. The implication is that if the volcanism and plutonism are tectonically related, the Confederation and St. Joseph assemblages were formed from episodes of magmatism on the margin of a growing composite terrane that included the Woman assemblage of an earlier episode. The leading edge of this developing continent is inferred, from comparable features for the Quetico-Wabigoon subprovinces boundary (Blackburn et al, this volume), to include a fore-arc accretionary prism - the English River Subprovince- and to have overridden a "northward" (using present azimuth references) subducting oceanic plate until it ultimately collided with continental crust from the "south", the Winnipeg River and Wabigoon subprovinces.

An analogue, which accommodates the limitations to the original setting of Woman and younger assemblage volcanism, implied in the presence of synchronous plutonic phases intruding older crust, is the setting of a Cretaceous island arc - marginal basin complex that developed along the western margin of southern South America. This is the "Roca Verdes" marginal basin complex of Chile that Tarney et al. (1976) had advocated in very general terms as a model for the evolution of Archean greenstone belts and it partially satisfies the features observed in the southern half of the Uchi Subprovince. There are features, including the volume of andesitic volcanism in the island arc, which are not present in the Uchi assemblages. However, some elements of this continental marginal setting merit detailed comparison in future with the geological framework of the southern half of the Uchi Subprovince.

Stage 3: Continental Collision Between Superterranes

The evidence for displacement and deformation, especially for the southern half of the Uchi Subprovince, shows that the long, but episodic history of crustal growth along the Uchi-Sachigo convergent continental margin, including the late stage history of the English River assemblage as a forearc-accretionary prism, came to an end when this superterrane collided with a superterrane converging from the south (in the present-day azimuth) -probably consisting of the Winnipeg River and Wabigoon subprovince-blocks. This collisional event is the "Uchian phase" of the Kenoran orogeny and marks one of a series of superterrane collisions recorded across the Superior Province, including the "Shebandowanian phase" of the Wawa-Wabigoon collision. The styles of deformation during the Uchian collision include initial "thin-skin" thrusting, leading to "thick-skin" folding and thrusting that was accompanied by 1) down-dip displacements near the leading edge of the Uchi-Sachigo continent, 2) moderately plunging, orogen-parallel stretching lineations further inboard and 3) extensive production of granitic plutons in a chain parallel to the subprovince trend, which compare in size with the Coastal Batholith of Peru (Cobbing 1985) or the Southern Patagonian Batholith of Chile (Bruce et al. 1991). The southern half of the Uchi Subprovince, dominated by the Confederation and St. Joseph assemblages, shows evidence of some tectonic displacement northward but these assemblages are thought to have formed along an evolving continental margin, the St. Joseph assemblage evidently having developed up to the time of continental collision. These two assemblages, therefore, are viewed as having formed what is labelled in Figure 24 as the South Uchi parautochthon. It is speculated that this segment of crust partially lapped onto the Woman assemblage, locally forming northward projected finger-like protrusions, as in the Birch-Uchi belt, and locally dismembered to form separate allochthons, as in the northern part of the Red Lake belt and the Lang Lake belt. The simplified picture that has so far emerged from the Uchi Subprovince indicates that the asymmetric distribution of volcanic assemblages, and the styles and sequence of deformation, especially at the terminating stage of collision (Figure 25), are similar to those documented in Phanerozoic orogens (e.g., Vauchez and Nicolas 1991).

Problems for Future Consideration:

There is an abundance of opportunity for research in the Uchi Subprovince on all scales of investigation. Much of the Uchi story outlined in this chapter is based on inferences derived from stratigraphic and geochronological patterns and requires testing in several potentially fruitful areas. Areas that have sufficient bedrock exposure to permit detailed investigations include the Bee Lake and Red Lake belts, western Lake St. Joseph and parts of the Meen-Dempster belt. Of special importance are the thrust faults inferred from the age relationships of the stacked and uptilted assemblages; the crustal evolution of the Uchi Subprovince as a "fold and thrust belt" remains to be documented in detail. Detailed investigations are also warranted on the timing of gold mineralization in the Pickle Lake belt where there is evidence of gold mineralization that predates the Kenoran orogeny. Not the least, the relationship between the tectonic settings and the igneous rock record remains to be told. Questions of regional-scale relationships to pursue include the following:

1) To what extent are the northeastward and northwestward trending greenstone belts, in the northern half of the Uchi Subprovince, part of an older fabric that evolved within the North Caribou terrane?

2) Do the northeast-trending long axes of granitoid batholiths, in the northern half of the subprovince, reflect an earlier (pre-Kenoran) orogenic flattening history or have the batholiths been rotated?

3) How far north can we trace a penetrative Kenoran orogenic shortening? Evidence in the Pickle Lake belt, for example, implies that older fabrics survive and that there may be an "orogenic front", north of which the expression of the Kenoran orogeny is restricted to non-penetrative fault-dislocations and block rotations.

4) To what extent is the Woman assemblage a parautochthonous unit, which grew on the flanks of an evolving continent and was later partly dislocated and transported northwards?

5) Can a better case be made for the dislocation and northward transportation of the Confederation assemblage? It has been suggested by Stott and Corfu 1991 and in this report that the eastern half of the Birch-Uchi belt is an allochthonous or parautochthonous "finger" protruding into the heart of the Uchi Subprovince; can this be confirmed? Are the greenstone belts and segments that are seemingly "out of place", such as the 2730 Ma volcanic sequence of the northern Red Lake belt, or the 2749 Ma Lang Lake belt, allochthonous slices that were transported to the northern half of the subprovince?

6) What is the origin of the sedimentary assemblages in the midst of the greenstone belts? For example, is the Billett assemblage a foreland basin sequence, formed during *circa* 2709 Ma collision of the Uchi-Sachigo superterrane with a superterrane from the south?

7) To what extent is the formation of granite-greenstone subprovinces a product of terrane accretion, as recorded in the North American Cordillera, or a product of growth by continental arc magmatism, viewed by some workers as the principal process of growth in the Peruvian Andes (Cobbing, in Pitcher et al. 1985)? In either case, there is clear evidence that collision of crustal blocks (superterranes), during the Kenoran orogeny, sufficiently displaced and deformed crust as to make the resolution of this question a continuing challenge.

8) Notwithstanding the position taken in this report and by Stott and Corfu 1991, should the Kenoran orogeny be viewed as composed of orogenic phases, the "Uchian" and "Shebandowanian" for example, or are each of these phases the products of separate orogenies, with terranes rapidly assembled to form the Superior craton? Is our difficulty, in comparing the orogenic patterns of the Archean with those of subsequent eons, one of scale as well as rate of subduction and process?

9) It is apparent, from the crustal record and the inferred sequence of events, that the process of growth in each superterrane of northwestern Ontario terminated when the superterranes collided and welded together to form an Archean supercontinent (of which the Superior Province is a piece), effectively closing the Archean chapter of active plate convergence. Will the applications of high precision U/Pb geochronology and stratigraphic analysis eventually permit the correlation of individual subprovinces amongst the various Archean cratons in the world? How long are the subprovinces? There are sufficient contrasting features amongst the granite-greenstone subprovinces in the Superior Province to suggest that distinctive regional patterns of stratigraphy and structure across Archean cratons in different continents can eventually be matched up.

Conclusions

The Uchi Subprovince is a ribbon-like portion of greenstone-granite crust composed of remnants of a protracted, episodic history of growth through Archean time from about 3 Ga to about 2.69 Ga. The central part of the Uchi Subprovince contains geological relationships which reveal that the most pronounced crust-forming periods, involving magmatism and sedimentation, occurred during 2992 to 2925 Ma, 2840 to 2806 Ma, and 2750 to 2713 Ma. Only the northernmost part of the subprovince (including part of the Red Lake belt and the Berens River batholithic belt) is interpreted as part of an older 2.9-3.0 Ga crust in the North Caribou terrane. Possible remnants of a later terrane, the Pickle terrane, may have accreted to the proto-North Caribou continent before 2.84 Ga. However, subsequent crustal additions as volcanic assemblages and accompanying plutons were most likely products of a convergent continental margin. The most pronounced crust-thickening period, dominated by thrust-stacking of volcanic strata and folding of sedimentary assemblages, occurred mainly during 2710-2700 Ma. This was accompanied by extensive melting of the upper lithosphere to form numerous granitic plutons that show late to post kinematic relations to the surrounding rocks.

The post 2.84 Ga history of the Uchi Subprovince is, therefore, best viewed as the record of an evolving Andean-type continental margin with a long history of crustal growth by continental arc magmatism. The record of clastic sedimentation is limited and reflects the products derived largely from erosion of volcanic edifices. This stage concluded with continental collision with a superterrane to the south at about 2710-2700 Ma (the Uchian phase of the Kenoran orogeny). This collision produced a "fold and thrust" belt encompassing most of the Uchi Subprovince, dominated by northward-directed thrusting and stacking of volcanic strata, and accompanied by folding, transcurrent faulting, and substantial exhumation and erosion of the continental crust to form syn-orogenic flysch-type basins; NNW-directed transpressive deformation concentrated in the terminating stages of deformation along the leading edge of the continent, where back-thrusting along a precursor of the Sydney Lake-Lake St. Joseph fault changed to trancurrent shear. Accompanying and following the most penetrative phase of this collision event, was a thermal event that produced a sizable volume of plutonic magma to form numerous plutons within the subprovince and a plutonic belt analogous in scale to the Coastal Batholith of Peru or the Southern Patagonian Batholith of Chile. The longevity and significance of the Uchi Subprovince, as the leading edge of a continent that suffered the brunt of collision, is mirrored in the pronounced geophysical anomalies that characterize it and the underlying Archean mantle.

Economic Geology of the central Uchi Subprovince

Introduction

The Uchi Subprovince has received exploration activity in periodic bursts - since the 1920's and more recently in the 1980's when the belt attracted attention for its gold potential. At present there are 3 active gold mines in this subprovince: two in the Red Lake belt plus the Golden Patricia mine in the Meen-Dempster belt. Other former gold mines, principally in the Red Lake and Pickle Lake belts and to a lesser extent in the Birch-Uchi belt, have seen differing degrees of success and their records can be extracted from the Reports of Activities of the Resident Geologists over the years, published by the Ontario Geological Survey.

A volcanic-hosted massive sulphide deposit in the Confederation assemblage of the Birch-Uchi belt experienced a brief but profitable life as the South Bay mine in the 1970's, but base metal exploration in this subprovince has received much less attention compared to exploration for gold. Base metal occurrences were explored in the 1970's jointly by Selco Inc. and Cochenour Willans Gold Mines Limited, south of the Meen-Dempster belt, just east of Bamaji Lake. The former gold belt at Pickle Lake saw the geophysical discovery of a low grade copper-nickel deposit, the Thierry deposit, which also had a brief history as a mine before closing in 1982. There is continued exploration for gold, although not at the same intensity as in the 1980's, and a renewed interest in base metal exploration.

Mineral occurrences and mines are shown in relation to the geology on Figures 8, 13, 15, and 20 and a general map of deposit types and their distribution (Figure 26) shows a very general zoning of metal types across the breadth of the central part of the subprovince. A more detailed review of the mineral deposits in the Meen Lake-Kasagiminnis Lake portion of the central Uchi Subprovince can be obtained from Seim (1993). Brief descriptions of deposits in the Pickle Lake belt, focussing on gold, is given by Stott and Brown (1986). Kay and Stott (1985) described various mineral occurrences in the Lake St. Joseph belt. Descriptions of some of the occurrences in this region and exploration activity are given in the annual Resident Geologist's Report of Activities published by the Ontario Geological Survey. Details on the distribution and characteristics of all the various mineralization occurrences, prospects and former and active mines can be obtained from the Assessment Files Research Office, Toronto, Sudbury or the Resident Geologist's office, Sioux Lookout.

Deposit Types

Gold Deposits

In the Meen-Dempster belt, gold occurrences as well as the Golden Patricia Mine lie within narrow deformation zones within or near the flanks of a strain domain (D_2) shown in Figure 8 and described earlier. The Golden Patricia Mine occurs within a narrow, sheared quartz sheet interpreted by Rodd and Hutchinson (1991) to be originally a chert unit but which the author interprets from structural relationships as more closely resembling a substratiform vein: it is enclosed in sheared host rocks, it is close to the felsic volcanic contact but does not follow it consistently, and it is accompanied by a thin, biotitic alteration zone. The strain domain, in which the shear zone-hosted gold occurs, is interpreted by the author as a product of orogenic regional shortening during which the Dobie Lake Pluton rotated and compressed the greenstone belt; consequently, the mineralization would have concentrated during the late stages of the Kenoran orogeny.

In the Pickle Lake belt, gold deposits (Barrett and Johnston 1948; Corking 1948; Cohoon 1986) are located in separate strain domains shown in Figure 13. The Pickle Crow deposits are products of an early strain event (Domain 1) that preceded the emplacement of the Hooker-Burkoski Stock, which is coeval with the 2741 Ma Ochig Lake Pluton. Part of the string of Pickle Crow deposits lie within Domain 3, which is interpreted as a late, contact strain aureole imposed by the adjacent 2711 Ma Second Loon Pluton and likely represents a structural overprint on the pre-existing gold deposits. In contrast, the Dona Lake Mine is localized in a folded, sheared and sulphidized banded magnetite iron formation within the strain aureole of the 2741 Ma Ochig Lake pluton. One could interpret the shear zone as a product of contact strain, which would imply that each of the two principal episodes of gold mineralization in the Pickle Lake belt preceded the main period of Kenoran orogenesis and thus predated the mineralization at Red Lake (Stott and Corfu 1991). The relation of such pre-Kenoran gold mineralization to earlier orogenic episodes remains to be studied.

The structural setting for some gold deposits can be attributed directly to the emplacement of a felsic pluton as envisaged by Stott and Smith (1988) and illustrated in Figure 27. This figure is a schematic block diagram of a contact strain aureole around a pluton; within such a strain zone, five types of gold-bearing shear zones can be identified, two of which (types C and D) may be represented in the Pickle Lake belt:
Type A - set of shear zones bordering an uplifted and rotated wedge of supracrustal rock, exemplified along the flank of the Canoe Lake stock in the western Wabigoon Subprovince;
Type B - shear zone defining the outer margin of a pluton-induced strain aureole;
Type C - shear zone focussed along a contrast in rock ductility, as in the vicinity of an iron formation unit in basalt, exemplified by the Dona Lake Mine;
Type D - shear zones in conjugate sets at small angles to the schistosity; this strain environment may correspond to regional orogenic shortening or to a pluton-induced strain aureole; exemplified by the Pickle Crow gold deposits;

Type E - shear zones, tangential to a strain aureole, may have been initiated during earlier orogenic shortening and locally reactivated.

Table 5 summarizes the timing constraints interpreted for gold mineralization in the Pickle Lake belt, based on crosscutting relationships and structural criteria. Evidence that gold mineralization accompanied earlier magmatism and orogenic events (pre-2720 Ma) should be anticipated in the northern part of the Superior Province where there are broader terranes containing older Archean crust.

Base Metal Deposits

The Uchi Subprovince contains few indications of volcanic-hosted massive sulphide (VMS) deposits and only one - the South Bay Mine of the Birch-Uchi greenstone belt - has been profitably extracted. Portions of the southern Birch-Uchi belt, mainly in the Confederation Lake area have been reported to bear pre-deformational alteration in the form of epidotization, silicification, sericitization and chloritization (Fyon and Lane 1985) and occurrences of VMS and accompanying alteration have been reported elsewhere in the Confederation assemblage along strike from the South Bay Mine (Atkinson et al. 1990). Since strata of corresponding age to the 2730-2740 Ma Confederation assemblage in the Birch-Uchi belt can be traced into the central part of the Uchi Subprovince, it is reasonable to suggest that a comparable potential for base metal exploration is worth investigating in the Meen-Dempster and other belts included in this report.

Evidence of extensive synvolcanic hydrothermal alteration in central Uchi Subprovince is very limited. However, exploration for base metal deposits has been focussed in only a few localities. In the vicinity of Bamaji-Fry lakes, south of the Meen-Dempster greenstone belt, Cochenour Willans Gold Mines Ltd. in joint venture with Selco Exploration Ltd. explored several base metal occurrences from 1969 to 1973 (Sage and Breaks 1982; MNDM Assessment Files Office). Extensive exploration was carried out by Umex Inc. during the 1970's and by Cominco Ltd. during the early 1980's in the Meen-Dempster belt in particular and minor base metal occurrences have been found north of Dorothy Lake and on Kawinogans Lake, just north of Knupp Lake (MNDM Assessment Files Office). In the eastern part of the Pickle Lake belt, Minnova Inc. in the mid-1980's conducted a base metal exploration of a felsic tuffaceous unit in the Woman assemblage close to the Second Loon Pluton. The author has also observed pyritic massive sulphide clasts within the pyroclastic sequences of the volcanic edifice in western Lake St. Joseph. Additional descriptions of minor occurrences observed in the Lake St. Joseph belt are described by Kay and Stott (1985).

Magmatic Cu-Ni Deposits

The potential for the discovery of magmatic Cu-Ni deposits in the Uchi Subprovince has not been fully explored although considerable exploration for such deposits was conducted by Umex Inc. after their discovery of the Thierry deposit, which had a short 6 year history as an open pit and underground mine until its closure in 1982. This is the only Cu-Ni deposit that has been mined in the Uchi Subprovince. Several large mafic intrusions have since been indentified by the author during the mapping program.

The Thierry Mine

The Thierry Cu-Ni mine in the Pickle Lake belt is a low grade Cu-Ni deposit in tabular intrusive rocks of gabbro, peridotite and dunite (altered to talc-carbonate schist) within a narrow arm of basalts wedged between the Williams Lake batholith and the Pickle Lake Stock (see Figure 8). The host rocks are interpreted here to be part of an older assemblage, dominated by tholeiitic basalt in the northernmost part of Pickle Lake belt. The rocks are strongly deformed and locally mylonitic and the ore is principally contained in a hornblende-biotite-chlorite-schist (Verbeek et al. 1972; Sage and Breaks 1982, p.125) (Figure 28). The sulphide ore is interpreted to be magmatic in origin (Patterson and Watkinson 1984a) but has been remobilized and metamorphosed to form several types of ore association, notably as mylonite and breccia ore (Patterson and Watkinson 1984b). Observations by Stott et al. (1986) of the sense of displacement in the host rock indicate that the strain aureole surrounding the Pickle Lake Stock encompasses the Thierry deposit (see Figure 13) and the remobilization and concentration of sulphide mineralization is attributable to the deformation imposed by the emplacement of the 2740 Ma Pickle Lake Stock.

Rare-Element Pegmatites

The presence of sub-economic rare-element pegmatite bodies (especially those containing Li-bearing minerals) within the southern half of Uchi Subprovince has been known for many years (Sage and Breaks 1982, Kay and Stott 1985). Such bodies tend to concentrate near fundamental terrane boundaries in the Superior Province as described by several workers including Cerny and Meintzer (1988) and Breaks (1989), Breaks and Janes (1991) with useful references in each; Features of these pegmatites have been summarized by Cerny (1982) who supports a subdivision of the granitic pegmatites into four classes including the rare-element class of mineralized, highly fractionated granites formed within volcanic and sedimentary rocks and metamorphosed to cordierite-amphibolite and upper greenschist facies in low pressure, Abukuma-type terranes. Such a metamorphic environment is preserved locally in the southern part of Uchi Subprovince adjacent to the higher grade English River paragneisses and granites. For example, staurolite-andalusite-bearing metasedimentary rocks and adjacent amphibolitized basalts in the vicinity of eastern Lake St. Joseph and Pashkokogan Lake contain muscovite-granite pegmatite bodies (Figure 20) with anomalous, sub-economic concentrations of rare elements. These bodies are typically small, lenticular pods and dikes that conform to or crosscut the schistosity of the enveloping rocks. Kay and Stott (1985) have confirmed Goodwin's (1965) assessment of these pegmatite dikes, which show anomalous mineral chemistry of K-feldspar (Figure 29) compared to analyses of fertile pegmatite bodies in southeastern Manitoba; these dikes also bear anomalous mineral assemblages (notably Li-bearing, see Table 6a) and rare-element concentrations (Table 6b). A combination of appropriate metamorphic environment and proximity to the subprovince boundary limit the spatial distribution of favourable localities of rare-element pegmatite bodies to linear zones in the Uchi-Sachigo superterrane recognized by Breaks and Osmani (1989) and described by Thurston et al. (1991).

Tectonic Assemblages, Structures and Future Exploration

Regional scale correlations of assemblages encourage tracing potentially mineralized stratigraphic units over many 10's of km and also permit predicting the correlation of stratigraphic units between greenstone belts. For example, stratiform, low-grade zinc occurrences are associated with dacitic pyroclastic units of the Woman assemblage in eastern Pickle Lake belt (P. Lewis, Minnova Inc., personal communication, 1989) and one might speculate that the units are correlative with coarser dacitic pyroclastic units and a subvolcanic porphyry intrusion on Keezhik Lake in northern Miminiska-Fort Hope belt. The beginnings of a tectonostratigraphic subdivision of Archean greenstone belts is an invaluable step towards correlating strata of age and tectonic and depositional settings that appear favourable to the presence of base metal deposits.

We can anticipate that future VMS exploration will benefit from a clearer understanding as to how and when the greenstone belts and subprovinces were assembled; which stratigraphic units are potentially correlative, thereby tracing anomalous lithogeochemistry to larger deposits; and to answer questions such as whether (and why) there is a common episode of crustal growth in northwestern Ontario that is more fertile for VMS deposits amongst all the subprovinces.

A complex history has accompanied many of the fault zones in and adjacent to the greenstone belts, and not all regionally penetrative deformation is attributable to the *circa* 2700 Ma Kenoran orogeny; broad portions of the belts can be shown to retain earlier orogenic histories, consistent with episodic accretionary growth, as we see from the record of growth of the Uchi-Sachigo superterrane. Accordingly, gold could have been initially introduced at different episodes of crustal growth and record the termination of brittle-ductile deformation (eg. Pickle Crow mine) or it could have been remobilized during subsequent orogenic deformation (eg. Golden Patricia mine).

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Figure 25: Cartoon illustrations of the sequence of events in the southern Uchi Subprovince from the final stage of continental margin volcanism to the terminating stage of the Kenoran Orogeny.

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Figure 29: A comparison of K/Cs versus Cs for potassium feldspar samples in the pegmatites of Lake St. Joseph and southeastern Manitoba. Sample locations for the Lake St. Joseph pegmatites are shown in Figure 20.

Table 1
Lithologic Units of the central Uchi Subprovince

PHANEROZOIC
CENOZOIC
QUATERNARY
RECENT
Lake, stream and wetland deposits
PLEISTOCENE
till, glaciofluvial sand and gravel, glaciolacustrine sand and clay
unconformity
PRECAMBRIAN
PROTEROZOIC
PALEOPROTEROZOIC
Mafic Dikes
diabase dikes
ARCHEAN
MESOARCHEAN TO NEOARCHEAN
Felsic Intrusive Rocks
Unmetamorphosed late to posttectonic granitic rocks
Granodiorite, monzogranite, syenogranite, syenite, tonalite, trondhjemite, quartz diorite, granite pegmatite
intrusive contact
Metamorphosed pre- to syntectonic granitic rocks
Granodiorite, tonalite, trondhjemite, monzogranite, syenogranite, quartz diorite, granite pegmatite
intrusive contact
Metamorphosed felsic porphyry intrusive rocks
quartz porphyry, feldspar porphyry, quartz-feldspar porphyry, felsite
intrusive contact
Mafic to Ultramafic Intrusive Rocks
Metamorphosed mafic intrusive rocks
Gabbro, diorite, anorthosite, melanocratic gabbro, leucocratic gabbro, plagioclase feldspar -phyric mafic intrusive rock, quartz-bearing mafic intrusive rock, pegmatite
intrusive contact
Metavolcanics And Metasediments
Clastic metasediments
Lithic wacke, quartzose wacke, feldspathic wacke, mudstone
Chemical metasediments
Oxide facies (magnetite-bearing), sulphide facies (pyrite-bearing), silicate facies (amphibole -rich), and carbonate facies (siderite/ankerite) iron formation
Felsic metavolcanics
massive flows, tuff, lapilli tuff, lapillistone, quartz-feldspar porphyry

Intermediate metavolcanics
massive flows, pillowed flows, tuff, crystal tuff, lithic tuff, lapilli tuff, lapillistone, tuff breccia, pyroclastic breccia, quartz-feldspar porphyry

Mafic metavolcanics
massive flows, pillowed flows, pillowed breccia, amygdaloidal flows, variolitic flows, autoclastic flow breccia, tuff, crystal tuff, lapilli tuff, lapillistone, tuff breccia, pyroclastic breccia, ultramafic tuff, amphibolite, epidote-rich layered flows or pyroclastic rock

Table 2: Tectonic assemblages of the Meen-Dempster and Pickle Lake Belts

Name	Rock Types, Primary Structures (described from base to top where known)	Contacts	Interpreted Environment	Age (Ma)	References
Unnamed assemblage (North Pickle Lake belt)	- massive and locally pillowed basalt flows with banded, magnetite-ironstone; - minor dacite tuff interbeds.	- inferred fault contact with Pickle Crow from angular discordance of geophysical conductors in each assemblage; - (?) assemblage may correlate with McGruer asemblage of North Caribou Lake belt.	oceanic volcanism	2.9 Ga (est.)	Stott et al. (1989a, 1989b)
Pickle Crow	- pillowed tholeiitic basalt flows, intruded by quartz-porphyry sills and overlain by dacitic lapillistone, lapilli tuff, tuff and thick beds of fine grained tuff, possibly of ash flows. - pillowed to massive basalt flows, with banded, magnetite-ironstone interbeds.	- undetermined nature of contact with Woman assemblage. - (?) possible correlation with Bruce Channel assemblage of Red Lake belt and with unnamed assemblage in north Miminiska-Fort Hope Belt.	arc volcanism	2860 ±2 quartz porphyry	Stott et al. (1986)
Woman	- massive and minor pillowed tholeiitic basalt flows with banded magnetite ironstone interbeds; unit at least 3 km wide interlayered with units of dacitic, quartz-phyric and fine grained tuff, probably distal ash flows; interbedded with chloritic mudstone and chert - local proximal ash flows overlain by ferruginous chert beds, and local thin quartz-marble unit.	-complex and undetermined juxtaposition at low angle to strata with Confederation assemblage; inferred fault contact. - intrusive contact with 2713 Ma Second Loon pluton and 2740 Ma Ochig Lake pluton	oceanic volcanism with local subaqueous to subaerial arc sequence	2842 +5/-2 dacitic quartz phyric tuff; 2836±3 dacitic quartz phyric tuff; 2825 ±2 dacitic lapilli tuff	Corfu and Stott (1993a, 1993b)
Confederation	- 2000m thick vesicular, pillowed, and massive tholeiitic basalt flows with flow top breccia. - overlain by 1000m thick unit of distal fine grained dacitic ash flows and resedimented tuff, capped by volcanogenic sedimentary rocks.	- probable fault contact; assemblage base locally oblique to underlying Woman assemblage. - unconformably overlain, after internal tectonic stacking, by sedimentary basin of Billett assemblage.	oceanic volcanism	2740 ±1 2744 +3/-2	Corfu and Stott (1993a, 1993b)
Billett	- turbiditic AC wacke and banded magnetite iron formation interbeds - local interbeds of graded sandstone and conglomerate on north margin; trondhjemite cobble and pebble clasts derived from exhumed Dobie Lake pluton	- angular unconformity with and over-lying tectonically juxtaposed Woman and Confederation assemblages - cut by 2693 Ma Osnaburgh pluton - assemblage may be correlative with unnamed sedimentary assemblages in north Birch-Uchi greenstone belt and central Miminiska-Fort Hope greenstone belt	late orogenic basin (foreland basin) contains 2748 +5/-4 Ma tonalite clast in conglomerate, likely derived from erosion of Dobie Lake pluton	2710 est. deposition <2722 >2700	Stott and Wilson (1986b)

Table 3: Tectonic assemblages of the Lake St. Joseph Belt

Name	Rock Types, Primary Structures (described from base to top where known)	Contacts	Interpreted Environment	Age (Ma)	References
Confederation	- tholeiitic basalt flows with massive to pillowed facies progression in each flow unit; iron carbonate amygdules increase in abundance upward in stratigraphic section. - rhyolite-rhyodacite pyroclastic units of clast-supported flow breccias, pyroclastic flows with coarse lithic clasts and scarce rounded, massive sulphide clasts; abundant basalt dikes; pervasive iron carbonatization.	- base is intruded by 2701 Blackstone pluton - Confederation assemblage disconformably overlain by St. Joseph assemblage, apparently sharing same volcanic vent system with St. Joseph assemblage. - sequence of Confederation and overlying St. Joseph assemblages is repeated by unobserved thrust fault.	arc volcanism, proximal and vent facies	2733 +3/-2 cycle 1; 2730 ±1 cycle 3	Clifford (1969) Berger (1981) Stott et al. (1987a, 1987b) Corfu & Stott (1989) Corfu & Stott (1993a, 1993b)
St. Joseph	- hydrothermally altered, bleached basalt flows overlain by dominant vent facies sequence of massive rhyolite quartz-feldspar phyric flow, phreatic breccia, overlain by a suite of pyroclastic flow deposits. Clast sizes diminish on flanks of volcano away from vent area to distal dacitic to andesitic tuff and volcaniclastic sedimentary rock. - uppermost pyroclastic flow deposits 1000 m thick and traceable in a unit over 60 km long, of dacitic, lithic tuff breccia, vesiscular tuff breccia, and more voluminous dacitic to andesitic lapilli tuff, increasingly more mafic up-section.	- hiatus in volcanic activity between Confederation and St. Joseph assemblages; - unconformably overlain by Eagle Island assemblage.	arc volcanism, proximal and vent facies.	2724 ±2 cycle 2; 2731 +3/-2 cycle 4	Clifford (1969) Berger (1981) Stott et al. (1987a, 1987b) Corfu & Stott (1989) Corfu & Stott (1993a, 1993b)
Eagle Island	- wacke-arenite turbidites derived mainly from volcanics; basal sequence of volcaniclastic detritus - banded magnetite iron formation units concentrated mainly in upper part of assemblage	- erosional unconformity with adjacent St. Joseph assemblage felsic pyroclastic unit on west - fault contact with cycle 3 volcanics on east - postdates fault juxtaposition of cycle 3 on cycle 2	late orogenic proximal channel fill; submarine fan delta	<2713 >2702	Clifford (1969) Stott et al. (1987a, 1987b) Corfu and Stott (1993a, 1993b)

Table 4-1a. Location and rock name of a geochemical sample from mafic volcanic rocks of the Northern Pickle assemblage.

Sample No.	Rock Name	UTM Eastings	UTM Northings
86GRS-0044	basalt	292950	5715925

Table 4-1b. Major element geochemistry for a mafic volcanic rock of the Northern Pickle assemblage.

SAMPLE	SiO2	Al2O3	Fe2O3*	MgO	CaO	Na2O	K2O	TiO2	P2O5	MnO	CO2	S	LOI	TOTAL	Sp. Gr.	Mg #
86GRS-0044	45.10	15.10	16.20	6.68	10.50	0.79	0.07	1.55	0.13	0.13	0.25	0.01	3.10	99.40	3.07	0.45

Table 4-1c. Trace element geochemistry for a mafic volcanic rock of the Northern Pickle assemblage.

SAMPLE	Co	Cr	Cu	Ni	Pb	Zn	Nb	Rb	Sr	Y	Zr	Th	Pr	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	Ce	La	Nd	Y
86GRS-0044	44	243	26	96	15	103	<5	<5	135	39	109	<10	2.1	3.2	1.4	4.3	0.75	5.5	1.1	3.3	0.44	2.8	0.43	13	5.9	10	31

Table 4-1d. Location and rock names of geochemical samples from mafic volcanic rocks of the Pickle Crow assemblage.

Sample No.	Rock Name	UTM Eastings	UTM Northings
86GRS-0004	pillowed basalt	697180	5702700
86GRS-0027A	basalt	698920	5706535
86GRS-1181	altered basalt	702120	5708050
86GRS-1187	carb altered basalt	702275	5708200
86GRS-1189	altered basalt	702375	5708575
86GRS-1207	basalt	702775	5709100
86GRS-1211	carb altered basalt	702875	5710000
86GRS-1216	silicified basalt	706150	5711100
86GRS-1218	basalt	705850	5711195
86GRS-1220	pillowed basalt	705650	5711375
86GRS-1226	basalt	702175	5709000
86GRS-2156	pillowed basalt	703000	5696755
86GRS-2166	silicified basalt	703315	5697155
86GRS-2171	basalt	703600	5697575
86GRS-2178	basalt	703700	5698090
86GRS-2182	altered basalt	701910	5697180
86GRS-2209	basalt	703975	5698260
86GRS-2233	basalt	704555	5701625
86GRS-3203	basalt	703360	5709720
86GRS-3204	basalt	703355	5709555
86GRS-3205	basalt	703375	5709325
86GRS-3208	basalt	703325	5709170
86GRS-3210	basalt	703125	5708820
86GRS-3216	basalt	703325	5709875
86GRS-3223	basalt	706485	5711485
86GRS-4033	basalt	699650	5701920
86GRS-4063	basalt	702575	5701250
86GRS-4076	basalt	697390	5695890
86GRS-4107	basalt	701860	5699000
86GRS-4122	altered basalt	704575	5709275
86GRS-4133	basalt	703675	5708475
86GRS-4137	basalt	703500	5708980
86GRS-4138	basalt	703600	5709100
86GRS-4141	basalt	703750	5709190
86GRS-4144	basalt	704100	5709175
86GRS-4156	basalt	703720	5710000
86GRS-4159	basalt, minor alteration	705875	5708275
86GRS-4164	basalt, minor alteration	697050	5707100
86GRS-4167	basalt	697350	5706925
86GRS-4174	basalt, minor alteration	700600	5708200
86GRS-4179	basalt	699975	5707475
86GRS-4189	altered basalt	698600	5708450
86GRS-4193	basalt	697700	5707650
86GRS-4197	basalt, minor alteration	698650	5707250
86GRS-4204	basalt	698350	5707950
86GRS-4205	basalt	703050	5707230
86GRS-4208	basalt	702900	5706700

Table 4-1e. Major element geochemistry for mafic volcanic rocks of the Pickle Crow assemblage.

SAMPLE	SiO2	Al2O3	Fe2O3*	MgO	CaO	Na2O	K2O	TiO2	P2O5	MnO	CO2	S	LOI	TOTAL	Sp. Gr.	Mg #
86GRS-0004	48.30	14.60	13.10	7.64	11.60	1.36	0.10	0.83	0.06	0.19	0.24	0.02	1.10	98.90	3.09	0.54
86GRS-0027A	51.00	14.30	12.70	7.53	10.50	1.50	0.17	0.97	0.07	0.17	0.18	0.06	1.00	98.90	3.01	0.54
86GRS-1181	65.20	17.70	11.57	1.06	0.80	0.00	0.15	1.70	0.11	0.18	0.28	0.07	1.80	100.20	2.96	0.64
86GRS-1187	58.20	22.90	13.61	0.84	0.19	0.40	0.54	0.76	0.04	0.11	0.18	0.02	2.70	99.30	3.02	0.53
86GRS-1189	50.30	15.20	11.40	5.65	10.80	1.90	0.04	0.64	0.04	0.19	2.03	0.15	3.10	98.90	2.94	0.84
86GRS-1207	43.40	14.90	11.00	7.24	8.86	1.75	0.31	0.67	0.04	0.14	6.08	0.06	10.60	98.90	2.77	0.57
86GRS-1211	56.70	16.60	8.95	2.13	4.72	1.83	0.93	0.83	0.04	0.14	3.98	0.04	7.10	99.40	2.78	0.78
86GRS-1216	53.70	18.80	4.85	3.69	11.80	1.75	0.15	0.49	0.03	0.13	2.11	0.03	3.90	99.00	2.88	0.80
86GRS-1218	49.50	13.10	12.40	8.22	11.00	1.61	0.10	0.63	0.05	0.19	0.49	0.12	2.60	99.40	3.05	0.57
86GRS-1220	45.70	14.50	13.80	4.46	7.86	2.74	0.00	0.99	0.07	0.22	5.53	0.03	9.20	99.50	2.80	0.39
86GRS-1226	44.00	12.60	10.90	9.40	6.43	2.33	0.00	0.63	0.04	0.11	9.20	0.05	12.10	98.50	2.79	0.63
86GRS-2156	51.70	16.00	11.50	5.25	12.20	0.89	0.40	0.72	0.04	0.19	0.11	0.06	0.50	99.40	2.98	0.47
86GRS-2166	50.50	14.80	12.30	7.45	11.10	1.19	0.08	0.62	0.05	0.18	0.72	0.01	1.00	98.80	3.09	0.88
86GRS-2171	50.40	15.00	10.70	4.39	13.06	1.45	0.11	0.69	0.05	0.21	2.81	0.05	2.80	98.90	2.99	0.45
86GRS-2178	48.20	15.40	14.50	4.87	8.99	2.48	0.52	1.43	0.12	0.19	0.35	0.12	2.40	99.10	3.05	0.40
86GRS-2182	50.40	14.50	14.72	6.18	10.60	1.16	0.20	1.05	0.09	0.21	0.15	0.06	0.30	99.00	3.05	0.83
86GRS-2209	50.20	14.80	11.70	7.51	11.20	1.83	0.18	0.65	0.05	0.18	0.20	0.02	0.90	99.20	3.02	0.56
86GRS-2233	50.00	14.80	11.80	6.36	11.90	1.38	0.11	0.64	0.04	0.18	1.48	0.03	1.80	99.00	3.01	0.52
86GRS-3203	54.20	21.60	15.30	2.07	0.24	0.25	0.07	1.43	0.11	0.19	0.15	0.01	3.10	98.60	3.05	0.21
86GRS-3204	42.80	14.50	10.80	7.06	8.41	2.59	0.00	0.73	0.05	0.17	7.46	0.03	11.90	99.00	2.79	0.56
86GRS-3205	48.60	14.60	11.60	8.09	10.90	1.17	0.00	0.63	0.03	0.19	0.41	0.02	3.00	98.80	3.04	0.58
86GRS-3208	52.00	17.10	15.60	3.08	2.96	0.29	0.13	1.72	0.13	0.18	2.48	0.24	5.30	98.50	2.94	0.28
86GRS-3210	65.00	18.50	8.55	1.25	1.51	0.38	0.30	0.87	0.02	0.15	0.45	0.08	2.50	99.00	2.92	0.22
86GRS-3216	44.90	15.00	11.60	9.37	8.33	0.49	0.00	0.69	0.05	0.17	4.04	0.06	8.70	99.30	2.85	0.62
86GRS-3223	46.30	21.00	15.30	3.16	2.95	0.83	3.33	1.14	0.05	0.28	0.83	0.07	4.30	98.60	2.98	0.29
86GRS-4033	51.40	14.90	12.30	6.52	9.55	2.27	0.14	0.94	0.07	0.23	0.14	0.05	0.70	99.00	3.01	0.51
86GRS-4063	49.30	14.00	14.40	7.96	9.00	2.94	0.10	1.16	0.09	0.17	0.21	0.16	0.90	100.00	3.05	0.52
86GRS-4076	48.80	15.20	12.90	7.62	10.90	1.93	0.18	0.78	0.07	0.20	0.09	0.10	0.80	99.40	3.06	0.54
86GRS-4107	49.00	14.60	14.60	7.14	9.35	2.14	0.08	1.23	0.09	0.20	0.06	0.02	1.00	99.40	2.99	0.49
86GRS-4122	49.00	15.10	9.67	4.28	10.20	2.42	0.00	0.77	0.05	0.25	5.98	0.03	9.00	99.00	2.80	0.88
86GRS-4133	67.20	12.70	10.80	2.46	2.65	1.39	0.16	0.18	0.06	0.09	0.08	0.01	2.40	100.10	2.82	0.31
86GRS-4137	47.00	14.40	10.80	8.39	8.26	1.42	0.00	0.62	0.04	0.17	4.32	0.03	8.60	99.70	2.80	0.61
86GRS-4138	49.10	14.80	14.90	5.80	4.65	3.41	0.00	1.04	0.08	0.26	2.58	0.15	5.30	99.30	3.03	0.44
86GRS-4141	46.50	15.00	11.20	8.23	9.90	1.18	0.04	0.68	0.05	0.18	2.72	0.02	6.00	99.00	3.01	0.59
86GRS-4144	50.40	13.00	10.30	8.47	11.10	1.75	0.04	0.60	0.04	0.21	1.88	0.09	3.70	99.60	2.85	0.62
86GRS-4156	44.90	13.30	11.00	6.68	11.10	1.05	0.00	0.54	0.05	0.22	6.53	0.06	10.20	99.00	2.98	0.55
86GRS-4159	60.10	15.00	6.99	4.43	6.00	2.88	0.60	0.43	0.20	0.07	1.59	0.01	3.00	99.60	2.78	0.56
86GRS-4164	50.50	15.30	10.30	6.13	10.50	1.79	0.04	0.71	0.04	0.18	1.51	0.07	3.30	98.80	2.87	0.54
86GRS-4167	50.10	14.60	11.20	6.54	9.65	1.39	0.09	0.77	0.05	0.19	1.87	0.07	4.20	98.80	2.82	0.54
86GRS-4174	53.40	16.60	12.20	4.63	5.18	1.35	0.48	1.07	0.08	0.15	2.40	0.18	5.00	100.10	3.04	0.43
86GRS-4179	49.70	14.60	11.60	7.10	12.00	2.24	0.11	0.79	0.07	0.18	0.14	0.01	0.70	99.10	3.04	0.55
86GRS-4189	45.00	13.10	12.73	6.01	9.04	2.15	0.01	0.80	0.05	0.19	6.50	0.02	11.00	98.70	2.79	0.89
86GRS-4193	50.30	15.20	9.82	7.91	10.90	1.08	0.02	0.68	0.04	0.17	0.27	0.09	2.80	98.90	3.01	0.61
86GRS-4197	48.30	14.90	11.80	7.56	10.80	1.96	0.07	0.71	0.04	0.21	0.79	0.08	2.30	98.70	2.89	0.56
86GRS-4204	47.10	15.50	14.40	8.35	5.66	4.01	0.06	1.02	0.06	0.26	0.16	0.05	3.60	100.00	2.89	0.53
86GRS-4205	47.20	15.90	13.60	7.61	9.63	2.81	0.02	0.96	0.07	0.18	0.47	0.01	1.80	99.70	3.01	0.53
86GRS-4208	50.80	16.40	11.30	5.45	11.80	1.31	0.27	0.75	0.07	0.19	1.12	0.22	1.50	99.80	2.98	0.49

Table 4-1f. Trace element geochemistry for mafic volcanic rocks of the Pickle Crow assemblage.

SAMPLE	Co	Cr	Cu	Ni	Pb	Zn	Nb	Rb	Sr	Y	Zr	Th	Pr	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	Ce	La	Nd	Y
86GRS-0004	45	257	139	131	36	90	<5	<5	135	22	74	<10	1.2	1.9	0.75	2.5	0.44	2.8	0.67	1.9	0.27	2	0.31	6.7	5.5	5.3	17
86GRS-0027A	42	213	138	109	11	82	<5	7	114	30	82	<10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
86GRS-1181	33	236	94	137	<10	89	<5	<5	96	28	125	<10	1.3	1.7	0.55	1.4	0.2	1.4	0.31	1	0.16	1.3	0.21	8.5	3.1	6.2	7
86GRS-1187	72	500	25	290	<10	155	<5	18	64	11	60	<10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
86GRS-1189	40	435	128	215	<10	72	<5	<5	81	18	57	<10	0.59	1.2	0.42	1.7	0.33	2.4	0.56	1.6	0.25	1.5	0.23	3.5	1.2	3	11
86GRS-1207	44	340	120	122	52	79	<5	9	52	19	57	<10	0.73	1.2	0.5	1.6	0.28	1.7	0.37	1	0.14	0.99	0.16	4.2	2.4	3.6	8.3
86GRS-1211	29	294	133	86	<10	56	<5	31	98	18	71	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
86GRS-1216	45	399	38	200	<10	79	<5	5	106	21	55	<10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
86GRS-1218	44	525	101	113	24	78	<5	<5	84	21	63	<10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
86GRS-1220	47	148	164	100	<10	102	<5	<5	71	24	73	<10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
86GRS-1226	54	1080	100	285	<10	81	<5	<5	36	18	55	<10	0.6	0.86	0.26	0.91	0.13	0.8	0.16	0.46	0.07	0.65	0.11	3.7	2.3	3.1	3.6
86GRS-2156	41	390	54	112	<10	86	<5	10	99	21	65	<10	0.85	1.6	0.61	2.4	0.46	3	0.69	2	0.29	1.9	0.31	5.1	2.6	4.2	18
86GRS-2166	42	409	88	149	<10	82	<5	<5	81	22	61	<10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
86GRS-2171	43	368	56	104	14	75	<5	<5	102	25	66	<10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
86GRS-2178	42	183	94	91	11	122	<5	18	132	32	112	<10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
86GRS-2182	45	248	157	111	<10	101	<5	<5	157	28	95	<10	1.5	2.2	0.87	3.1	0.58	4	0.89	2.4	0.37	2.2	0.35	8.3	3.3	6.8	17
86GRS-2209	39	382	78	103	<10	81	<5	<5	106	20	65	<10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
86GRS-2233	42	387	42	111	14	104	<5	<5	85	22	63	<10	0.69	1.3	0.59	2.1	0.42	2.7	0.58	1.9	0.26	1.8	0.27	4.4	2	3.8	17
86GRS-3203	40	285	19	171	<10	94	<5	<5	24	30	89	<10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
86GRS-3204	44	338	136	147	<10	76	<5	<5	90	23	63	<10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
86GRS-3205	42	104	138	51	<10	70	<5	<5	130	17	60	<10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
86GRS-3208	61	199	130	133	<10	106	<5	<5	64	37	100	<10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
86GRS-3210	34	430	134	111	<10	82	<5	8	51	14	44	<10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
86GRS-3216	50	351	148	250	<10	100	<5	<5	101	20	58	<10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
86GRS-3223	39	470	17	180	<10	124	<5	100	92	14	79	<10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
86GRS-4033	45	203	138	115	25	102	<5	<5	109	27	82	<10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
86GRS-4063	43	151	120	55	40	86	<5	<5	149	28	98	<10	1.7	2.6	1.1	3.5	0.6	3.9	0.85	2.4	0.33	2.1	0.3	10	3.7	7.8	22
86GRS-4076	49	234	142	121	12	92	<5	<5	149	25	77	<10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
86GRS-4107	38	249	26	69	<10	113	<5	<5	147	31	94	<10	0.58	1.6	0.69	2.7	0.5	3.5	0.77	2.4	0.34	2.3	0.38	3.4	2.1	2.9	21
86GRS-4122	43	246	129	134	<10	94	<5	<5	125	21	70	<10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
86GRS-4133	17	16	20	28	<10	220	<5	<5	59	14	115	<10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
86GRS-4137	37	390	104	122	<10	84	<5	<5	86	19	59	<10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
86GRS-4138	38	164	135	94	<10	104	<5	<5	90	20	76	<10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
86GRS-4141	44	410	98	146	26	84	<5	<5	79	19	57	<10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
86GRS-4144	65	1070	90	305	39	180	<5	<5	115	17	64	<10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
86GRS-4156	42	220	112	101	<10	82	<5	<5	157	25	66	<10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
86GRS-4159	24	283	38	66	<10	55	<5	25	919	18	150	<10	4	3.1	0.99	2.7	0.33	1.9	0.41	1.1	0.15	1	0.16	32	16	15	11
86GRS-4164	43	405	92	148	<10	85	<5	<5	94	22	60	<10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
86GRS-4167	45	390	108	125	<10	92	<5	<5	110	22	65	<10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
86GRS-4174	48	246	178	123	<10	119	<5	10	86	28	77	<10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
86GRS-4179	46	380	90	128	<10	62	<5	<5	182	23	79	<10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
86GRS-4189	31	188	139	108	<10	87	<5	<5	79	23	67	12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
86GRS-4193	41	357	99	141	36	76	<5	<5	162	18	68	<10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
86GRS-4197	44	370	76	119	<10	94	<5	<5	91	25	65	<10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
86GRS-4204	38	244	24	61	<10	32	<5	<5	152	22	98	13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
86GRS-4205	46	235	98	124	22	96	<5	<5	133	25	81	<10	1.4	2.1	0.82	3.1	0.55	3.7	0.8	2.5	0.35	2.4	0.33	8.7	4.6	6.6	22
86GRS-4208	50	378	130	135	<10	90	<5	8	147	20	73	<10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 4-1g. Locations and rock names of geochemical samples from mafic volcanic rocks of the Woman assemblage.

Sample No.	Rock Name	UTM Eastings	UTM Northings
82GRS-0035	basalt	606893	5704634
82GRS-0139	fragmental basalt	615902	5700536
82GRS-1056	pillowed basalt	610677	5703664
82GRS-1582	basalt	610703	5703388
82GRS-1583	pillowed basalt	610677	5703664
84GRS-0046	pillowed basalt	636660	5686725
84GRS-0047	basalt	636275	5686730
84GRS-0075	basalt	637415	5683600
84GRS-0119	sheared basalt	636551	5687430
84GRS-0136	pillowed basalt	650250	5683850
84GRS-1056	basalt	636345	5685880
84GRS-1116	basalt	638025	5683665
84GRS-1166	basalt	646275	5685270
84GRS-1203	basalt	653175	5685465
84GRS-1206	basalt	653890	5685050
84GRS-1222	pillowed basalt	645650	5683855
84GRS-1225	basalt	645770	5684355
86GRS-1094	fragmental basalt	308500	5717820
86GRS-2159	pillowed basalt	704780	5695475

Table 4-1h. Major element geochemistry for mafic volcanic rocks of the Woman assemblage.

SAMPLE	SiO2	Al2O3	Fe2O3*	MgO	CaO	Na2O	K2O	TiO2	P2O5	MnO	CO2	S	LOI	TOTAL	Sp. Gr.	Mg #
82GRS-0035	46.60	15.70	11.40	8.32	13.40	1.52	0.19	0.73	0.04	0.18	0.13	0.02	0.40	98.23	3.00	0.59
82GRS-0139	50.50	14.70	12.40	4.80	9.89	1.79	0.20	1.03	0.11	0.16	0.20	0.04	0.80	95.82	3.00	0.43
82GRS-1056	46.50	13.10	12.60	9.32	14.40	0.50	0.14	0.73	0.02	0.22	0.56	0.04	0.90	98.13	3.03	0.59
82GRS-1582	49.40	14.90	11.80	6.73	13.40	1.55	0.27	0.63	0.02	0.21	0.23	0.06	0.50	99.20	3.10	0.53
82GRS-1583	49.90	17.40	9.25	5.95	12.90	2.10	0.25	0.50	0.02	0.16	0.44	0.06	0.60	98.93	3.10	0.56
84GRS-0046	48.40	15.10	11.31	8.32	12.20	1.25	0.18	0.64	0.01	0.17	0.13	0.04	1.60	99.10	3.10	0.87
84GRS-0047	48.40	14.60	12.57	8.29	11.90	1.49	0.06	0.77	0.03	0.17	0.07	0.06	1.00	99.30	3.04	0.89
84GRS-0075	48.00	15.70	13.77	7.30	9.19	2.60	0.11	1.09	0.07	0.18	0.18	0.07	1.40	99.30	2.96	0.87
84GRS-0119	48.00	14.90	11.11	8.43	12.10	1.56	0.12	0.68	0.02	0.14	0.10	0.17	2.20	99.20	3.05	0.85
84GRS-0136	48.00	15.30	12.28	7.26	11.40	2.30	0.13	0.79	0.04	0.19	1.04	0.02	1.60	98.90	2.98	0.87
84GRS-1056	47.20	13.90	16.72	6.36	8.78	2.41	0.18	1.63	0.13	0.20	0.24	0.09	2.00	99.10	3.06	0.78
84GRS-1116	47.60	15.30	13.55	8.23	9.72	2.42	0.11	0.89	0.04	0.17	0.16	0.07	1.00	99.70	2.98	0.86
84GRS-1166	48.00	15.40	11.34	9.23	12.20	1.55	0.11	0.61	0.02	0.16	0.38	0.04	1.20	99.20	3.01	0.89
84GRS-1203	48.00	14.40	14.35	7.61	9.85	2.84	0.25	1.04	0.09	0.19	0.19	0.01	1.00	99.40	2.99	0.84
84GRS-1206	52.50	14.50	10.21	7.36	11.60	2.11	0.21	0.70	0.07	0.16	0.18	0.01	1.20	100.30	2.98	0.88
84GRS-1222	43.20	16.90	15.27	8.30	8.68	1.84	0.06	1.16	0.08	0.17	0.15	0.01	3.80	98.90	2.96	0.82
84GRS-1225	48.60	15.10	12.40	5.59	12.60	1.68	0.16	0.81	0.03	0.22	1.43	0.02	2.70	99.60	3.04	0.78
86GRS-1094	49.00	10.10	11.80	7.87	17.00	1.53	0.49	0.52	0.17	0.42	0.17	0.01	0.80	99.70	3.18	0.57
86GRS-2159	49.20	14.60	11.80	7.11	13.20	1.50	0.24	0.63	0.05	0.20	0.24	0.01	1.10	99.60	3.14	0.54

Table 4-1i. Trace element geochemistry for mafic volcanic rocks of the Woman assemblage.

SAMPLE	Ba	Co	Cr	Cu	Li	Ni	Pb	Zn	Be	Mo	Sc	Sr	V	Y	Nb	Rb	Sr	Y	Zr	Th	Pr	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	Ce	La	Nd	Y	Sc
82GRS-0035	70	44	435	62	14	129	181	76	1	<10	-	105	235	19	21	-	-	-	30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	50
82GRS-0139	60	40	226	64	14	90	60	98	1	<10	-	80	220	30	22	-	-	-	94	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	40
82GRS-1056	60	44	405	38	6	139	113	79	1	<10	-	60	245	17	30	-	-	-	<10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	60
82GRS-1582	70	48	213	80	12	118	220	80	1	<10	-	50	160	14	22	-	-	-	20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	40
82GRS-1583	120	47	435	45	10	168	61	71	1	<10	-	120	160	14	23	-	-	-	12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	45
84GRS-0046	-	45	485	91	-	107	<10	90	1	<10	-	85	220	13	15	-	-	8	55	-	8	1	0.5	2	0.3	2	0.4	1.2	0.2	1	0.1	5	2	4	-	45
84GRS-0047	-	48	340	125	-	164	15	108	1	<10	45	75	280	14	-	-	-	-	60	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
84GRS-0075	-	44	198	154	-	92	<10	129	1	<10	-	230	305	24	19	-	-	14	80	-	1	2	0.9	3	0.5	3	0.7	2.1	0.3	1.5	0.3	9	3	7	-	50
84GRS-0119	-	45	385	102	-	176	117	88	1	<10	35	100	235	11	-	-	-	-	60	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
84GRS-0136	-	46	314	122	-	142	12	116	1	<10	35	100	225	19	-	-	-	-	65	-	1	2	0.7	2	0.5	2.6	0.5	1.6	0.2	1.4	0.2	7	2	5	11	-
84GRS-1056	-	45	222	107	-	72	<10	175	2	<10	45	125	415	25	-	-	-	-	115	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
84GRS-1116	-	46	240	115	-	122	<10	119	1	<10	-	165	270	20	18	-	-	18	75	-	1	2	0.8	3	0.5	2.8	0.7	2.2	0.3	1.7	0.3	8	3	6	-	45
84GRS-1166	-	46	415	88	-	169	<10	94	1	<10	30	80	180	14	-	-	-	-	60	-	8	1	0.5	2	0.3	1.7	0.4	1	0.1	1.3	0.2	5	2	4	10	-
84GRS-1203	-	48	247	156	-	119	<10	125	1	<10	35	200	325	18	-	-	-	-	90	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
84GRS-1206	-	44	410	79	-	92	<10	100	1	<10	35	125	250	12	-	-	-	-	80	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
84GRS-1222	-	50	332	100	-	126	<10	130	1	<10	35	125	355	14	-	-	-	-	90	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
84GRS-1225	-	46	296	137	-	136	<10	120	1	<10	40	115	240	21	-	-	-	-	65	-	1	2	0.7	2	0.4	2.4	0.6	1.6	0.2	1.7	0.2	7	2	5	12	-
86GRS-1094	-	42	600	12	-	69	<10	108	-	-	-	-	-	-	<5	15	398	12	113	<10	2.8	2.7	0.8	2.2	0.33	1.9	0.37	1.1	0.15	1.1	0.18	20	9.2	11	11	-
86GRS-2159	-	37	340	76	-	95	<10	62	-	-	-	-	-	-	<5	7	91	22	62	<10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 4-1j. Locations and rock names of geochemical samples from mafic volcanic rocks of the Confederation assemblage.

Sample No.	Rock Name	UTM Eastings	UTM Northings
82GRS-0056	ultramafic flow	608057	5700733
82GRS-0088	pillowed basalt	611423	5699601
82GRS-0105	mafic fragmental	604285	5700130
82GRS-0106	basalt flow	604558	5700939
82GRS-0109	amygdaloidal andesite flow	612980	5699913
82GRS-0117	amygdaloidal basalt flow	610266	5701244
82GRS-0159	basalt flow	615421	5698763
82GRS-0168	basalt flow	614736	5697418
82GRS-0172	pillowed basalt	615252	5697647
82GRS-0176	amygdaloidal basalt flow	615870	5698527
82GRS-0204	basalt flow	613572	5697579
82GRS-0254	porphyritic basalt	609988	5698953
82GRS-0263	pillowed basalt	611735	5698558
82GRS-0281	mafic fragmental	610002	5698303
82GRS-0292	basalt flow	610032	5697778
82GRS-0297	mafic fragmental	609671	5698420
82GRS-0304	mafic fragmental	609130	5698439
82GRS-0366	basalt flow	615657	5695987
82GRS-0405	mafic fragmental	604520	5697137
82GRS-0420	pillowed basalt	609743	5697771
82GRS-0424	altered mafic fragmental	609771	5697341
82GRS-1026	basalt flow	607369	5700410
82GRS-1028	pillowed basalt	607288	5700593
82GRS-1187	basalt flow	613222	5699425
82GRS-1305	basalt flow	618443	5694228
84GRS-0026	carbonatized basalt	626175	5690080
84GRS-0032	basalt flow	625625	5690325
84GRS-0235	basalt flow	653720	5675560
84GRS-0239	basalt flow	653625	5675450
84GRS-0254	basalt flow	670665	5681025
84GRS-1184	basalt flow	645925	5681510
84GRS-1190	pillowed basalt	650025	5683290
84GRS-1219	pillowed basalt	648215	5682025
84GRS-1229	basalt flow	643525	5677600
84GRS-1233	basalt flow	644075	5676100
84GRS-1244	basalt flow	640565	5676850
84GRS-1277	basalt flow	662625	5683985
85GRS-0236	basalt flow	629460	5648600
85GRS-0239	pillowed basalt	630225	5648330
85GRS-1235	basalt flow	636410	5651200
85GRS-1245	basalt flow	637175	5651250
85GRS-1264	pillowed basalt	630800	5654140
85GRS-1268	pillowed basalt	630140	5654645
85GRS-1270	pillowed basalt	630365	5655075
85GRS-1271	brecciated basalt	630215	5655150
85GRS-1275	pillowed basalt	630200	5653485
85GRS-1299	pillowed basalt	632000	5651370
85GRS-1345	basalt flow	638350	5646790
85GRS-2218	basalt flow	642020	5647015
85GRS-2221	basalt flow	630280	5655575
85GRS-2222	basalt flow	630345	5655260
85GRS-2224	basalt flow	630760	5655352
85GRS-2226	basalt flow	630765	5655960
85GRS-2227	mafic fragmental	630775	5656325
85GRS-2228	basalt flow	630935	5656190
85GRS-2229	basalt flow	630870	5655185
85GRS-2230	pillowed basalt	631400	5654995
85GRS-2235	mafic fragmental	632620	5655375
85GRS-2247	basalt flow	631751	5654225
85GRS-2261	basalt flow	636875	5648025
85GRS-2264	pillowed basalt	639375	5648000
85GRS-2269	pillowed basalt	637100	5648950
85GRS-2270	pillowed basalt	638000	5648055
85GRS-2285	basalt flow	630050	5647775
85GRS-2299	basalt flow	626650	5646730
85GRS-2300	basalt flow	626550	5646700
86GRS-3262	basalt flow	680425	5683125
86GRS-3277	basalt flow	682920	5682725
86GRS-3283	basalt flow	682125	5682400
86GRS-3302	basalt flow	688825	5684125

Table 4-1k. Major element geochemistry for mafic volcanic rocks of the Confederation assemblage.

SAMPLE	SiO2	Al2O3	Fe2O3*	MgO	CaO	Na2O	K2O	TiO2	P2O5	MnO	CO2	S	LOI	TOTAL	Sp. Gr.	Mg #
82GRS-0056	45.90	11.00	10.50	11.80	14.90	0.55	0.47	0.30	0.09	0.25	3.05	0.02	3.30	98.83	3.02	0.69
82GRS-0088	50.10	14.10	12.60	6.88	12.00	1.60	0.21	0.83	0.10	0.19	0.23	0.11	0.40	98.95	3.06	0.52
82GRS-0105	52.70	13.00	12.80	9.12	9.56	0.61	0.14	0.70	0.10	0.21	0.29	0.03	0.40	99.26	3.00	0.59
82GRS-0106	48.10	12.40	18.90	5.31	8.26	3.43	0.42	1.88	0.11	0.22	0.14	0.03	0.00	99.20	3.06	0.36
82GRS-0109	46.60	13.60	14.50	4.69	11.70	2.20	0.50	1.18	0.13	0.23	3.68	0.05	3.30	99.06	3.02	0.39
82GRS-0117	48.50	14.40	16.00	6.38	7.83	3.28	0.41	1.28	0.08	0.18	0.32	0.05	0.10	98.71	3.02	0.44
82GRS-0159	45.60	12.00	17.00	8.59	11.20	1.99	0.33	1.04	0.12	0.25	0.31	0.11	0.50	98.54	2.99	0.50
82GRS-0168	48.90	14.70	12.10	7.10	12.30	1.32	0.17	0.70	0.09	0.19	1.76	0.02	2.10	99.35	2.99	0.54
82GRS-0172	51.10	13.70	12.70	7.30	11.00	1.76	0.14	0.79	0.05	0.18	0.16	0.03	0.40	98.91	3.01	0.53
82GRS-0176	45.20	12.90	18.10	4.74	12.10	2.64	0.24	1.26	0.08	0.35	0.46	0.12	0.70	98.19	3.14	0.34
82GRS-0204	50.10	14.40	12.20	7.34	11.00	1.22	0.21	0.71	0.05	0.18	0.88	0.06	1.10	98.35	3.15	0.54
82GRS-0254	45.90	16.20	14.70	7.15	10.80	2.23	0.25	1.12	0.05	0.18	0.23	0.03	0.70	98.84	3.07	0.49
82GRS-0263	51.20	15.00	12.10	7.39	9.60	2.12	0.12	0.70	0.03	0.19	0.98	0.04	0.90	99.47	2.99	0.55
82GRS-0281	48.40	13.30	12.40	7.53	8.48	2.56	2.78	0.96	0.27	0.20	1.34	0.02	2.10	98.24	2.91	0.55
82GRS-0292	47.40	14.80	13.00	8.29	11.70	1.59	0.24	0.93	0.05	0.19	0.11	0.09	0.60	98.39	3.04	0.56
82GRS-0297	54.60	13.50	9.20	4.39	11.90	1.45	1.98	0.70	0.14	0.18	0.15	0.29	1.50	98.48	2.90	0.49
82GRS-0304	48.00	13.10	12.00	7.53	9.21	2.73	2.66	0.96	0.18	0.18	1.40	0.02	2.10	97.97	2.93	0.55
82GRS-0366	58.20	11.50	17.30	1.60	3.80	3.86	0.16	1.12	0.15	0.19	0.82	0.14	0.80	98.84	2.86	0.15
82GRS-0405	47.50	13.80	12.80	6.72	13.20	2.45	0.68	0.68	0.05	0.25	0.15	0.17	0.70	98.45	3.10	0.51
82GRS-0420	47.50	13.60	11.80	9.95	12.30	1.42	0.30	0.61	0.03	0.15	0.19	0.02	0.60	97.87	3.02	0.63
82GRS-0424	45.20	14.50	14.00	3.74	16.60	1.44	0.36	0.92	0.05	0.41	0.29	0.41	1.40	97.92	3.16	0.35
82GRS-1026	48.70	14.80	12.00	7.85	12.30	0.87	0.18	0.71	0.05	0.18	0.15	0.12	0.50	97.91	3.02	0.56
82GRS-1028	48.00	15.00	12.30	7.86	12.00	2.04	0.11	0.72	0.04	0.20	0.27	0.03	0.50	98.57	2.99	0.56
82GRS-1187	46.80	12.90	19.50	4.30	9.32	2.43	0.35	2.18	0.13	0.25	0.23	0.09	0.30	98.48	3.13	0.30
82GRS-1305	50.30	13.60	12.50	6.25	11.90	1.42	0.17	0.82	0.04	0.22	2.19	0.02	2.30	99.43	2.99	0.50
84GRS-0026	49.30	15.70	11.68	5.93	10.90	1.79	0.37	0.94	0.02	0.22	1.86	0.02	2.00	99.40	2.88	0.88
84GRS-0032	49.00	14.50	14.91	6.21	7.51	3.75	0.12	1.75	0.11	0.23	0.20	0.01	0.30	98.50	3.02	0.76
84GRS-0235	54.30	14.60	13.56	4.54	8.82	2.66	0.13	1.01	0.03	0.38	0.52	0.01	0.40	100.60	2.95	0.82
84GRS-0239	49.90	15.00	14.22	5.67	10.00	2.44	0.22	1.02	0.07	0.24	0.17	0.02	0.50	98.80	2.99	0.85
84GRS-0254	50.80	14.70	10.71	7.92	11.60	1.62	0.16	0.69	0.03	0.17	0.37	0.01	1.00	99.00	3.01	0.90
84GRS-1184	50.50	13.10	14.28	5.80	7.25	2.97	0.08	1.75	0.07	0.21	0.70	0.05	3.50	99.40	2.92	0.72
84GRS-1190	47.80	15.50	11.24	8.33	11.20	1.59	0.12	0.78	0.03	0.17	0.91	0.04	3.20	99.60	2.97	0.86
84GRS-1219	50.50	14.20	13.86	5.40	7.85	3.90	0.40	1.20	0.04	0.16	0.71	0.03	2.40	99.90	2.91	0.77
84GRS-1229	48.60	14.30	13.98	8.35	7.85	1.79	0.04	0.82	0.06	0.20	0.64	0.01	4.40	99.90	2.93	0.82
84GRS-1233	56.40	11.60	13.41	1.45	8.12	4.03	0.39	1.01	0.35	0.25	3.40	0.01	3.60	100.50	2.91	0.45
84GRS-1244	58.50	11.90	16.63	1.79	5.71	2.90	0.43	1.14	0.28	0.26	0.11	0.01	0.40	99.90	2.93	0.45
84GRS-1277	48.20	14.80	13.16	6.89	12.10	2.18	0.17	0.83	0.05	0.29	0.09	0.02	0.50	98.80	3.04	0.85
85GRS-0236	45.80	14.50	15.40	8.12	9.96	1.29	0.00	0.99	0.04	0.20	0.28	0.07	3.50	99.80	3.02	0.51
85GRS-0239	53.70	14.20	11.30	3.31	6.28	1.38	0.23	0.90	0.04	0.27	4.35	0.04	7.30	98.90	2.76	0.37
85GRS-1235	47.70	16.80	14.70	5.26	8.81	2.92	0.05	0.96	0.00	0.27	0.30	0.01	1.80	99.30	3.00	0.41
85GRS-1245	49.00	15.80	9.72	6.85	8.62	2.15	0.00	1.00	0.00	0.10	3.39	0.01	6.70	99.90	2.74	0.58
85GRS-1264	49.20	14.20	10.80	6.19	12.90	1.42	0.04	0.80	0.00	0.20	2.81	0.01	2.90	98.70	2.93	0.53
85GRS-1268	49.20	13.00	16.10	6.34	9.62	2.99	0.12	1.34	0.05	0.22	0.21	0.01	0.30	99.30	3.02	0.44
85GRS-1270	48.70	15.00	11.10	7.60	13.70	1.17	0.02	0.61	0.00	0.19	1.07	0.03	1.30	99.40	3.01	0.58
85GRS-1271	46.40	15.20	11.80	10.20	11.50	1.39	0.09	0.71	0.00	0.17	0.12	0.06	1.70	99.20	3.00	0.63
85GRS-1275	47.40	14.00	14.10	6.82	11.60	2.30	0.00	1.22	0.04	0.19	0.64	0.03	0.90	98.50	3.01	0.49
85GRS-1299	54.60	13.90	15.80	2.78	5.34	0.70	0.00	0.94	0.03	0.17	2.48	0.01	5.20	99.40	2.83	0.26
85GRS-1345	39.50	13.80	12.40	7.86	7.89	0.09	2.04	0.79	0.00	0.17	10.60	0.01	14.10	98.60	2.86	0.56
85GRS-2218	51.20	15.80	14.00	4.47	4.87	0.88	0.45	0.99	0.03	0.23	3.16	0.01	6.70	99.60	2.78	0.39
85GRS-2221	49.00	14.20	14.40	6.06	10.80	2.50	0.03	1.42	0.06	0.17	0.09	0.06	0.60	99.20	3.02	0.45
85GRS-2222	50.50	16.90	11.50	4.81	11.20	2.05	0.08	0.86	0.03	0.22	0.73	0.03	0.90	99.00	2.96	0.45
85GRS-2224	48.30	14.90	12.40	8.17	12.30	1.73	0.00	0.70	0.04	0.20	0.28	0.03	0.70	99.40	3.04	0.57
85GRS-2226	53.90	16.40	10.70	4.07	10.30	2.01	0.17	0.87	0.05	0.17	0.43	0.10	0.60	99.20	2.95	0.43
85GRS-2227	54.80	16.10	11.00	2.27	9.11	2.61	0.38	1.18	0.06	0.23	1.47	0.04	1.60	99.30	2.86	0.29
85GRS-2228	47.90	14.00	12.80	7.97	12.60	1.54	0.02	0.77	0.04	0.21	1.22	0.02	1.80	99.60	3.04	0.55
85GRS-2229	46.80	13.00	10.20	6.82	16.50	0.17	0.01	0.52	0.02	0.20	4.53	0.21	4.80	99.00	2.99	0.57
85GRS-2230	48.80	14.80	13.90	6.14	10.90	1.84	0.13	0.89	0.04	0.22	1.15	0.01	1.30	99.00	3.03	0.47
85GRS-2235	49.60	15.40	14.60	5.80	9.55	2.25	0.09	1.50	0.07	0.18	0.20	0.01	0.30	99.30	3.02	0.44
85GRS-2247	56.30	14.10	8.49	3.17	8.77	2.30	0.97	1.18	0.23	0.26	2.64	0.01	2.90	98.70	2.80	0.43
85GRS-2261	53.90	16.30	9.49	1.53	5.65	4.09	1.00	1.05	0.10	0.14	3.97	0.01	6.20	99.40	2.77	0.24
85GRS-2264	45.20	13.10	13.10	5.59	11.10	1.26	0.00	1.30	0.07	0.19	5.11	0.01	8.40	99.30	2.87	0.46
85GRS-2269	55.80	13.30	10.20	4.29	4.92	2.97	0.08	0.84	0.03	0.16	3.51	0.02	6.20	98.80	2.72	0.45
85GRS-2270	41.90	13.20	19.00	3.17	9.22	0.96	0.00	0.73	0.03	0.42	6.56	0.01	10.50	99.10	2.85	0.25
85GRS-2285	59.90	14.60	8.30	2.84	4.15	2.05	0.26	1.37	0.06	0.07	2.94	0.03	5.60	99.20	2.77	0.40
85GRS-2299	55.40	13.30	10.00	3.82	5.77	3.77	0.00	1.22	0.20	0.12	3.93	0.17	6.00	99.60	2.75	0.43
85GRS-2300	51.70	14.50	11.30	4.70	4.09	4.67	0.00	1.57	0.16	0.14	4.76	0.01	6.90	99.70	2.66	0.45
86GRS-3262	47.30	16.60	12.50	8.53	10.40	2.03	0.12	0.62	0.05	0.17	0.14	0.01	0.80	99.10	3.03	0.57
86GRS-3277	49.90	14.30	13.70	6.17	10.10	2.91	0.17	0.83	0.06	0.23	1.04	0.02	1.10	99.50	2.97	0.47
86GRS-3283	55.60	13.30	14.80	3.41	6.20	3.05	0.40	1.59	0.14	0.26	0.16	0.01	0.00	98.80	2.98	0.31
86GRS-3302	47.80	13.40	18.20	6.70	7.89	3.97	0.16	1.20	0.11	0.17	0.09	0.01	0.30	99.90	3.05	0.42

Table 4-1l. Trace element geochemistry for mafic volcanic rocks of the Confederation assemblage.

SAMPLE	Ba	Co	Cr	Cu	Li	Ni	Pb	Zn	Be	Mo	Sc	Sr	V	Y	Nb	Rb	Sr	Y	Zr	Th	Pr	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	Ce	La	Nd	Y	Sc
82GRS-0056	120	59	855	74	9	540	<10	88	1	<10	-	110	90	10	10	-	-	-	40	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	25
82GRS-0088	60	42	325	91	10	91	149	103	1	<10	-	100	290	20	20	-	-	-	35	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	65
82GRS-0105	50	44	357	60	10	108	66	97	1	<10	-	40	280	18	19	-	-	-	17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	60
82GRS-0106	50	50	48	78	14	54	29	180	2	<10	-	245	300	25	25	-	-	-	130	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	30
82GRS-0109	110	49	23	220	18	66	69	134	1	<10	-	360	225	20	23	-	-	-	66	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	30
82GRS-0117	130	57	20	270	16	66	78	140	2	<10	-	260	210	19	24	-	-	-	57	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	30
82GRS-0159	60	49	33	230	13	94	240	128	2	<10	-	225	220	19	23	-	-	-	58	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	35
82GRS-0168	50	42	374	86	14	109	69	93	1	<10	-	55	280	19	21	-	-	-	14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	65
82GRS-0172	60	37	278	87	12	67	49	98	1	<10	-	165	290	20	20	-	-	-	23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	60
82GRS-0176	50	51	25	250	4	58	32	170	2	<10	-	130	230	19	20	-	-	-	72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	30
82GRS-0204	60	45	373	124	10	108	34	89	1	<10	-	70	290	17	18	-	-	-	32	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	60
82GRS-0254	80	49	193	88	14	86	43	118	1	<10	-	215	260	20	20	-	-	-	44	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	40
82GRS-0263	50	48	398	92	14	152	81	92	1	<10	-	45	255	15	16	-	-	-	20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	55
82GRS-0281	400	36	232	89	28	52	39	116	3	<10	-	540	260	20	17	-	-	-	62	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	40
82GRS-0292	110	43	330	111	24	124	36	118	2	<10	-	90	245	20	19	-	-	-	35	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	50
82GRS-0297	450	29	470	97	6	67	197	78	2	<10	-	390	195	15	13	-	-	-	58	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	35
82GRS-0304	350	33	259	126	22	62	37	122	2	<10	-	580	240	20	18	-	-	-	64	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	45
82GRS-0366	130	20	<5	57	6	<5	129	66	1	<10	-	150	50	50	9	-	-	-	185	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	40
82GRS-0405	130	39	435	46	22	120	124	124	3	<10	-	95	230	13	14	-	-	-	20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	45
82GRS-0420	60	38	455	67	22	84	<10	79	1	<10	-	90	235	11	13	-	-	-	19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	45
82GRS-0424	80	34	335	159	28	82	<10	98	2	<10	-	95	255	16	14	-	-	-	27	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	40
82GRS-1026	80	38	376	94	14	106	<10	89	1	<10	-	115	280	20	25	-	-	-	31	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	65
82GRS-1028	80	40	388	78	17	111	220	94	1	<10	-	120	280	18	24	-	-	-	20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	60
82GRS-1187	90	51	6	142	12	16	70	165	1	<10	-	155	250	40	35	-	-	-	150	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	35
82GRS-1305	70	46	343	130	8	102	102	94	1	<10	-	60	260	24	30	-	-	-	32	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	65
84GRS-0026	-	41	359	77	-	90	<10	108	1	<10	-	130	290	20	18	-	-	-	70	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	50
84GRS-0032	-	42	67	66	-	37	<10	150	2	<10	-	220	365	30	23	-	-	21	120	-	2	4	1.4	4	0.8	4.8	1	2.6	0.4	2.2	0.4	15	6	12	-	45
84GRS-0235	-	50	254	46	-	100	14	128	1	<10	40	170	270	22	-	-	-	-	80	-	1	2	0.6	2	0.4	2.5	0.8	1.9	0.3	1.3	0.2	5	2	4	13	-
84GRS-0239	-	50	267	90	-	90	12	146	2	<10	40	95	275	22	-	-	-	-	80	-	1	2	0.7	2	0.5	3.1	0.7	2	0.3	1.8	0.3	7	2	6	15	-
84GRS-0254	-	43	465	83	-	115	28	104	1	<10	40	95	220	17	-	-	-	-	65	-	8	2	0.6	2	0.4	2.3	0.5	1.6	0.2	1.4	0.2	4	2	4	12	-
84GRS-1184	-	35	49	90	-	33	<10	180	2	<10	35	75	325	30	-	-	-	-	120	-	3	4	1.3	5	0.8	4.5	0.9	2.7	0.4	2.2	0.3	20	7	14	20	-
84GRS-1190	-	43	460	94	-	137	10	103	1	<10	35	95	220	19	-	-	-	-	70	-	1	2	0.7	2	0.3	2.5	0.6	1.9	0.2	1.6	0.2	8	3	6	12	-
84GRS-1219	-	43	41	188	-	61	<10	144	2	<10	20	480	175	17	-	-	-	-	115	-	4	4	1.2	3	0.5	2.2	0.5	1.1	0.1	0.1	0.1	31	13	18	10	-
84GRS-1229	-	47	356	106	-	97	<10	165	1	<10	45	55	305	11	-	-	-	-	60	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
84GRS-1233	-	28	<10	17	-	<5	10	150	1	<10	40	205	60	40	-	-	-	-	150	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
84GRS-1244	-	29	<10	6	-	<5	<10	180	2	<10	45	145	60	40	-	-	-	-	140	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
84GRS-1277	-	49	298	72	-	143	<10	155	1	<10	40	145	295	16	-	-	-	-	75	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-0236	-	47	270	92	-	114	<10	106	2	<10	40	115	305	25	-	-	-	-	60	-	1.4	2.3	0.95	3.2	0.64	3.9	0.85	2.6	0.37	2.7	0.41	8.6	3.2	7.2	20	-
85GRS-0239	-	62	204	158	-	128	<10	105	1	<10	45	70	290	20	-	-	-	-	50	-	0.99	1.7	0.69	2.5	0.49	3.1	0.69	2.1	0.26	2	0.33	6.1	2.3	5	15	-
85GRS-1235	-	52	325	41	-	132	<10	107	2	<10	45	125	295	30	-	-	-	-	75	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-1245	-	47	298	64	-	136	<10	82	1	<10	35	110	245	22	-	-	-	-	65	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-1264	-	50	210	102	-	112	<10	86	2	<10	45	90	305	19	-	-	-	-	50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-1268	-	43	115	41	-	59	<10	110	2	<10	35	95	355	30	-	-	-	-	85	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-1270	-	45	390	80	-	179	<10	74	<1	<10	30	90	205	13	-	-	-	-	37	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-1271	-	48	410	90	-	185	<10	74	1	<10	30	85	235	13	-	-	-	-	39	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-1275	-	47	303	95	-	101	<10	98	2	<10	40	125	340	30	-	-	-	-	70	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-1299	-	42	185	8	-	117	<10	92	2	<10	35	55	240	21	-	-	-	-	50	-	1.2	2	1.4	2.6	0.5	3.3	0.71	2.2	0.25	1.8	0.2	7.3	2.5	5.9	17	-
85GRS-1345	-	45	229	128	-	177	<10	100	<1	<10	25	100	185	4	-	-	-	-	31	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-2218	-	41	271	12	-	112	<10	105	1	<10	35	85	230	17	-	-	-	-	60	-	1.1	1.4	0.7	2.2	0.41	2.5	0.55	1.6	0.2	1.3	0.22	6.5	2.4	5.2	12	-
85GRS-2221	-	40	148	98	-	56	<10	114	2	<10	40	225	350	35	-	-	-	-	95	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-2222	-	52	384	66	-	169	<10	80	1	<10	40	100	255	19	-	-	-	-	55	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-2224	-	49	395	84	-	146	<10	84	1	<10	35	120	245	16	-	-	-	-	46	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-2226	-	49	294	108	-	123	<10	84	2	<10	45	85	285	20	-	-	-	-	50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-2227	-	53	130	61	-	98	<10	98	2	<10	45	125	330	25	-	-	-	-	70	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-2228	-	45	232	98	-	80	<10	97	2	<10	40	95	260	21	-	-	-	-	50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-2229	-	43	304	114	-	140	<10	63	1	<10	40	45	225	18	-	-	-	-	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-2230	-	48	223	23	-	102	<10	109	2	<10	50	115	315	22	-	-	-	-	50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-2235	-	43	140	17	-	71	<10	139	1	<10	25	250	205	22	-	-	-	-	85	-	1.4	2.8	1.2	3.6	0.61	3.5	0.71	2	0.27	1.8	0.29	8.6	2.7	7.7	16	-
85GRS-2247	-	28	139	20	-	55	<10	70	1	<10	17	250	135	22	-	-	-	-	140	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-2261	-	16	<10	16	-	<5	<10	98	<1	<10	14	245	40	15	-	-	-	-	115	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-2264	-	39	164	100	-	87	<10	104	2	<10	40	125	320	30	-	-	-	-	80	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-2269	-	38	188	108	-	74	<10	72	1	<10	35	65	230	9	-	-	-	-	44	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-2270	-	36	241	66	-	118	19	94	<1	<10	30	45	210	9	-	-	-	-	55	-	1.1	1.4	0.51	1.6	0.27	1.2	0.23	0.77	0.13	1.1	0.19	6.7	2.3	5.1	5.6	-
85GRS-2285	-	59	232	210	-	85	20	120	2	<10	45	105	295	7	-	-	-	-	75	-	1.8	2.6	0.83	2	0.24	1.3	0.23	0.71	0.12	0.92	0.15	12	5	8.6	5.2	-
85GRS-2290	-	31	43	117	-	20	<10	97	1	<10	25	100	170	21	-	-	-	-	195	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-2300	-	32	120	7	-	49	<10	86	1	<10	30	75	200	12	-	-	-	-	115	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
86GRS-3262	-	57	81	182	-	220	<10	84	-	-	-	-	-	-	<5	<5	115	18	64	<10	1	1.6	0.69	2.2	0.36	2.3	0.5	1.5	0.2	1.5	0.22	6.3	2.8	4.6	14	-
86GRS-3277	-	46	125	107	-	74	<10	102	-	-	-	-	-	-	<5	<5	119	28	74	<10	0.84	1.7	0.74	2.7	0.49	3.8	0.83	2.5	0.34	2.5	0.4	4.8	2.7	4.5	23	-
86GRS-3283	-	41	25	8	-	22	<10	134	-	-	-	-	-	-	<5	15	189	39	157	<10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
86GRS-3302	-	37	117	13	-	67	24	90	-	-	-	-	-	-	<5	9	148	31	93	<10	1.5	2.6	1.3	3.7	0.65	4.2	0.91	2.7	0.37	2.6	0.41	9.7	3.7	7.9	25	-

Table 4-1m. Locations and rock names of geochemical samples from mafic volcanic rocks of the St. Joseph assemblage.

Sample No.	Rock Name	UTM Eastings	UTM Northings
85GRS-0061	pillowed basalt	685215	5655750
85GRS-0067	fragmental basalt	689485	5659955
85GRS-0184	massive basalt	655175	5649900
85GRS-0252	pillowed basalt	633160	5648530
85GRS-1000	massive basalt	685000	5651325
85GRS-1032	massive basalt	679700	5649635
85GRS-1033	massive basalt	679525	5649700
85GRS-1039	fragmental basalt	688448	5661791
85GRS-1042	massive basalt	689125	5662033
85GRS-1141	massive basalt	671375	5649650
85GRS-1308	pillowed basalt	632450	5651095
85GRS-1349	pillowed basalt	631615	5649600
85GRS-1350	pillowed basalt	632125	5649495
85GRS-2009	massive basalt	691242	5656275
85GRS-2011	massive basalt	688130	5654000
85GRS-2025	massive basalt	688500	5651625
85GRS-2030	massive basalt	694623	5651412
85GRS-2034	massive basalt	685000	5652450
85GRS-2035	massive basalt	686060	5662100
85GRS-2038	massive basalt	688600	5662850
85GRS-2041	fragmental basalt	687200	5662500
85GRS-2058	massive basalt	689987	5663852
85GRS-2091	massive basalt	689150	5662900
85GRS-2093	massive basalt	688700	5662750
85GRS-2095	massive basalt	688425	5662750
85GRS-2109	massive basalt	689090	5663355
85GRS-2131	pillowed basalt	678100	5661925
85GRS-2133	fragmental basalt	677230	5661000
85GRS-2145	massive basalt	660740	5654465
85GRS-2153	massive basalt	674010	5648772
85GRS-2156	massive basalt	655248	5650000
85GRS-2157	massive basalt	655448	5650168
85GRS-2159	massive basalt	656178	5650985
85GRS-2160	massive basalt	656195	5650790
85GRS-2172	massive basalt	672497	5648126
85GRS-2204	pillowed basalt	647375	5650850
85GRS-2211	massive basalt	645950	5648575
85GRS-2245	massive basalt	632075	5655027
85GRS-2251	pillowed basalt	632220	5654000
85GRS-2256	pillowed basalt	632777	5652980

Table 4-1n. Major element geochemistry for mafic volcanic rocks of the St. Joseph assemblage.

SAMPLE	SiO_2	Al_2O_3	$Fe_2O_3^*$	MgO	CaO	Na_2O	K_2O	TiO_2	P_2O_5	MnO	CO_2	S	LOI	TOTAL	Sp. Gr.	Mg #
85GRS-0061	49.70	14.70	14.30	4.78	11.40	2.22	0.21	1.27	0.04	0.21	0.30	0.02	0.80	99.60	3.04	0.40
85GRS-0067	49.30	16.40	14.30	4.98	7.82	3.52	0.63	1.31	0.01	0.22	0.22	0.01	0.20	98.70	2.98	0.41
85GRS-0184	48.10	15.10	14.80	4.27	11.90	1.47	1.10	1.25	0.04	0.20	1.52	0.10	1.20	99.40	3.06	0.36
85GRS-0252	52.00	15.40	18.80	4.20	2.00	1.22	0.53	0.57	0.11	0.16	1.39	0.01	4.90	99.90	2.75	0.31
85GRS-1000	49.50	15.50	14.40	4.99	9.54	2.43	0.11	1.15	0.02	0.18	0.79	0.11	1.10	98.90	2.96	0.41
85GRS-1032	54.10	17.40	8.15	4.68	9.92	2.49	0.46	0.97	0.17	0.13	0.46	0.01	0.90	99.40	2.91	0.53
85GRS-1033	53.20	16.90	9.04	6.13	8.44	2.84	1.19	0.69	0.10	0.13	0.43	0.01	0.90	99.50	2.84	0.57
85GRS-1039	51.10	17.20	13.20	3.89	8.69	3.10	0.32	1.29	0.00	0.18	0.34	0.02	0.50	99.50	2.92	0.37
85GRS-1042	48.00	15.40	13.50	6.63	10.40	3.10	0.01	1.37	0.00	0.17	1.07	0.01	1.20	99.70	3.03	0.49
85GRS-1141	53.30	15.70	11.90	2.96	10.00	2.46	0.17	1.73	0.12	0.17	1.44	0.01	1.40	99.90	2.93	0.33
85GRS-1308	61.20	13.80	8.11	2.16	5.49	2.59	0.73	0.86	0.15	0.17	2.92	0.01	4.10	99.40	2.76	0.35
85GRS-1349	51.90	14.10	10.50	3.68	6.97	3.08	0.58	0.73	0.16	0.21	5.08	0.01	7.70	99.60	2.72	0.41
85GRS-1350	49.10	13.90	24.50	2.66	1.99	0.98	0.23	0.90	0.15	0.47	1.52	0.01	5.00	99.90	2.88	0.18
85GRS-2009	48.80	14.10	15.70	6.39	10.30	1.95	0.09	1.26	0.05	0.18	0.64	0.01	0.60	99.40	3.01	0.45
85GRS-2011	49.40	15.00	11.50	5.76	13.40	1.29	0.03	0.51	0.00	0.17	2.12	0.05	2.30	99.40	2.95	0.50
85GRS-2025	45.30	14.10	12.00	12.10	12.00	1.69	0.00	0.56	0.00	0.17	0.12	0.04	0.90	98.80	3.08	0.67
85GRS-2030	55.10	15.30	9.54	5.07	9.29	2.03	0.55	1.07	0.32	0.15	0.41	0.01	0.50	98.90	2.90	0.51
85GRS-2034	51.00	12.60	16.70	6.30	8.37	2.70	0.00	1.14	0.00	0.24	0.12	0.01	0.10	99.20	3.02	0.43
85GRS-2035	50.90	16.00	13.60	2.53	10.50	1.68	0.13	0.88	0.05	0.40	2.12	0.05	2.00	98.70	2.96	0.27
85GRS-2038	46.10	13.00	12.30	8.19	16.00	0.68	0.26	0.46	0.01	0.33	1.35	0.01	2.00	99.30	3.02	0.57
85GRS-2041	51.40	16.70	11.90	4.55	9.28	3.22	0.25	1.13	0.08	0.16	0.12	0.01	0.30	99.00	2.94	0.43
85GRS-2058	51.10	15.00	13.40	5.30	10.90	1.04	0.00	0.64	0.02	0.40	1.17	0.25	1.00	98.80	3.02	0.44
85GRS-2091	44.30	13.00	12.40	14.90	12.00	1.50	0.02	0.49	0.00	0.19	0.19	0.01	1.00	99.80	3.13	0.70
85GRS-2093	48.10	14.50	14.10	6.67	11.10	2.56	0.04	1.01	0.02	0.22	0.24	0.01	0.40	98.70	3.01	0.48
85GRS-2095	44.90	13.90	16.30	8.76	11.00	1.74	0.01	0.60	0.01	0.42	0.41	0.01	0.80	98.40	3.11	0.52
85GRS-2109	48.00	12.90	12.50	10.90	11.70	2.12	0.00	0.65	0.03	0.31	0.21	0.01	0.70	99.80	3.01	0.63
85GRS-2131	51.30	14.10	12.80	5.75	11.30	2.18	0.18	1.05	0.07	0.17	0.15	0.01	0.50	99.40	3.02	0.47
85GRS-2133	53.90	14.00	16.70	2.41	7.10	2.39	0.87	1.50	0.16	0.20	0.13	0.10	0.70	99.90	2.98	0.22
85GRS-2145	47.50	14.40	13.40	7.03	12.10	2.48	0.22	1.04	0.06	0.20	0.84	0.01	1.30	99.70	3.02	0.51
85GRS-2153	47.40	13.40	15.00	5.95	11.00	2.34	0.09	1.55	0.11	0.22	1.95	0.02	2.10	99.20	3.02	0.44
85GRS-2156	49.50	14.60	14.90	6.50	9.59	2.13	0.00	1.30	0.04	0.19	0.66	0.05	0.90	99.60	3.01	0.46
85GRS-2157	47.80	13.90	14.70	7.65	10.20	2.78	0.12	0.95	0.04	0.21	0.20	0.01	0.80	99.10	3.01	0.51
85GRS-2159	43.00	10.60	11.50	17.00	12.20	0.30	0.00	0.41	0.00	0.19	1.60	0.02	4.00	99.20	3.05	0.75
85GRS-2160	47.70	14.80	12.30	9.04	11.60	2.01	0.49	0.64	0.03	0.17	0.48	0.04	0.90	99.70	3.03	0.59
85GRS-2172	45.90	16.00	13.50	8.93	10.30	2.41	0.02	0.98	0.01	0.19	0.58	0.05	1.40	99.60	3.00	0.57
85GRS-2204	46.90	16.10	12.50	7.56	12.50	1.45	0.02	0.67	0.02	0.18	0.80	0.01	1.70	99.60	3.03	0.54
85GRS-2211	47.00	16.30	12.10	4.62	13.40	1.63	0.10	0.91	0.01	0.26	2.55	0.06	2.70	99.00	3.00	0.43
85GRS-2245	44.70	14.50	16.00	7.42	11.90	1.37	0.12	1.01	0.06	0.22	1.44	0.04	1.70	99.00	3.09	0.48
85GRS-2251	47.70	13.80	15.70	5.22	10.70	1.71	0.12	1.06	0.05	0.25	2.32	0.09	2.80	99.10	3.05	0.40
85GRS-2256	47.90	15.70	13.10	3.60	9.16	2.29	0.01	1.35	0.05	0.23	3.72	0.07	5.40	98.80	2.81	0.35

Table 4-1o. Trace element geochemistry for mafic volcanic rocks of the St. Joseph assemblage.

SAMPLE	Au	Co	Cr	Cu	Ni	Pb	Zn	Be	Mo	Sc	Sr	V	Y	Zr	Pr	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	Ce	La	Nd	Y
85GRS-0061	-	49	163	89	77	43	116	2	<10	40	180	310	30	85	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-0067	-	48	25	28	45	17	144	1	<10	25	135	205	25	65	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-0184	-	49	205	127	91	22	135	2	<10	35	90	340	30	90	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-0252	<0.002	24	112	9	95	<10	114	<1	<10	14	70	105	11	145	3.7	2.7	0.7	2.4	0.29	1.7	0.28	0.92	0.13	1.1	0.21	33	16	14	7.3
85GRS-1000	-	57	264	140	153	<10	106	1	<10	35	270	280	23	60	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-1032	-	25	88	117	32	<10	80	<1	<10	13	465	120	15	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-1033	-	37	103	70	143	<10	95	1	<10	25	215	180	19	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-1039	-	55	315	31	146	<10	120	2	<10	35	180	275	23	60	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-1042	-	51	358	69	220	<10	112	2	<10	25	185	250	21	70	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-1141	-	36	12	20	23	12	131	1	<10	20	225	175	30	145	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-1308	-	16	135	7	42	<10	59	2	<10	16	290	125	18	135	4	3.4	1.1	3	0.48	2.8	0.56	1.4	0.22	1.5	0.25	32	14	15	13
85GRS-1349	-	26	118	32	80	<10	103	<1	<10	19	160	130	16	140	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-1350	-	18	113	12	50	<10	89	1	<10	16	50	180	9	120	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-2009	-	46	202	30	94	<10	121	2	<10	35	125	315	30	85	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-2011	-	46	405	34	135	<10	94	1	<10	40	140	230	15	43	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-2030	-	28	119	26	82	<10	100	1	<10	19	385	145	22	155	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-2034	-	46	<10	29	24	<10	115	3	<10	40	110	425	25	60	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-2035	-	52	265	78	136	23	99	1	<10	24	85	215	21	65	-	-	-	-	-	-	-	-	-	-	-	9.7	3.6	6.4	16
85GRS-2038	-	77	1510	74	680	<10	73	<1	<10	30	150	180	12	43	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-2041	-	35	55	28	53	<10	110	1	<10	25	295	180	22	95	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-2058	-	52	520	70	335	<10	87	1	<10	25	140	200	16	50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-2091	-	71	1480	15	565	<10	78	<1	<10	21	45	185	9	33	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-2093	-	49	220	108	107	<10	104	2	<10	35	95	305	25	65	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-2095	-	55	440	8	330	<10	80	1	<10	30	100	210	14	40	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-2109	-	55	382	6	260	<10	93	<1	<10	19	90	180	14	47	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-2131	-	44	221	33	152	<10	116	1	<10	25	315	200	22	85	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-2133	-	35	<10	132	7	<10	165	<1	<10	24	920	100	45	170	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-2145	-	51	183	8	105	<10	113	2	<10	40	135	305	25	65	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-2153	-	47	104	76	52	<10	110	2	<10	35	155	290	25	90	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-2156	-	47	181	104	86	63	145	2	<10	35	120	315	30	95	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-2157	-	47	127	50	69	20	73	2	<10	45	120	305	25	70	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-2159	-	65	1240	92	505	12	72	<1	<10	12	30	175	12	25	0.51	0.95	0.47	1.4	0.25	1.5	0.34	1.1	0.12	0.95	0.14	3.4	1.2	2.9	7.5
85GRS-2160	-	48	358	56	129	<10	84	1	<10	35	65	240	20	42	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-2172	-	54	262	77	147	<10	93	1	<10	25	150	225	16	65	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-2204	-	47	390	62	121	<10	82	1	<10	40	85	270	18	44	0.74	1.3	0.5	2	0.44	2.6	0.62	1.9	0.27	1.8	0.26	4.3	1.5	3.6	13
85GRS-2211	-	52	318	84	147	<10	84	1	<10	35	100	235	22	70	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-2245	-	48	217	122	93	<10	122	2	<10	50	150	330	21	65	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-2251	-	50	166	124	113	<10	117	2	<10	45	75	315	25	60	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-2256	-	50	167	146	108	12	107	2	<10	45	75	335	25	60	1.2	1.9	0.76	3	0.55	3.4	0.84	2.4	0.33	2.6	0.34	7.5	2.6	6.1	18

Table 4-2a. Locations and rock names of geochemical samples from felsic to intermediate volcanic rocks of the Pickle Crow assemblage.

Sample No.	Sample Description	UTM Eastings	UTM Northings
86GRS-0155	dacite	704725	5708400
86GRS-2206	dacite	704855	5698300
86GRS-2222	dacite	704900	5698900
86GRS-3201	intermediate volcanic	705600	5708950
86GRS-4123	dacite	704730	5709100
86GRS-4163	altered dacite	706100	5767160
86GRS-6001	andesite	705900	5707025

Table 4-2b. Major element geochemistry for felsic to intermediate volcanic rocks of the Pickle Crow assemblage.

SAMPLE	SiO2	Al2O3	Fe2O3	MgO	CaO	Na2O	K2O	TiO2	P2O5	MnO	CO2	S	LOI	TOTAL	Sp. Gr.
86GRS-0155	65.80	16.00	3.34	1.62	3.89	2.10	2.50	0.44	0.09	0.03	1.73	0.01	2.90	98.70	2.74
86GRS-2206	63.90	15.20	7.17	2.22	3.14	3.78	1.76	0.85	0.27	0.13	0.10	0.01	1.10	99.50	2.75
86GRS-2222	75.90	12.70	2.63	0.51	1.66	3.73	1.57	0.23	0.04	0.05	0.26	0.01	0.90	99.90	2.66
86GRS-3201	63.40	13.20	4.65	2.07	6.92	2.92	0.93	0.39	0.15	0.13	3.03	0.01	3.70	98.50	2.73
86GRS-4123	57.50	17.20	7.18	3.07	6.33	2.22	2.53	0.76	0.23	0.13	0.73	0.01	1.90	99.10	2.73
86GRS-4163	57.50	15.20	7.94	4.82	6.21	3.21	1.26	0.51	0.19	0.13	2.04	0.01	2.70	99.10	2.81
86GRS-6001	51.60	16.70	7.96	4.06	8.85	3.13	2.25	0.55	0.17	0.10	3.03	0.01	3.50	98.90	2.85

Table 4-2c. Trace element geochemistry for felsic to intermediate volcanic rocks of the Pickle Crow assemblage.

SAMPLE	Co	Cr	Cu	Ni	Pb	Zn	Nb	Rb	Sr	Y	Zr	Th	Pr	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	Ce	La	Nd	Y
86GRS-0155	8	54	30	15	29	44	5	84	200	12	144	10	3.5	2.4	0.62	2	0.27	1.6	0.26	0.84	0.12	0.8	0.13	31	16	12	8.7
86GRS-2206	11	<10	18	<5	<10	67	6	56	243	21	227	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
86GRS-2222	<5	<10	6	<5	<10	40	9	67	150	18	264	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
86GRS-3201	13	102	44	29	32	53	<5	39	366	16	145	<10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
86GRS-4123	19	47	40	34	14	80	5	107	462	20	203	13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
86GRS-4163	24	165	56	53	<10	77	<5	43	633	14	160	<10	4.7	3.6	1	2.9	0.43	2.4	0.49	1.3	0.21	1.2	0.2	36	18	18	10
86GRS-6001	26	142	36	38	43	80	<5	69	734	15	169	<10	5.2	3.8	1.1	3	0.4	2.2	0.44	1.4	0.17	1.4	0.21	39	22	19	13

Table 4-2d. Locations and rock names of geochemical samples from felsic to intermediate volcanic rocks of the Woman assemblage.

Sample No.	Sample Description	UTM Eastings	UTM Northings
82GRS-0120	felsic fragmental	613611	5700236
82GRS-0221	intermediate fragmental	614774	5699181
82GRS-0224	rhyolite	614771	5699305
82GRS-0323	dacite	609350	5701690
82GRS-0348	intermediate volcanic breccia	608153	5701632
82GRS-1020	intermediate fragmental	607520	5702421
82GRS-1022	dacite	607213.	5702260
82GRS-1040	intermediate fragmental	611278	5701823
82GRS-1079	felsic fragmental	610852	5701877
82GRS-1087	dacite	607762	5701871
82GRS-1163	intermediate fragmental	612918	5700099
82GRS-1404	felsic fragmental	620297	5695166
84GRS-0022	rhyolite	635525	5689930
84GRS-0033	intermediate lapilli tuff	630575	5687600
84GRS-0080	intermediate lapilli tuff	635225	5681940
84GRS-1058	intermediate tuff breccia	635900	5685375
84GRS-1096	intermediate fragmental	636300	5682790
84GRS-1171	intermediate fragmental	634445	5684500

Table 4-2e. Major element geochemistry for felsic to intermediate volcanic rocks of the Woman assemblage.

SAMPLE	SiO2	Al2O3	Fe2O3	MgO	CaO	Na2O	K2O	TiO2	P2O5	MnO	CO2	S	LOI	TOTAL	Sp. Gr.
82GRS-0120	71.20	16.10	2.31	0.68	1.85	2.77	2.53	0.47	0.13	0.11	0.34	0.02	1.30	98.51	2.70
82GRS-0221	68.80	15.40	3.50	1.27	3.68	4.42	0.70	0.57	0.11	0.09	0.07	0.18	0.70	98.79	2.71
82GRS-0224	74.10	16.60	0.19	0.34	2.08	2.81	2.44	0.46	0.04	0.02	0.21	0.03	1.20	99.32	2.69
82GRS-0323	64.70	14.50	6.69	2.48	4.33	3.30	1.45	0.49	0.09	0.09	0.24	0.03	0.40	98.39	2.75
82GRS-0348	67.50	15.30	5.70	1.30	3.80	2.71	1.61	0.45	0.09	0.37	0.32	0.07	0.70	99.22	2.77
82GRS-1020	66.20	14.90	5.58	1.99	8.14	0.52	1.03	0.53	0.07	0.08	0.18	0.02	0.30	99.24	2.81
82GRS-1022	75.00	14.20	0.96	0.49	0.82	5.06	2.28	0.12	0.03	0.02	0.33	0.02	0.70	99.33	2.63
82GRS-1040	67.30	15.00	3.85	2.83	4.06	3.51	1.42	0.55	0.11	0.04	0.31	0.01	0.30	98.99	2.72
82GRS-1079	67.80	15.70	3.26	1.47	3.56	2.97	2.43	0.36	0.09	0.08	0.70	0.01	1.00	98.43	2.70
82GRS-1087	71.40	13.50	2.92	0.87	2.29	4.31	1.48	0.30	0.04	0.06	1.54	0.18	1.70	98.89	2.68
82GRS-1163	61.80	13.70	9.08	3.84	5.21	3.29	0.51	0.57	0.08	0.19	0.80	0.38	0.70	99.45	2.76
82GRS-1404	69.50	19.30	0.20	0.47	1.36	4.08	2.72	0.54	0.09	0.01	0.58	0.01	1.60	98.86	2.69
84GRS-0022	71.50	15.70	0.86	0.96	2.34	3.84	1.41	0.42	0.14	0.01	0.18	0.01	1.30	98.70	2.69
84GRS-0033	50.30	14.80	3.71	2.75	12.30	5.37	0.39	0.60	0.14	0.23	7.24	0.02	9.80	99.50	2.70
84GRS-0080	65.90	18.70	2.15	0.58	1.69	5.81	2.20	0.46	0.13	0.05	0.56	0.04	1.70	99.70	2.63
84GRS-1058	57.00	14.70	7.01	4.29	6.34	5.40	0.80	0.77	0.42	0.08	1.44	0.01	2.70	99.70	2.81
84GRS-1096	62.80	16.00	2.17	1.42	3.57	7.49	0.86	0.54	0.18	0.04	3.09	0.01	3.80	99.30	2.60
84GRS-1171	63.00	17.90	4.37	1.64	4.80	3.12	1.62	0.57	0.10	0.08	0.29	0.01	1.40	98.60	2.74

Table 4-2f. Trace element geochemistry for felsic to intermediate volcanic rocks of the Woman assemblage.

SAMPLE	Ba	Co	Cr	Cu	Li	Ni	Pb	Zn	Be	Mo	Sc	Sr	V	Y	Nb	Zr	Sc
82GRS-0120	510	12	13	17	12	12	61	32	1	<10	-	215	60	7	12	95	11
82GRS-0221	200	10	19	19	9	15	27	40	1	<10	-	340	80	8	10	60	12
82GRS-0224	370	5	16	8	6	11	31	44	1	<10	-	180	50	6	8	85	8
82GRS-0323	320	18	63	34	24	27	45	88	1	<10	-	530	90	14	10	120	20
82GRS-0348	290	8	29	14	21	9	43	124	1	<10	-	215	60	12	15	105	16
82GRS-1020	200	15	88	9	10	38	10	77	1	<10	-	140	80	10	11	18	13
82GRS-1022	610	<5	<5	53	6	5	<10	16	1	<10	-	115	4	3	1	70	1
82GRS-1040	240	14	167	48	12	49	96	98	1	10	-	440	95	14	22	115	22
82GRS-1079	300	9	11	13	13	10	40	46	1	11	-	200	50	12	21	80	14
82GRS-1087	310	7	13	22	10	8	51	24	1	11	-	190	35	13	21	160	16
82GRS-1163	140	18	13	51	11	21	131	80	2	<10	-	320	110	16	24	70	21
82GRS-1404	500	5	21	14	4	5	40	10	1	13	-	225	60	9	15	60	13
84GRS-0022	-	9	12	20	-	10	26	44	<1	<10	-	220	30	7	6	110	5
84GRS-0033	-	15	55	26	-	31	11	78	1	<10	-	555	75	11	9	140	11
84GRS-0080	-	5	13	12	-	<5	<10	46	1	<10	-	265	35	3	7	125	5
84GRS-1058	-	22	173	56	-	63	13	85	2	<10	13	605	130	11	-	190	-
84GRS-1096	-	8	19	60	-	13	17	24	<1	<10	-	230	60	5	7	105	8
84GRS-1171	-	7	<10	27	-	6	35	82	1	<10	8	355	70	6	-	125	-

Table 4-2g. Locations and rock names of geochemical samples from felsic to intermediate volcanic rocks of the Confederation assemblage.

Sample No.	Sample Description	UTM Eastings	UTM Northings
82GRS-0290	Intermediate fragmental	610572	5697852
82GRS-0411	dacite dike	610096	5698399
82GRS-0412	porphyritic rhyolite	610117	5698336
84GRS-0161	rhyolite	650450	5680410
84GRS-0205	rhyolite	638225	5677525
84GRS-0212	intermediate tuff	657485	5679875
84GRS-0214	intermediate lapilli tuff	657790	5680260
84GRS-0218	intermediate tuff	659125	5681275
84GRS-0221	intermediate tuff	661725	5683515
84GRS-0222	intermediate tuff	662000	5683630
84GRS-0223	intermediate tuff	662400	5683575
84GRS-0240	intermediate tuff	663550	5680100
84GRS-0261	dacitic tuff	671155	5680205
84GRS-1179	rhyolite	643975	5680115
84GRS-1183	dacite	645025	5680520
84GRS-1268	felsic tuff	658950	5680815
84GRS-1272	felsic tuff	662825	5682570
84GRS-1278	dacite	662550	5683655
84GRS-1297	felsic fragmental	664320	5680575
84GRS-1300	andesitic tuff	663375	5679600
84GRS-1302	mafic fragmental	663075	5679175
84GRS-1303	intermediate fragmental	666625	5682465
84GRS-1305	intermediate fragmental	666420	5681835
84GRS-1306	intermediate fragmental	666235	5681950
85GRS-1230	felsic fragmental	637170	5651390
85GRS-1247	felsic fragmental	637173	5651525
85GRS-1300	rhyodacitic lapillistone	632225	5651305
85GRS-1324	felsic quartz porphyry	629825	5649365
85GRS-1343	felsic breccia	638150	5646815
85GRS-2215	massive felsic volcanic	641105	5647280
85GRS-2231	intermediate fragmental	631350	5655250
85GRS-2232	intermediate fragmental	631625	5655120
85GRS-2233	intermediate fragmental	631790	5654995
85GRS-2234	intermediate fragmental	631150	5655380
85GRS-2244	intermediate fragmental	631880	5654940
85GRS-2257	felsic porphyry	627300	5647480
85GRS-2260	felsic porphyry	627600	5647503
85GRS-2280	felsic porphyry	629275	5647387
85GRS-2283	intermediate fragmental	629400	5647075
85GRS-2297	rhyolite flow	627300	5647475
86GRS-0161	felsic volcanic	629000	5647410
86GRS-0163	felsic tuff	642780	5647000
86GRS-0168	dacitic tuff	664200	5679460
86GRS-3226	intermediate volcanic	685740	5684020
86GRS-3228	intermedate volcanic	685690	5683425
86GRS-3236	intermediate volcanic	684725	5683180
86GRS-3250	intermediate volcanic	679870	5681300
86GRS-3257	intermediate volcanic	681450	5681525
86GRS-3265	intermediate volcanic	680950	5683500
86GRS-3268	intermediate fragmental	681025	5684200
86GRS-3297	intermediate volcanic	688600	5684990
86GRS-3300	intermediate volcanic	688600	5684220

Table 4-2h. Major element geochemistry for felsic to intermediate volcanic rocks of the Confederation assemblage.

SAMPLE	SiO2	Al2O3	Fe2O3	MgO	CaO	Na2O	K2O	TiO2	P2O5	MnO	CO2	S	LOI	TOTAL	Sp. Gr.
82GRS-0290	51.00	13.80	11.10	6.84	8.92	2.76	2.61	0.87	0.17	0.18	0.23	0.04	0.60	98.52	2.92
82GRS-0411	62.30	17.00	4.41	2.92	4.25	3.50	3.00	0.56	0.22	0.06	0.24	0.04	0.60	98.50	2.72
82GRS-0412	74.30	14.40	1.65	0.56	1.26	5.28	1.45	0.21	0.02	0.03	0.24	0.15	0.40	99.55	2.64
84GRS-0161	70.30	15.50	2.45	0.91	2.00	5.53	1.26	0.37	0.11	0.00	0.20	0.01	0.80	99.50	2.67
84GRS-0205	70.10	15.80	2.47	0.68	1.94	4.60	1.39	0.47	0.12	0.00	0.53	0.13	1.60	98.70	2.70
84GRS-0212	67.20	16.40	3.79	0.95	3.81	4.21	1.55	0.52	0.14	0.02	0.44	0.01	1.00	99.80	2.71
84GRS-0214	61.30	17.00	6.97	1.72	4.87	3.35	1.58	1.10	0.43	0.06	0.18	0.01	0.80	99.40	2.75
84GRS-0218	65.30	16.80	3.99	1.89	3.89	4.01	1.42	0.58	0.15	0.03	0.11	0.01	0.60	98.80	2.73
84GRS-0221	49.80	13.80	12.38	8.78	10.60	2.28	0.31	0.72	0.05	0.19	0.07	0.03	1.00	99.20	3.03
84GRS-0222	49.50	15.40	10.50	7.00	12.70	1.52	0.84	0.70	0.04	0.16	0.11	0.08	1.20	98.90	2.91
84GRS-0223	69.70	14.70	4.43	1.39	3.30	3.57	1.40	0.56	0.17	0.07	0.06	0.08	1.90	100.50	2.70
84GRS-0240	66.20	17.20	3.19	1.29	4.30	4.03	1.46	0.38	0.06	0.04	0.30	0.01	0.80	99.10	2.72
84GRS-0261	57.40	15.90	5.15	3.68	6.61	1.36	4.41	0.74	0.27	0.09	2.62	0.01	3.60	98.80	2.76
84GRS-1179	69.00	16.10	2.26	0.72	2.46	3.81	1.58	0.34	0.00	0.03	2.14	0.01	3.40	100.20	2.71
84GRS-1183	62.50	16.00	4.25	1.45	3.07	4.95	0.96	0.58	0.20	0.06	3.49	0.01	4.80	98.90	2.75
84GRS-1268	67.10	16.50	3.40	1.33	3.69	4.25	1.25	0.55	0.11	0.02	0.27	0.01	1.20	99.20	2.72
84GRS-1272	60.70	14.30	7.17	3.86	8.71	2.54	0.70	0.55	0.16	0.13	0.12	0.01	0.50	99.20	2.81
84GRS-1278	65.50	16.00	4.13	2.07	4.21	3.56	1.70	0.62	0.12	0.02	0.06	0.01	0.70	98.30	2.75
84GRS-1297	66.20	16.00	3.87	2.30	4.20	3.97	1.22	0.47	0.11	0.06	0.43	0.03	1.90	100.00	2.75
84GRS-1300	50.40	14.10	9.24	6.04	8.11	3.98	0.11	0.58	0.14	0.16	4.79	0.01	8.00	99.90	2.91
84GRS-1302	49.20	13.60	17.08	2.98	9.52	3.10	0.27	1.75	0.10	0.25	1.56	0.07	1.70	99.30	3.20
84GRS-1303	55.40	15.70	8.46	3.50	9.24	3.66	0.92	0.80	0.28	0.14	1.07	0.02	0.60	100.00	2.69
84GRS-1305	63.00	16.00	5.42	3.40	4.82	3.70	1.11	0.58	0.17	0.04	0.11	0.01	1.90	100.40	2.76
84GRS-1306	56.30	14.70	8.29	5.39	7.76	1.67	2.41	0.67	0.48	0.20	0.25	0.02	2.40	99.70	2.95
85GRS-1230	66.00	16.50	3.46	1.50	4.39	3.45	2.02	0.48	0.09	0.06	1.18	0.01	1.80	99.70	2.69
85GRS-1247	69.90	13.80	1.91	1.13	4.15	3.95	1.15	0.42	0.09	0.08	2.15	0.01	2.00	98.60	2.66
85GRS-1300	72.90	14.30	3.86	0.49	0.36	0.49	4.53	0.09	0.00	0.05	0.17	0.01	2.00	98.60	2.73
85GRS-1324	69.10	15.00	3.05	0.81	2.96	4.67	0.72	0.34	0.12	0.05	1.55	0.02	2.60	99.40	2.70
85GRS-1343	69.90	15.30	0.94	0.12	3.07	5.51	0.86	0.49	0.10	0.04	2.18	0.02	3.40	99.70	2.65
85GRS-2215	52.00	15.20	12.40	3.29	9.86	1.12	0.00	1.19	0.09	0.20	1.96	0.13	4.20	99.50	2.95
85GRS-2231	69.00	15.00	2.58	0.95	3.75	3.30	1.49	0.81	0.12	0.06	1.21	0.01	1.70	98.80	2.70
85GRS-2232	72.20	14.70	2.50	0.43	3.44	2.93	0.99	0.75	0.09	0.06	0.50	0.01	0.90	99.00	2.68
85GRS-2233	71.10	16.00	1.83	0.29	3.57	2.94	1.55	0.84	0.12	0.04	0.72	0.01	1.20	99.50	2.70
85GRS-2234	67.40	14.70	4.07	1.31	4.45	2.91	2.01	0.61	0.11	0.07	1.51	0.01	1.60	99.20	2.71
85GRS-2244	70.80	16.20	0.85	0.32	5.63	2.19	1.00	0.70	0.12	0.04	1.19	0.01	1.60	99.40	2.67
85GRS-2257	68.80	15.20	3.57	1.05	2.26	4.14	1.41	0.36	0.13	0.05	1.51	0.02	2.60	99.60	2.70
85GRS-2260	66.00	18.30	1.56	0.18	2.91	5.67	1.70	0.43	0.12	0.08	2.08	0.01	2.70	99.60	2.67
85GRS-2280	77.70	13.00	1.44	0.03	0.78	4.38	1.57	0.00	0.04	0.07	0.59	0.01	0.80	99.80	2.66
85GRS-2283	41.00	16.00	24.40	2.88	4.28	2.06	0.66	0.44	0.15	0.51	4.72	0.43	7.30	99.70	2.91
85GRS-2297	76.90	12.20	1.15	0.22	0.79	4.48	2.32	0.11	0.03	0.03	0.88	0.07	1.00	99.20	2.66
86GRS-0161	75.50	13.10	0.86	0.53	1.06	3.60	3.16	0.05	0.02	0.01	1.40	0.01	1.80	99.70	2.67
86GRS-0163	67.10	16.60	2.95	0.61	3.33	4.40	1.59	0.51	0.10	0.10	0.72	0.01	1.60	98.90	2.74
86GRS-0168	68.80	15.40	2.61	1.18	2.90	5.06	0.73	0.37	0.11	0.07	1.24	0.01	1.20	98.40	2.69
86GRS-3226	61.30	15.70	5.37	3.45	8.67	2.41	1.53	0.56	0.09	0.08	0.35	0.02	0.90	100.00	2.90
86GRS-3228	69.20	15.10	2.58	0.95	2.34	6.10	1.27	0.31	0.07	0.03	0.87	0.01	0.90	98.90	2.69
86GRS-3236	64.70	16.20	4.66	2.60	5.17	2.85	1.21	0.48	0.20	0.08	0.42	0.01	1.00	99.20	2.76
86GRS-3250	66.80	16.20	3.09	1.48	4.31	4.33	1.26	0.45	0.14	0.04	0.09	0.01	0.50	98.60	2.71
86GRS-3257	58.20	15.40	5.58	4.01	8.35	4.01	1.64	0.50	0.17	0.09	1.02	0.01	1.10	99.10	2.81
86GRS-3265	57.70	16.00	6.84	6.31	6.51	3.27	0.75	0.55	0.09	0.15	0.11	0.01	1.40	99.60	2.82
86GRS-3268	50.90	14.60	9.24	2.66	11.70	3.49	0.47	1.04	0.25	0.16	3.93	0.02	4.30	98.80	2.88
86GRS-3297	69.20	15.70	2.65	0.93	2.80	3.27	2.55	0.25	0.12	0.08	0.48	0.01	1.10	98.70	2.68
86GRS-3300	70.10	15.20	2.34	0.91	2.51	3.90	2.14	0.38	0.10	0.07	0.93	0.01	1.50	99.20	2.70

Table 4-2i. Trace element geochemistry for felsic to intermediate volcanic rocks of the Confederation assemblage.

SAMPLE	Ba	Co	Cr	Cu	Li	Ni	Pb	Zn	Be	Mo	Sc	Sr	V	Y	Nb	Rb	Sr	Y	Zr	Th	Pr	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	Ce	La	Nd	Y	Sc
82GRS-0290	540	32	210	32	41	58	39	124	4	22	-	540	225	45	18	-	-	-	80	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	40
82GRS-0411	830	16	67	16	33	39	12	72	2	<10	-	850	65	10	11	-	-	-	165	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8
82GRS-0412	630	5	10	8	6	<5	<10	32	1	<10	-	200	20	5	3	-	-	-	115	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3
84GRS-0161	-	5	15	18	-	7	<10	56	<1	<10	4	415	30	5	-	-	-	-	125	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
84GRS-0205	-	6	<10	36	-	5	17	53	1	<10	4	540	35	5	-	-	-	-	125	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
84GRS-0212	-	11	43	10	-	22	21	71	1	<10	9	340	60	10	-	-	-	-	145	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
84GRS-0214	-	19	84	16	-	47	10	132	1	<10	13	545	105	14	-	-	-	-	200	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
84GRS-0218	-	11	62	8	-	22	<10	73	1	<10	8	345	75	7	-	-	-	-	160	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
84GRS-0221	-	46	505	46	-	116	<10	118	1	<10	40	170	255	16	-	-	-	-	90	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
84GRS-0222	-	38	535	61	-	81	12	100	3	<10	45	185	270	14	-	-	-	-	80	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
84GRS-0223	-	9	29	24	-	11	29	82	3	<10	11	325	65	16	-	-	-	-	165	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
84GRS-0240	-	11	24	16	-	18	29	60	1	<10	3	345	35	<5	-	-	-	-	130	-	3	1	0.5	1	0.2	0.9	0.1	0.3	0.1	1.3	0.2	26	13	10	4	-
84GRS-0261	-	17	40	14	-	38	24	78	2	<10	14	360	110	15	-	-	-	-	150	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
84GRS-1179	-	6	<10	24	-	7	58	66	1	<10	4	220	25	<5	-	-	-	-	115	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
84GRS-1183	-	11	55	23	-	35	21	70	1	<10	7	240	55	6	-	-	-	-	125	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
84GRS-1268	-	11	56	20	-	21	11	124	1	<10	9	360	55	8	-	-	-	-	140	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
84GRS-1272	-	21	110	56	-	50	<10	180	1	<10	12	250	90	10	-	-	-	-	145	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
84GRS-1278	-	13	53	26	-	19	<10	64	1	<10	12	325	85	13	-	-	-	-	155	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
84GRS-1297	-	12	72	24	-	36	24	66	1	<10	8	315	50	8	-	-	-	-	140	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
84GRS-1300	-	31	337	14	-	57	18	100	1	<10	20	115	140	7	-	-	-	-	85	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
84GRS-1302	-	48	17	40	-	18	11	180	2	<10	35	80	350	75	-	-	-	-	125	-	4	3	1.1	4	0.7	4.2	0.7	2.3	0.3	2.4	0.4	27	12	4	17	-
84GRS-1303	-	33	282	41	-	87	<10	95	1	<10	23	405	180	14	-	-	-	-	145	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
84GRS-1305	-	17	91	32	-	41	13	86	1	<10	11	345	80	8	-	-	-	-	160	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
84GRS-1306	-	25	339	16	-	109	17	122	1	<10	21	640	110	18	-	-	-	-	145	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-1230	-	11	13	14	-	10	<10	61	<1	<10	8	310	60	9	-	-	-	-	110	-	4.5	2.8	0.77	2	0.25	1.4	0.25	0.72	0.11	0.66	0.9	38	18	16	6.9	-
85GRS-1247	-	7	<10	13	-	7	<10	54	<1	<10	5	190	40	7	-	-	-	-	85	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-1300	-	<5	<10	5	-	6	<10	50	2	<10	7	40	15	30	-	-	-	-	155	-	3.3	3.2	0.56	4.3	0.77	5.4	1.1	3.3	0.55	3.3	0.55	44	12	12	30	-
85GRS-1324	-	5	<10	36	-	5	<10	60	<1	<10	5	285	25	7	-	-	-	-	120	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-1343	-	7	11	22	-	5	<10	29	<1	<10	4	340	35	6	-	-	-	-	105	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-2215	-	43	243	62	-	114	<10	86	2	<10	45	120	305	25	-	-	-	-	70	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-2231	-	11	22	14	-	18	<10	50	<1	<10	10	230	50	13	-	-	-	-	120	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-2232	-	8	19	20	-	9	<10	31	<1	12	10	260	65	11	-	-	-	-	135	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-2233	-	6	21	27	-	6	<10	22	<1	<10	6	260	55	12	-	-	-	-	150	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-2234	-	11	18	9	-	16	<10	60	<1	<10	9	220	55	13	-	-	-	-	140	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-2244	-	5	24	14	-	9	<10	24	<1	<10	9	385	65	13	-	-	-	-	145	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-2257	-	6	12	61	-	8	<10	30	<1	<10	6	120	40	11	-	-	-	-	130	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-2260	-	<5	18	7	-	<5	<10	13	<1	<10	5	250	50	7	-	-	-	-	105	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-2280	-	<5	<10	26	-	<5	21	20	<1	<10	3	60	3	9	-	-	-	-	43	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-2283	-	41	17	97	-	27	<10	305	<1	<10	15	100	115	9	-	-	-	-	115	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-2297	-	<5	<10	18	-	<5	12	22	<1	<10	2	115	<1	9	-	-	-	-	50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
86GRS-0161	-	<5	<10	<5	-	<5	12	12	-	-	-	-	-	-	5	70	72	13	74	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
86GRS-0163	-	10	17	28	-	7	<10	32	-	-	-	-	-	-	<5	27	279	12	130	<10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
86GRS-0168	-	8	24	8	-	12	<10	39	-	-	-	-	-	-	<5	14	272	10	147	<10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
86GRS-3226	-	32	915	53	-	203	<10	70	-	-	-	-	-	-	<5	39	231	13	99	<10	3.4	2.8	0.83	2.3	0.3	1.8	0.37	0.98	0.13	0.88	0.15	27	13	13	9.1	-
86GRS-3228	-	6	19	13	-	<5	12	53	-	-	-	-	-	-	<5	39	351	11	161	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
86GRS-3236	-	13	59	24	-	27	<10	30	-	-	-	-	-	-	<5	25	413	12	154	<10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
86GRS-3250	-	12	36	6	-	23	<10	64	-	-	-	-	-	-	<5	258	586	7	149	<10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
86GRS-3257	-	17	120	22	-	63	<10	65	-	-	-	-	-	-	<5	21	532	16	160	11	6	4.1	1.2	3.3	0.43	2.3	0.43	1.1	0.15	1	0.17	48	24	22	12	-
86GRS-3265	-	26	258	19	-	153	<10	74	-	-	-	-	-	-	<5	20	306	16	123	<10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
86GRS-3268	-	25	274	45	-	64	<10	96	-	-	-	-	-	-	6	9	422	24	169	<10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
86GRS-3297	-	<5	<10	6	-	<5	29	40	-	-	-	-	-	-	<5	71	344	11	151	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
86GRS-3300	-	<5	10	8	-	<5	41	52	-	-	-	-	-	-	<5	64	258	10	158	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 4-2j. Locations and rock names of geochemical samples from felsic to intemediate volcanic rocks of the St. Joseph assemblage.

Sample No.	Sample Description	UTM Eastings	UTM Northings
85GRS-0004	intermediate fragmental	678580	5648110
85GRS-0015	intermediate fragmental	680875	5646700
85GRS-0019	intermediate fragmental	681350	5646250
85GRS-0032	intermediate fragmental	690750	5647100
85GRS-0033	intermediate fragmental	690900	5647250
85GRS-0035	intermediate fragmental	692250	5648775
85GRS-0052	intermediate fragmental	694071	5646868
85GRS-0054	intemediate fuff	689875	5646000
85GRS-0148	intermediate fragmental	667275	5659575
85GRS-0151	intermediate fragmental	665650	5658950
85GRS-0152	intermediate fragmental	665175	5658750
85GRS-0168	intermediate fragmental	658860	5659015
85GRS-0174	intermediate fragmental	656098	5652045
85GRS-0192	intermediate fragmental	683025	5661225
85GRS-0193	mafic fragmental	682900	5661135
85GRS-0196	intermediate fragmental	683530	5662050
85GRS-0253	felsic porphyry	633920	5648470
85GRS-1003	intermediate fragmental	683075	5649225
85GRS-1005	intermediate fragmental	681660	5648920
85GRS-1009	intermediate fragmental	680185	5648125
85GRS-1015	intermediate fragmental	693100	5648050
85GRS-1023	intermediate fragmental	694800	5648475
85GRS-1029	intermediate fragmental	694915	5648320
85GRS-1030	felsic fragmental	679900	5649400
85GRS-1177	felsic tuff	649720	5651370
85GRS-1178	intermediate fragmental	651125	5651520
85GRS-1194	intermediate fragmental	643300	5652150
85GRS-1310	rhyolite	633015	5651232
85GRS-2007	intermediate fragmental	691100	5654756
85GRS-2014	intermediate fragmental	681500	5647775
85GRS-2015	felsic fragmental	681650	5647100
85GRS-2017	intermediate fragmental	682225	5646725
85GRS-2018	massive rhyodacite	682850	5645825
85GRS-2027	intermediate fragmental	692948	5651035
85GRS-2043	massive intemediate volcanic	688800	5663100
85GRS-2047	intermediate fragmental	680075	5664600
85GRS-2128	dacite	676375	5649675
85GRS-2143	felsic volcanic	662370	5654995
85GRS-2147	intermediate fragmental	659205	5653203
85GRS-2155	massive felsic volcanic	673965	5648568
85GRS-2161	massive felsic volcanic	655745	5650610
85GRS-2198	intermediate fragmental	646645	5651885
85GRS-2199	felsic fragmental	646860	5651930
85GRS-2202	intermediate fragmental	648000	5651090
85GRS-2203	intermediate fragmental	647535	5651290
85GRS-2237	intermediate fragmental	632445	5655400
85GRS-2238	intermediate fragmental	632445	5655400
85GRS-2249	intermediate fragmental	632365	5654190
85GRS-2254	intermediate fragmental	633000	5653430
85GRS-2289	rhyolite flow	631575	5646975
86GRS-0159	intermediate fragmental	683050	5661500
86GRS-0162	rhyolitic tuff	634200	5648560

Table 4-2k. Major element geochemistry for felsic to intermediate volcanic rocks of the St. Joseph assemblage.

SAMPLE	SiO2	Al2O3	Fe2O3	MgO	CaO	Na2O	K2O	TiO2	P2O5	MnO	CO2	S	LOI	TOTAL	Sp. Gr.
85GRS-0004	58.50	15.40	8.77	3.36	6.36	2.71	1.41	0.81	0.18	0.21	1.28	0.01	1.70	99.40	2.83
85GRS-0015	62.90	14.10	7.32	3.40	6.92	2.40	0.38	0.72	0.16	0.20	0.11	0.01	0.60	99.10	2.77
85GRS-0019	58.50	14.10	7.13	7.69	6.71	1.58	1.58	0.83	0.16	0.13	0.28	0.01	1.70	100.10	2.84
85GRS-0032	60.90	14.60	6.90	3.66	6.43	2.79	0.91	0.58	0.14	0.12	1.66	0.01	2.70	99.70	2.71
85GRS-0033	54.20	16.90	8.22	5.39	6.47	1.88	1.74	0.92	0.15	0.13	0.72	0.01	3.00	99.00	2.83
85GRS-0035	57.70	15.10	6.77	4.16	9.33	2.01	1.24	0.57	0.08	0.12	2.13	0.01	2.70	99.80	2.85
85GRS-0052	58.70	16.80	6.65	4.03	6.69	2.84	1.39	0.47	0.09	0.09	1.02	0.01	1.50	99.30	2.84
85GRS-0054	53.90	15.90	6.82	3.95	10.30	3.60	0.57	0.80	0.11	0.12	3.04	0.01	3.50	99.60	2.92
85GRS-0148	57.00	17.50	11.00	2.37	5.03	4.61	0.57	1.32	0.13	0.16	0.10	0.04	0.10	99.80	2.83
85GRS-0151	57.60	16.60	11.20	2.39	6.74	2.37	1.02	1.11	0.10	0.19	0.19	0.07	0.50	99.80	2.89
85GRS-0152	54.50	16.10	9.94	4.26	9.77	3.23	0.15	1.11	0.09	0.15	0.10	0.01	0.30	99.60	2.93
85GRS-0168	66.90	15.30	6.42	0.66	2.42	4.04	1.65	1.03	0.07	0.10	0.49	0.03	0.80	99.40	2.74
85GRS-0174	64.80	13.80	6.67	1.93	3.66	3.13	2.20	0.89	0.44	0.14	1.47	0.01	1.90	99.60	2.73
85GRS-0192	65.40	14.70	4.83	1.84	4.55	3.86	1.58	0.58	0.08	0.10	1.69	0.02	1.60	99.10	2.73
85GRS-0193	46.00	13.50	17.80	5.16	11.90	1.54	0.16	1.40	0.12	0.40	1.88	0.03	2.00	99.90	3.12
85GRS-0196	62.50	16.00	6.40	2.49	6.16	3.15	0.78	1.17	0.10	0.10	0.55	0.01	0.60	99.40	2.79
85GRS-0253	71.10	15.70	1.67	0.20	2.12	4.20	1.91	0.28	0.05	0.05	1.23	0.01	2.20	99.50	2.67
85GRS-1003	66.40	15.40	3.67	0.99	4.89	3.80	1.21	0.53	0.06	0.08	1.90	0.01	2.30	99.30	2.70
85GRS-1005	61.90	15.00	6.93	4.02	6.97	2.15	0.83	0.60	0.15	0.10	0.32	0.01	0.80	99.40	2.79
85GRS-1009	63.50	15.00	5.41	3.19	4.18	2.68	1.95	0.61	0.13	0.08	1.33	0.01	2.50	99.20	2.69
85GRS-1015	60.00	15.50	6.46	2.90	5.15	2.57	2.11	0.62	0.09	0.12	1.09	0.05	3.00	98.50	2.75
85GRS-1023	63.20	15.20	5.54	2.30	4.98	2.74	1.65	0.56	0.11	0.11	1.32	0.06	3.00	99.40	2.72
85GRS-1029	58.30	18.20	8.07	2.35	5.80	1.89	1.83	0.73	0.07	0.11	0.49	0.01	2.00	99.30	2.78
85GRS-1030	66.80	16.60	4.52	0.63	2.43	3.56	2.34	0.60	0.13	0.06	0.41	0.01	1.00	98.70	2.70
85GRS-1177	63.40	15.40	5.45	1.48	2.87	3.98	3.09	0.63	0.28	0.10	1.78	0.01	2.40	99.10	2.75
85GRS-1178	68.40	15.70	5.60	0.51	2.61	1.58	3.07	0.62	0.23	0.10	0.79	0.01	0.80	99.20	2.71
85GRS-1194	50.40	17.90	9.67	5.13	10.50	2.30	0.48	0.54	0.28	0.14	0.94	0.01	1.80	99.10	2.92
85GRS-1310	69.60	15.00	3.66	1.17	2.85	3.20	1.14	0.48	0.14	0.08	0.66	0.01	1.80	99.10	2.71
85GRS-2007	71.90	14.20	4.18	0.70	4.25	1.74	1.40	0.24	0.05	0.12	0.51	0.01	0.90	99.70	2.70
85GRS-2014	60.20	16.70	6.33	2.71	6.56	3.32	0.71	0.61	0.10	0.11	0.97	0.01	1.40	98.80	2.77
85GRS-2015	55.80	14.30	10.70	5.78	6.49	2.33	0.92	1.04	0.21	0.21	0.24	0.01	1.50	99.30	2.87
85GRS-2017	70.20	16.00	2.26	0.46	2.01	3.51	3.56	0.39	0.04	0.09	0.25	0.01	0.70	99.20	2.64
85GRS-2018	60.30	16.00	8.73	3.27	2.37	2.97	2.27	0.52	0.09	0.09	0.27	0.05	2.90	99.50	2.72
85GRS-2027	58.40	16.20	7.20	4.20	6.03	0.47	3.13	1.09	0.25	0.10	0.42	0.01	2.40	99.50	2.78
85GRS-2043	43.80	12.50	11.30	15.30	13.00	1.31	0.06	0.48	0.00	0.19	0.46	0.01	1.00	98.90	3.11
85GRS-2047	73.40	15.50	3.04	1.60	1.02	2.30	1.44	0.24	0.03	0.04	0.15	0.01	1.10	99.70	2.73
85GRS-2128	50.60	14.30	13.20	5.02	8.87	2.45	0.24	1.58	0.12	0.17	2.08	0.07	2.20	98.80	2.92
85GRS-2143	69.00	17.00	1.99	0.79	3.26	4.26	2.48	0.65	0.08	0.03	0.13	0.01	0.60	100.10	2.67
85GRS-2147	68.10	15.00	6.78	0.62	1.05	2.52	2.95	0.91	0.10	0.10	0.17	0.01	1.00	99.10	2.74
85GRS-2155	60.00	16.50	6.13	4.50	4.28	4.63	0.66	0.52	0.07	0.08	0.77	0.01	1.60	99.00	2.72
85GRS-2161	74.20	15.20	1.52	0.25	2.64	4.33	1.01	0.12	0.04	0.03	0.13	0.01	0.60	99.90	2.68
85GRS-2198	52.50	16.10	10.40	5.02	8.40	2.17	0.87	0.87	0.26	0.16	0.32	0.04	1.80	98.60	2.91
85GRS-2199	65.20	15.80	6.34	1.01	4.32	2.42	1.50	0.97	0.14	0.12	0.14	0.24	1.30	99.10	2.75
85GRS-2202	47.50	17.50	11.50	6.73	9.48	2.91	1.13	0.90	0.14	0.15	0.31	0.01	1.20	99.10	2.95
85GRS-2203	53.20	20.40	8.32	1.31	4.33	5.44	2.58	0.84	0.75	0.12	0.73	0.01	1.80	99.10	2.79
85GRS-2237	67.90	16.80	2.96	1.23	4.24	3.76	0.84	0.54	0.12	0.05	0.39	0.01	1.00	99.40	2.70
85GRS-2238	55.20	14.20	9.04	4.30	11.30	0.54	0.25	0.33	0.05	0.14	3.25	0.01	3.80	99.10	2.88
85GRS-2249	48.50	17.50	8.76	4.97	9.29	2.39	0.56	0.98	0.08	0.12	4.17	0.02	6.10	99.30	2.78
85GRS-2254	57.10	14.70	6.81	2.59	8.20	3.25	0.32	0.79	0.08	0.21	4.51	0.01	5.60	99.60	2.74
85GRS-2289	74.10	15.50	1.91	0.08	0.44	2.54	2.57	0.44	0.07	0.03	0.36	0.02	1.90	99.60	2.64
86GRS-0159	60.60	18.20	5.49	2.39	4.29	4.12	1.99	0.67	0.14	0.09	0.12	0.01	0.50	98.50	2.75
86GRS-0162	69.90	14.30	0.78	0.17	4.29	3.86	1.65	0.22	0.05	0.07	3.20	0.01	4.00	99.30	2.69

Table 4-2l. Trace element geochemistry for felsic to intermediate volcanic rocks of the St. Joseph assemblage.

SAMPLE	Au	Co	Cr	Cu	Ni	Pb	Zn	Be	Mo	Sc	Sr	V	Y	Nb	Rb	Sr	Y	Zr	Th	Pr	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	Ce	La	Nd	Y
85GRS-0004	-	21	99	34	62	<10	94	<1	<10	13	250	110	13	-	-	-	-	130	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-0016	-	21	206	28	104	<10	48	<1	<10	15	590	95	13	-	-	-	-	135	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-0019	-	32	435	38	210	<10	75	<1	<10	21	360	125	14	-	-	-	-	120	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-0032	-	24	162	22	86	35	67	<1	<10	18	265	110	16	-	-	-	-	135	-	5.7	3.6	0.91	2.6	0.39	2.5	0.48	1.2	0.19	1.3	0.19	48	22	19	12
85GRS-0033	-	28	111	64	61	<10	86	1	<10	20	255	155	17	-	-	-	-	125	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-0036	-	24	197	28	101	11	76	<1	<10	13	180	85	12	-	-	-	-	120	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-0052	-	27	302	49	147	<10	62	<1	10	15	180	90	10	-	-	-	-	60	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-0054	-	27	75	41	80	<10	57	<1	<10	22	195	125	15	-	-	-	-	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-0148	-	30	67	37	30	20	122	1	<10	18	515	155	20	-	-	-	-	125	-	4.2	3.6	1.2	3.3	0.56	3.2	0.61	1.6	0.21	1.4	0.22	29	14	17	14
85GRS-0151	-	45	113	63	62	11	102	1	<10	20	365	185	19	-	-	-	-	110	-	5.8	4.6	1.2	4	0.5	3.2	0.55	1.7	0.22	1.5	0.23	43	21	24	14
85GRS-0152	-	34	180	13	95	10	104	1	<10	25	465	180	21	-	-	-	-	115	-	4	3.6	1.2	3.6	0.54	3.4	0.71	2.2	0.29	1.8	0.3	29	13	16	16
85GRS-0168	-	11	21	54	11	29	76	1	<10	12	225	90	19	-	-	-	-	140	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-0174	-	9	<10	6	<5	14	109	1	<10	17	465	70	25	-	-	-	-	195	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-0192	-	11	20	20	13	23	56	<1	<10	9	365	70	13	-	-	-	-	110	-	4.7	2.8	0.9	2.5	0.34	1.9	0.37	1.1	0.13	1	0.16	36	18	17	9.5
85GRS-0193	-	33	111	20	72	11	125	<1	<10	18	265	155	24	-	-	-	-	115	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-0196	-	23	25	8	28	<10	86	1	<10	13	380	110	20	-	-	-	-	125	-	6.8	5.1	1.4	4.1	0.57	3.3	0.62	1.7	0.22	1.6	0.21	56	28	26	15
85GRS-0253	<0.002	5	<10	6	<5	12	36	<1	<10	3	215	19	5	-	-	-	-	120	-	3	1.5	0.47	1	0.12	0.57	0.14	0.3	<0.05	0.3	0.05	29	17	9.4	3.1
85GRS-1003	-	12	134	30	25	<10	48	<1	<10	9	320	85	10	-	-	-	-	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-1006	-	21	162	38	78	<10	70	<1	<10	14	506	106	16	-	-	-	-	160	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-1009	-	18	161	62	66	<10	57	<1	<10	13	325	100	13	-	-	-	-	150	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-1015	-	28	302	60	114	11	69	1	<10	16	295	100	13	-	-	-	-	120	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-1023	-	18	113	300	56	<10	48	1	<10	11	240	100	13	-	-	-	-	155	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-1029	-	28	185	30	142	<10	92	1	<10	21	280	125	14	-	-	-	-	160	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-1030	-	13	11	22	16	18	52	1	<10	8	340	60	14	-	-	-	-	155	-	5.1	3.6	0.95	3	0.4	2.6	0.48	1.3	0.17	1.3	0.21	56	20	19	13
85GRS-1177	-	13	18	12	9	16	80	1	<10	9	515	70	16	-	-	-	-	210	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-1178	-	11	15	14	10	13	87	<1	<10	11	295	55	24	-	-	-	-	306	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-1194	-	42	130	49	136	18	77	1	<10	24	755	165	16	-	-	-	-	130	-	14	8	2	5	0.61	2.9	0.64	1.3	0.21	1.2	0.19	105	47	51	13
85GRS-1310	-	7	23	8	10	19	58	<1	<10	7	285	45	10	-	-	-	-	125	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-2007	-	6	15	44	6	<10	60	<1	<10	5	235	35	6	-	-	-	-	110	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-2014	-	18	41	6	38	<10	68	<1	<10	16	240	115	15	-	-	-	-	130	-	4.4	3.1	0.9	2.4	0.35	2.3	0.6	1.2	0.2	1.3	0.2	37	20	16	11
85GRS-2015	-	30	269	41	159	<10	82	1	<10	20	380	130	16	-	-	-	-	140	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-2017	-	6	19	10	9	<10	46	<1	<10	5	245	30	5	-	-	-	-	125	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-2018	-	19	142	14	63	<10	72	<3	<10	15	255	105	25	-	-	-	-	155	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-2027	-	26	45	11	50	<10	88	1	<10	15	135	115	18	-	-	-	-	160	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-2043	-	69	1340	62	59	<10	86	<1	<10	19	35	160	9	-	-	-	-	29	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-2047	-	6	23	5	16	<10	16	<1	<10	4	120	30	4	-	-	-	-	65	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-2128	-	40	117	102	56	<10	97	2	<10	40	130	265	25	-	-	-	-	90	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-2143	-	7	<10	6	9	<10	37	<1	<10	3	290	30	5	-	-	-	-	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-2147	-	13	25	12	16	<10	68	<1	<10	13	95	90	12	-	-	-	-	135	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-2155	-	22	176	10	67	<10	54	<1	<10	16	320	105	12	-	-	-	-	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-2161	-	<5	<10	13	<5	12	36	1	<10	2	200	6	6	-	-	-	-	75	-	1.8	1.2	0.41	0.93	0.14	0.86	0.11	0.31	<0.05	0.24	<0.05	21	7.3	6.9	3.1
85GRS-2198	-	30	44	24	50	<10	72	1	<10	23	650	165	21	-	-	-	-	155	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-2199	-	13	17	28	13	<10	54	<1	<10	11	345	65	14	-	-	-	-	140	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-2202	-	44	261	13	101	<10	102	2	<10	25	600	205	22	-	-	-	-	155	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-2203	-	17	<10	9	<5	15	83	2	<10	11	1300	125	22	-	-	-	-	235	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-2237	-	12	31	34	23	<10	41	<1	<10	5	260	50	9	-	-	-	-	105	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-2238	-	30	83	62	113	16	116	<1	<10	18	135	90	10	-	-	-	-	90	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-2249	-	49	337	102	135	<10	88	1	<10	40	115	230	20	-	-	-	-	65	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-2254	-	37	290	62	129	<10	62	1	<10	30	170	195	14	-	-	-	-	60	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85GRS-2299	-	5	27	11	13	18	18	<1	<10	5	125	35	10	-	-	-	-	115	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
86GRS-0159	-	14	27	12	23	<10	70	-	-	-	-	-	-	<5	66	530	18	175	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
86GRS-0162	-	<5	<10	5	<5	37	10	-	-	-	-	-	-	<5	42	209	9	139	<10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 4-3a. Locations and rock names of geochemical samples from selected mafic intrusive rocks.

Sample No.	Rock Name	UTM Eastings	UTM Northings
82GRS-0386	peridotite	610039	5696574
82GRS-1164	gabbro	612935	5700191
84GRS-0157	gabbro, chill zone	651530	5681470
84GRS-1151	gabbro	635000	5682815
84GRS-1194	gabbro	650625	5684330
84GRS-1238	quartz-bearing diorite	640920	5676500
84GRS-1250	gabbro	640925	5676725
86GRS-0027	diabase dike	698920	5706535

Table 4-3b. Major element geochemistry of selected mafic intrusive rocks.

SAMPLE	SiO2	Al2O3	Fe2O3	MgO	CaO	Na2O	K2O	TiO2	P2O5	MnO	CO2	S	LOI	TOTAL	Sp. Gr.
82GRS-0386	41.70	4.46	14.80	26.50	4.93	0.00	0.03	0.22	0.02	0.20	0.19	0.14	6.30	99.16	2.90
82GRS-1164	49.10	14.20	11.40	7.99	12.80	1.38	0.19	0.58	0.03	0.20	0.17	0.21	0.80	98.25	3.05
84GRS-0157	49.80	15.30	9.82	8.54	10.10	2.38	0.30	0.84	0.04	0.16	0.08	0.07	1.60	98.80	2.95
84GRS-1151	49.30	14.20	12.38	7.79	10.10	3.13	0.20	0.79	0.07	0.18	0.57	0.04	1.50	99.60	2.95
84GRS-1194	52.10	12.90	13.76	6.30	11.00	1.64	0.16	1.18	0.10	0.18	0.46	0.02	0.90	100.00	3.02
84GRS-1238	71.10	12.30	7.16	0.15	2.13	5.01	1.24	0.45	0.03	0.10	0.37	0.01	0.80	100.30	2.76
84GRS-1250	53.50	12.50	16.66	3.37	6.74	3.29	0.55	1.41	0.11	0.18	0.45	0.06	1.30	99.50	3.03
86GRS-0027	66.50	16.80	2.61	1.77	3.12	4.81	2.39	0.37	0.10	0.02	0.20	0.01	1.30	99.80	2.67

Table 4-3c. Trace element geochemistry for selected mafic intrusive rocks.

SAMPLE	Ba	Co	Cr	Cu	Li	Ni	Pb	Zn	Be	Mo	Sc	Sr	V	Y	Nb	Rb	Sr	Y	Zr	Th	Pr	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	Ce	La	Nd	Y	Sc
82GRS-0386	30	96	4360	54	4	1100	86	103	<1	<10	-	16	85	6	8	-	-	-	<10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	19
82GRS-1164	70	44	455	64	16	102	134	80	1	13	-	100	250	14	20	-	-	-	12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	40
84GRS-0157	-	43	395	106	-	158	<10	104	1	<10	35	155	270	12	-	-	-	-	75	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
84GRS-1151	-	41	795	240	-	87	<10	165	1	<10	45	135	290	13	-	-	-	-	70	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
84GRS-1194	-	39	193	310	-	58	<10	120	1	<10	45	135	360	30	-	-	-	-	110	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
84GRS-1238	-	5	<10	10	-	<5	<10	104	1	<10	9	230	5	60	-	-	-	-	230	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
84GRS-1250	-	53	<10	52	-	14	<10	120	2	<10	55	190	495	24	-	-	-	-	125	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
86GRS-0027	-	9	33	14	-	15	66	48	-	-	-	-	-	-	<5	72	592	6	148	<10	3.4	2.3	0.62	1.5	0.18	0.85	0.15	0.4	0.06	0.4	0.08	28	16	13	4.4	-

Table 4-4a. Locations and rock names of geochemical samples of selected felsic intrusive rocks.

Sample No.	Rock Name	UTM Eastings	UTM Northings
84GRS-0104	felsite dike, Kaminiskag Lake	636640	5684480
84GRS-0241	quartz porphyry, Sky Lake stock	665125	5679500
84GRS-1038	feld. porph. sill, Muskegsagagen lake	629425	5691710
84GRS-1150	trondhjemite, Kawashe stock	635350	5684555
84GRS-1252	felsic porphyry, synvolcanic, Mousetrap Lake	641150	5676820
86GRS-0042	trondhjemite, Ochig Lake pluton	699620	5698425
86GRS-0156	quartz porphyry, Pickle Crow zone	706040	5711226
86GRS-0160	granite, Blackstone pluton	618825	5648200
86GRS-0164	tonalite, Pembina gneiss, Lake St. Joseph	660460	5665230
86GRS-0169	granodiorite, Osnaburgh pluton	666975	5674325
86GRS-1291	granodiorite, Kagami pluton	700690	5670300
86GRS-1304	granodiorite, s. margin Kagami pluton	701000	5667700

Table 4-4b. Major element geochemistry of selected felsic intrusive rocks.

SAMPLE	SiO2	Al2O3	Fe2O3	MgO	CaO	Na2O	K2O	TiO2	P2O5	MnO	CO2	S	LOI	TOTAL	Sp. Gr.
84GRS-0104	69.90	14.30	1.90	0.49	2.07	5.53	1.73	0.26	0.08	0.02	1.90	0.34	2.80	99.50	2.67
84GRS-0241	68.60	15.40	1.82	0.72	2.21	6.55	1.32	0.28	0.06	0.04	1.51	0.44	1.80	99.50	2.67
84GRS-1038	56.60	15.10	7.76	2.68	5.07	4.53	2.28	1.56	0.67	0.09	1.51	0.12	2.40	98.80	2.77
84GRS-1150	70.10	15.70	2.46	0.75	2.67	4.24	2.53	0.31	0.01	0.04	0.20	0.01	0.90	99.60	2.69
84GRS-1252	73.90	14.60	1.24	0.09	0.80	4.97	3.56	0.07	0.01	0.00	0.47	0.01	1.10	100.40	2.64
86GRS-0042	68.20	16.90	1.76	0.94	2.53	5.28	2.08	0.25	0.07	0.01	0.12	0.01	0.90	98.90	2.69
86GRS-0156	65.10	15.30	3.05	1.37	3.17	4.91	2.19	0.38	0.23	0.04	2.90	0.03	3.70	99.40	2.71
86GRS-0160	70.60	16.10	1.62	0.63	2.72	4.88	1.71	0.16	0.06	0.01	0.07	0.01	0.40	98.90	2.67
86GRS-0164	65.10	16.00	5.81	1.82	4.68	3.68	1.16	0.71	0.17	0.08	0.10	0.01	0.40	99.60	2.77
86GRS-0169	71.20	15.60	1.45	0.50	1.41	3.79	4.04	0.21	0.09	0.02	0.09	0.01	0.40	98.70	2.65
86GRS-1291	69.60	16.10	1.88	0.82	2.78	5.34	1.96	0.23	0.08	0.01	0.12	0.01	0.20	99.00	2.67
86GRS-1304	68.60	15.90	2.55	1.39	2.98	4.80	1.69	0.29	0.11	0.03	0.15	0.01	0.60	98.90	2.70

Table 4-4c. Trace element geochemistry for selected felsic intrusive rocks.

SAMPLE	Au	Co	Cr	Cu	Ni	Pb	Zn	Be	Mo	Sc	Sr	V	Y	Nb	Rb	Sr	Y	Zr	Th	Pr	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	Ce	La	Nd	Y	Sc
84GRS-0104	-	6	11	11	<5	11	42	2	<10	-	680	35	3	5	-	-	-	110	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4
84GRS-0241	50	5	<10	14	6	33	48	2	<10	4	590	30	6	-	-	-	-	135	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
84GRS-1150	-	5	<10	9	9	37	54	1	<10	4	290	25	6	-	-	-	-	115	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
84GRS-1252	-	<5	<10	8	<5	21	60	1	<10	2	180	6	3	-	-	-	-	70	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
86GRS-0042	<0.002	<5	<10	18	<5	23	30	-	-	-	-	-	-	<5	64	514	5	138	<10	2.7	1.6	0.44	0.95	0.1	0.52	0.07	0.22	<0.05	0.22	<0.05	23	13	9.4	2.5	-
86GRS-0156	<0.002	8	18	10	10	24	41	-	-	-	-	-	-	<5	50	704	11	176	14	12	6.6	1.5	3.4	0.39	1.6	0.25	0.61	0.09	0.59	0.11	110	49	41	8	-
86GRS-0160	-	<5	14	<5	5	38	30	-	-	-	-	-	-	<5	48	413	7	125	<10	2.5	1.4	0.41	0.88	0.11	0.64	0.1	0.31	<0.05	0.34	0.06	23	12	8.2	3.5	-
86GRS-0164	-	12	12	14	7	34	71	-	-	-	-	-	-	11	26	234	52	266	<10	7.6	7.7	1.2	7.6	1.3	8.3	1.7	4.8	0.68	4.2	0.59	56	21	31	48	-
86GRS-0169	-	<5	<10	8	<5	25	37	-	-	-	-	-	-	10	246	196	8	151	14	5.5	2.9	0.59	1.9	0.27	1.6	0.27	0.71	0.09	0.79	0.13	53	27	18	9	-
86GRS-1291	-	<5	14	74	5	13	36	-	-	-	-	-	-	<5	43	430	7	135	<10	2.6	1.7	0.48	1.3	0.17	0.79	0.13	0.31	<0.05	0.29	0.05	22	11	9.2	3.7	-
86GRS-1304	-	7	16	8	12	10	44	-	-	-	-	-	-	<5	45	490	9	142	11	3.7	2.3	0.7	1.8	0.21	1.1	0.17	0.48	<0.05	0.42	0.06	32	14	14	5.2	-

Table 5: Criteria used to constrain the timing of gold mineralization in the Mee-Dempster and Pickle Lake greenstone belts.

Gold mineralization	Criteria
Golden Patricia gold mineralization in substratiform quartz vein (post 2722 Ma, pre 2700 Ma)	gold mineralized vein in shear zone carries D_2 deformation, which postdates 2722 Ma Kawashe Lake stock; but predates main transcurrent displacement along Bear Head Fault, which transects *circa* 2700 Ma plutons in Berens river Subprovince; and predates 2700 Ma post-D_2 Graniteboss pluton.
Dona Lake gold mineralization in sheared and sulphidized iron formation (*circa* 2741 Ma)	2741 Ma Ochig Lake pluton produced a broad contact strain aureole in enveloping volcanics including sulphidized iron formation where mineralization carries strain aureole fabric, the last penetrative deformation event in this area. Preferential shearing of mineralized iron formation implies relationship between emplacement of Ochig Lake pluton, which induced the shearing, and the gold mineralization and accompanying hydrothermal alteration.
Pickle Crow veins (post 2860 Ma, pre 2740 Ma)	Veins carry a pre-2740 Ma D_1 deformation fabric in 2860 Ma volcanics which is observed to be deflected by the Hooker-Burkoski pluton, one of the local suite of post-D_1 2740 Ma plutons.

Table 6a: Mineral assemblages of pegmatites observed in eastern Lake St. Joseph and east Pashkokogan Lake.

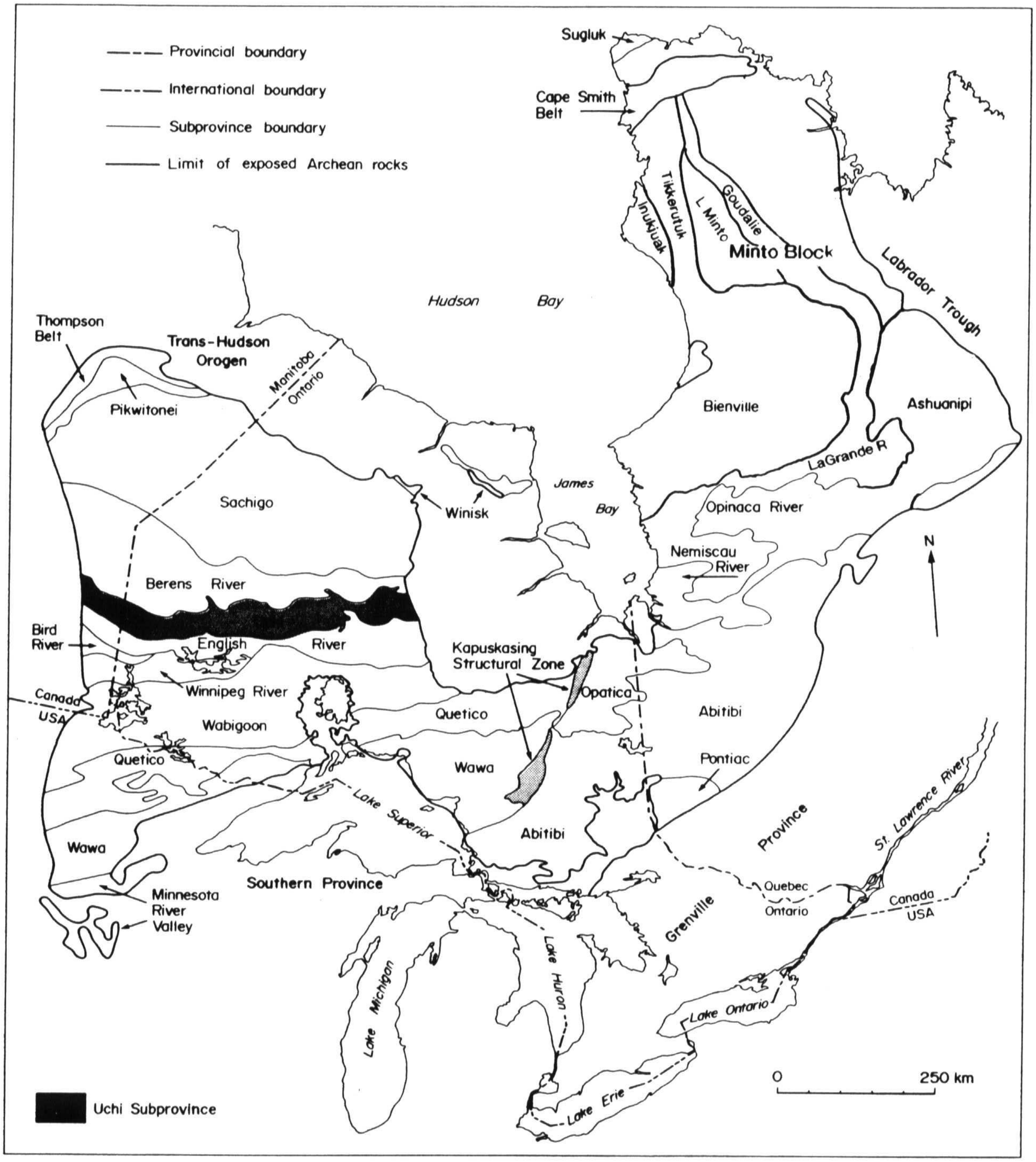
MINERAL	PEGMATITE					
	East Pashkokogan Lake			Eastern Lake St. Joseph		
	1*	2*	3*	5*	7*	8*
Quartz	x	x	x	x	x	x
Plagioclase	x	x	x	x	x	x
Orthoclase	x	x	x	x	x	x
Spodumene		x				
Muscovite	x	x	x	x	x	x
Tourmaline	x	x	x	x	x	x
Garnet	x	x	x	x	x	x
Apatite		x	x			
Columbite-Tantalite?	x	x				

* Numbers indicate station location on Figure 6.29.

Table 6b: Rare element concentrations in pegmatite dikes.

Sample	Li ppm	Ta ppm	Nb ppm	Cs ppm	Be ppm	Ti $\%TiO_2$	Bi ppm	Sn ppm
East Pashkokogan								
Sample 1	10	80	38	32	140	0.03	<0.1	87.1
Sample 2A	7100	26	31	115	140	0.03	0.2	136
Sample 2B	1260	19	36	33	100	0.05	0.1	133
Sample 2C	90	16	49	110	110	<0.01	0.1	126
Sample 3	16	23	26	130	150	0.05	<0.1	36.1
Eastern Lake St. Joseph								
Sample 4	5	23	36	50	15	0.05	2.7	4.6
Background in felsic intrusions[1]	40	20	10	2-6	20[2]	0.25	0.1	16.3[3]

[1] From Wedepohl (1978).
[2] Background concentration in pegmatites.
[3] Background concentration in Sn-bearing granites.



Provincial boundary
International boundary
Subprovince boundary
Limit of exposed Archean rocks
Sugluk
Cape Smith Belt
Tikkerutuk
Inukjuak
L Minto
Goudalie
Minto Block
Labrador Trough
Hudson Bay
Thompson Belt
Trans-Hudson Orogen
Manitoba
Ontario
Pikwitonei
Bienville
Ashuanipi
LaGrande R
James Bay
Sachigo
Winisk
Opinaca River
Nemiscau River
N
Berens River
Bird River
English River
Kapuskasing Structural Zone
Winnipeg River
Opatica
Canada
USA
Wabigoon
Quetico
Abitibi
Quetico
Pontiac
Wawa
Lake Superior
Province
St. Lawrence River
Abitibi
Wawa
Southern Province
Quebec
Ontario
Canada
USA
Minnesota River Valley
Grenville
Lake Huron
Lake Michigan
Lake Ontario
0
250 km
Lake Erie
Uchi Subprovince

Figure 1

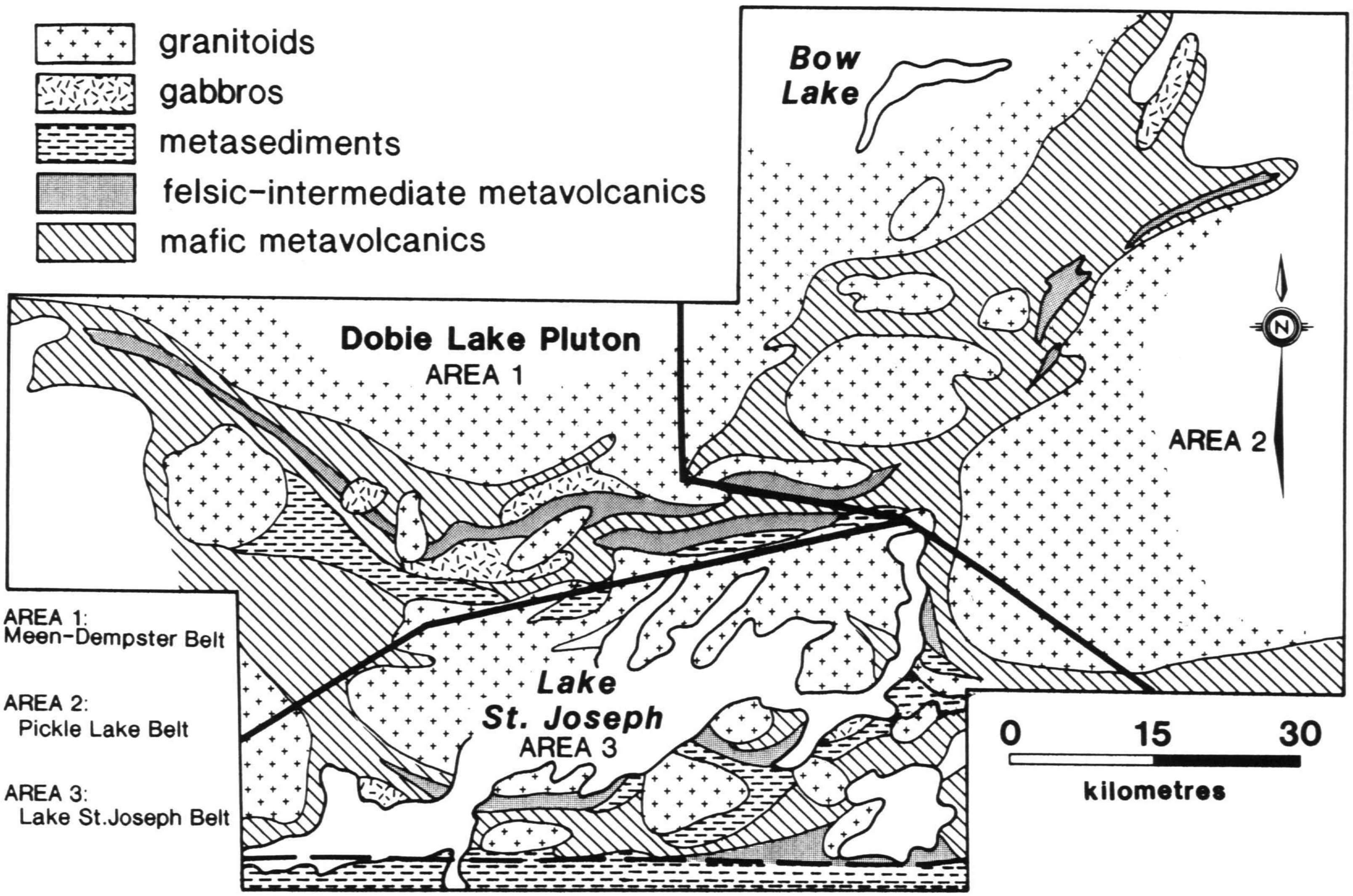
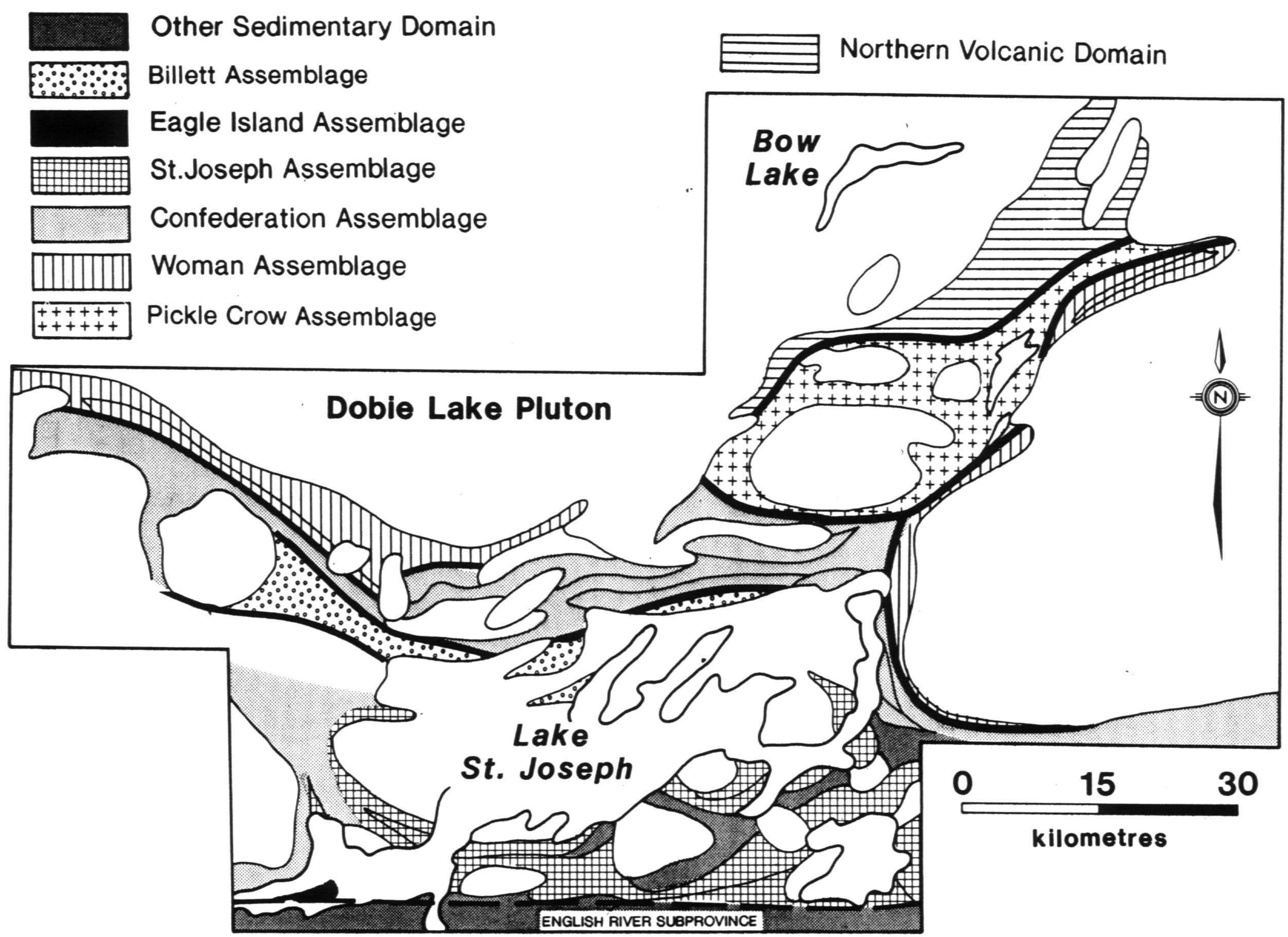
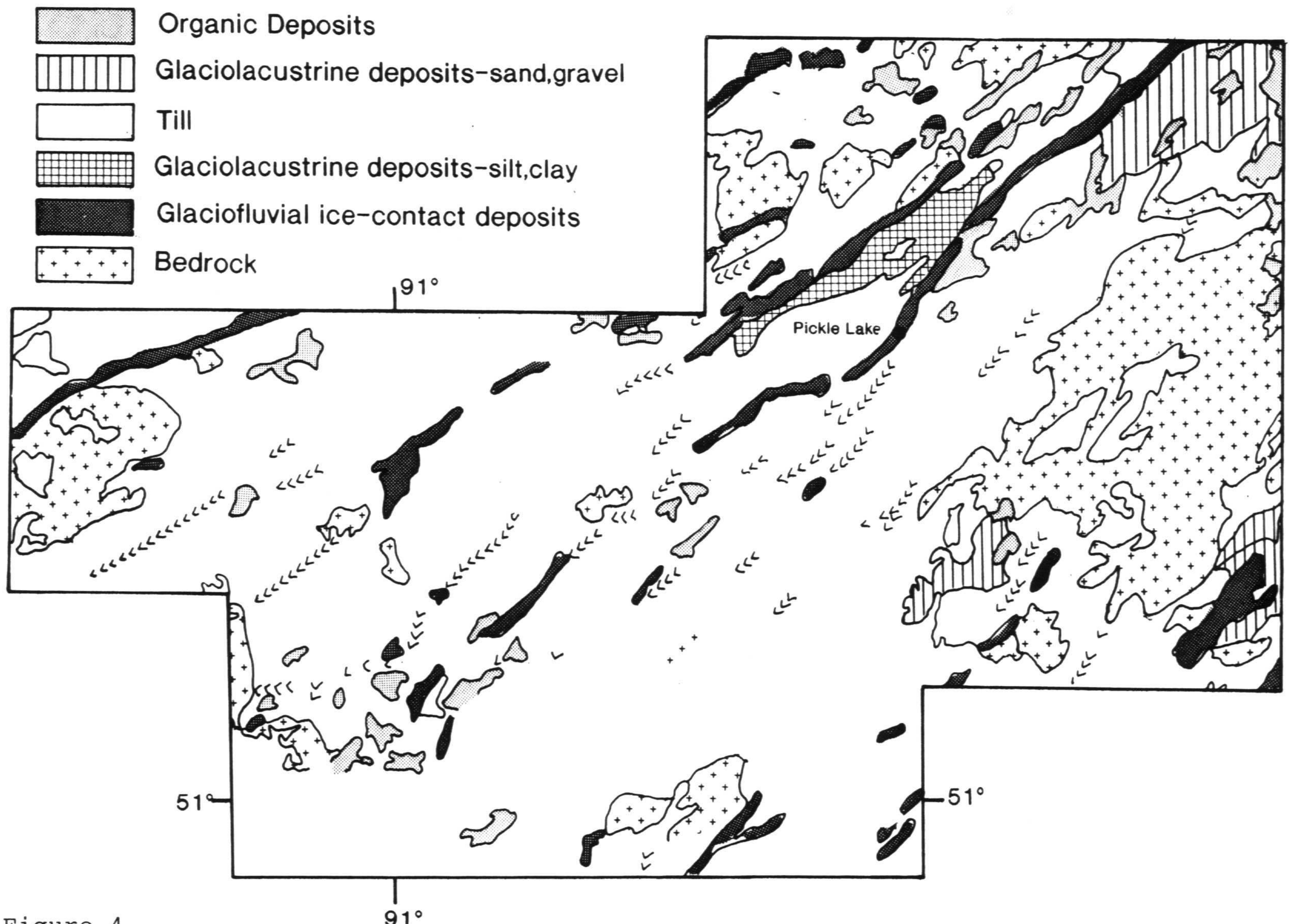

granitoids
gabbros
metasediments
felsic-intermediate metavolcanics
mafic metavolcanics
Bow
Lake
Dobie Lake Pluton
AREA 1
AREA 2
Lake
St. Joseph
AREA 3
0
15
30
kilometres
N
AREA 1:
Meen-Dempster Belt
AREA 2:
Pickle Lake Belt
AREA 3:
Lake St.Joseph Belt

Figure 2



Other Sedimentary Domain
Billett Assemblage
Eagle Island Assemblage
St.Joseph Assemblage
Confederation Assemblage
Woman Assemblage
Pickle Crow Assemblage
Northern Volcanic Domain
Bow Lake
Dobie Lake Pluton
Lake St. Joseph
ENGLISH RIVER SUBPROVINCE
0
15
30
kilometres
N

Figure 3



Organic Deposits
Glaciolacustrine deposits-sand,gravel
Till
Glaciolacustrine deposits-silt,clay
Glaciofluvial ice-contact deposits
Bedrock
91°
Pickle Lake
51°
51°
91°

Figure 4

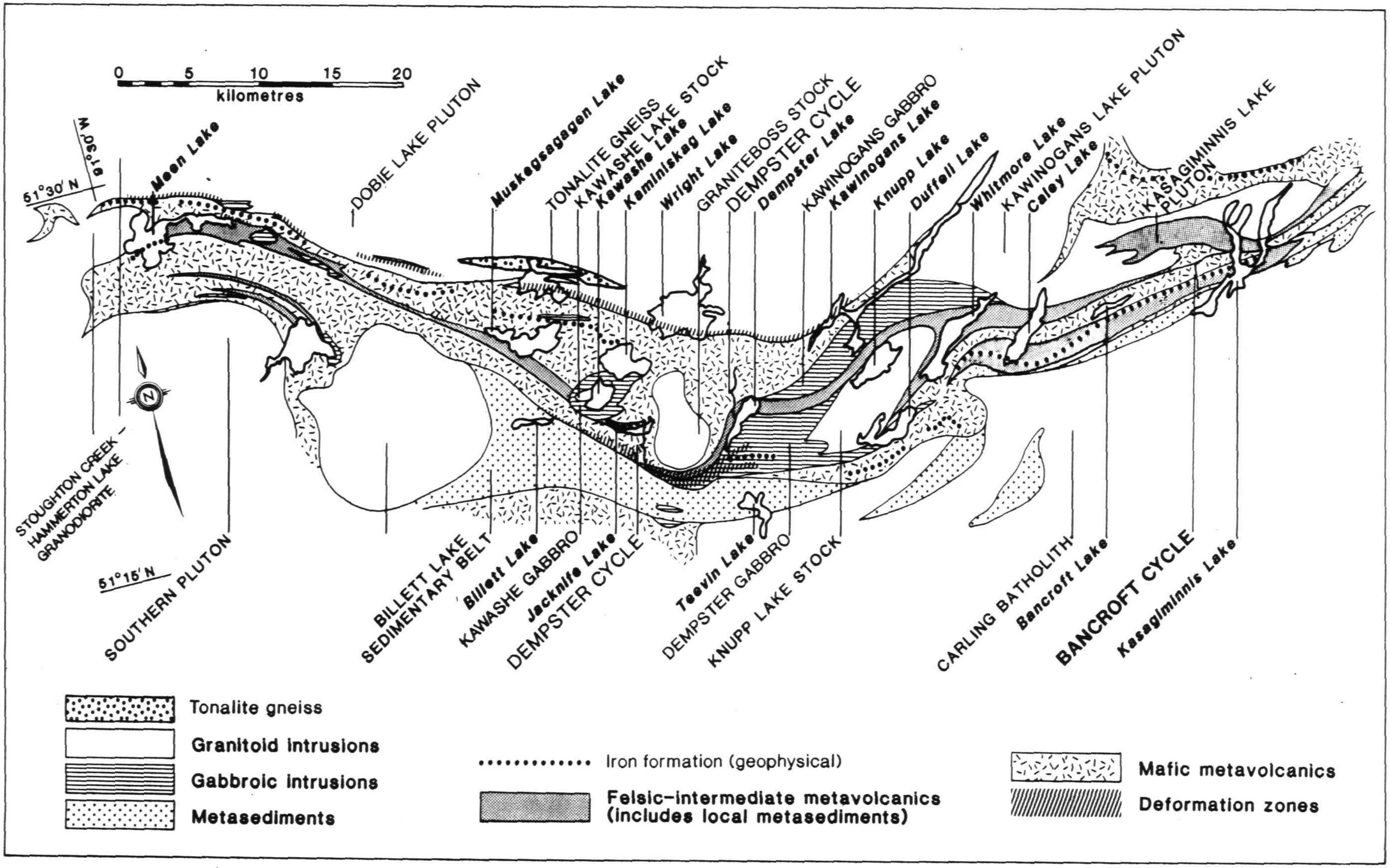
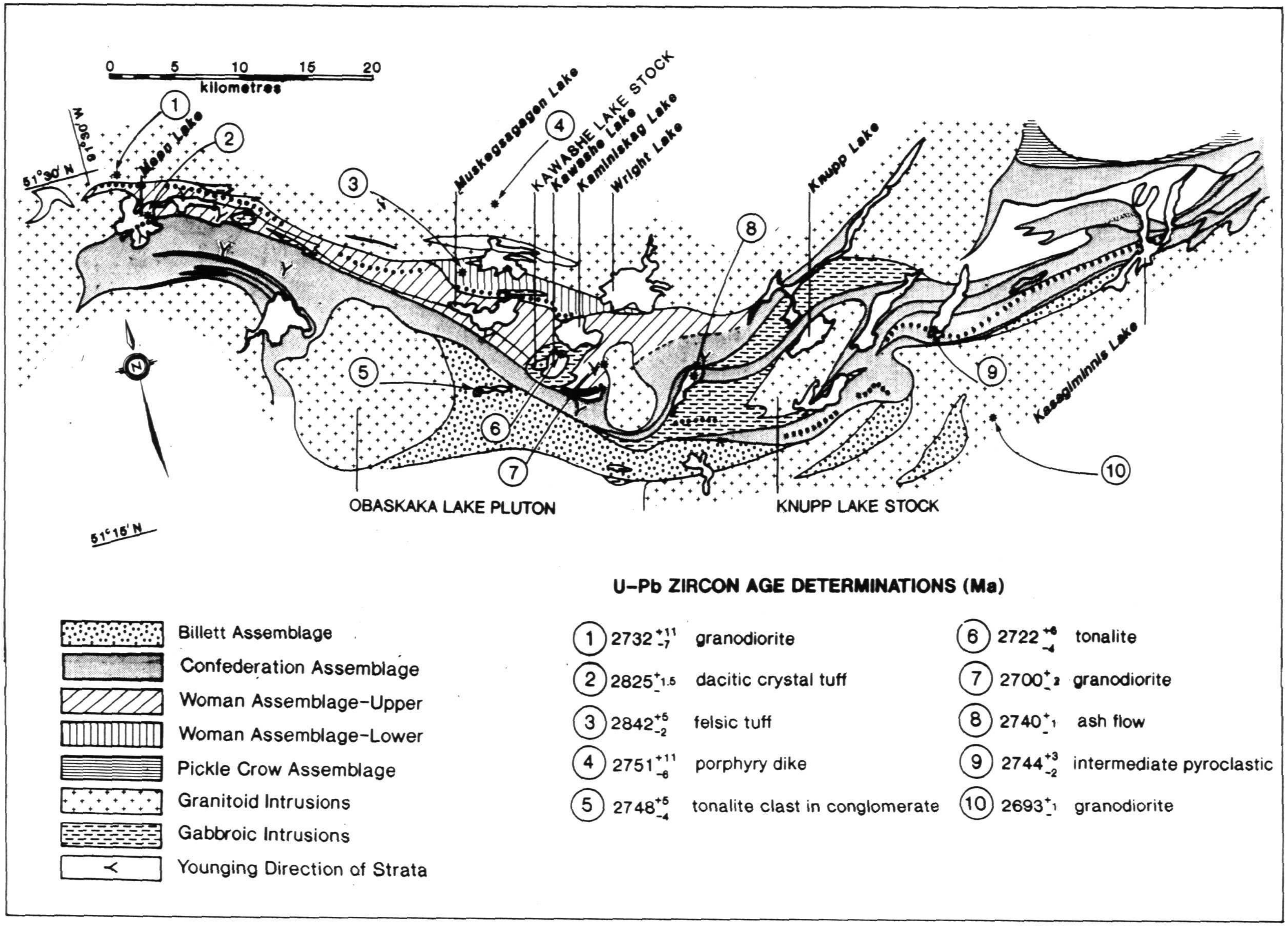

0 5 10 15 20
kilometres
51°30′ N
91°30′ W
Meen Lake
DOBIE LAKE PLUTON
Muskegsagagen Lake
TONALITE GNEISS
KAWASHE LAKE STOCK
Kawashe Lake
Kaminiskag Lake
Wright Lake
GRANITEBOSS STOCK
DEMPSTER CYCLE
Dempster Lake
KAWINOGANS GABBRO
Kawinogans Lake
Knupp Lake
Duffell Lake
Whitmore Lake
KAWINOGANS LAKE PLUTON
Caley Lake
KASAGIMINNIS LAKE PLUTON
STOUGHTON CREEK - HAMMERTON LAKE GRANODIORITE
N
51°15′ N
SOUTHERN PLUTON
BILLETT LAKE SEDIMENTARY BELT
Billett Lake
KAWASHE GABBRO
Jacknife Lake
DEMPSTER CYCLE
Teevin Lake
DEMPSTER GABBRO
KNUPP LAKE STOCK
CARLING BATHOLITH
Bancroft Lake
BANCROFT CYCLE
Kasagiminnis Lake
Tonalite gneiss
Granitoid intrusions
Gabbroic intrusions
Metasediments
Iron formation (geophysical)
Felsic-intermediate metavolcanics (includes local metasediments)
Mafic metavolcanics
Deformation zones

Figure 5

A



0 5 10 15 20
kilometres
51°30' N
91°30' W
Meso Lake
Muskegsagagen Lake
KAWASHE LAKE STOCK
Kawashe Lake
Kaminiskag Lake
Wright Lake
Knupp Lake
Kasagiminnis Lake
OBASKAKA LAKE PLUTON
KNUPP LAKE STOCK
51°15' N
N
1
2
3
4
5
6
7
8
9
10
Billett Assemblage
Confederation Assemblage
Woman Assemblage-Upper
Woman Assemblage-Lower
Pickle Crow Assemblage
Granitoid Intrusions
Gabbroic Intrusions
Younging Direction of Strata
U-Pb ZIRCON AGE DETERMINATIONS (Ma)
1 2732^{+11}_{-7} granodiorite
2 $2825^{+}_{-1.5}$ dacitic crystal tuff
3 2842^{+5}_{-2} felsic tuff
4 2751^{+11}_{-6} porphyry dike
5 2748^{+5}_{-4} tonalite clast in conglomerate
6 2722^{+6}_{-4} tonalite
7 2700^{+}_{-2} granodiorite
8 2740^{+}_{-1} ash flow
9 2744^{+3}_{-2} intermediate pyroclastic
10 2693^{+}_{-1} granodiorite

Figure 6

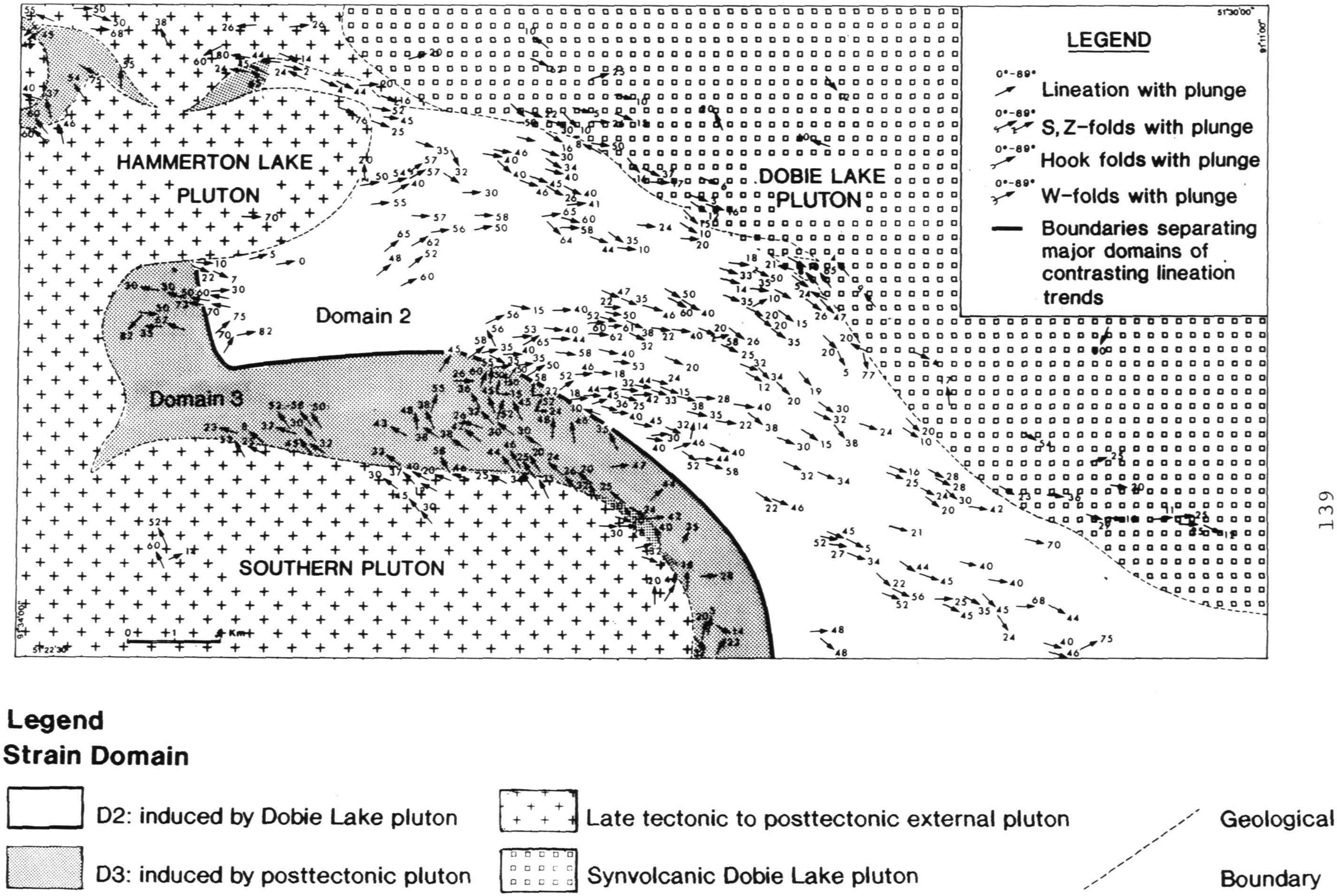

HAMMERTON LAKE PLUTON
DOBIE LAKE PLUTON
Domain 2
Domain 3
SOUTHERN PLUTON
LEGEND
Lineation with plunge
S, Z-folds with plunge
Hook folds with plunge
W-folds with plunge
Boundaries separating major domains of contrasting lineation trends
0 1 2 Km
Legend
Strain Domain
D2: induced by Dobie Lake pluton
D3: induced by posttectonic pluton
Late tectonic to posttectonic external pluton
Synvolcanic Dobie Lake pluton
Geological Boundary

Figure 7

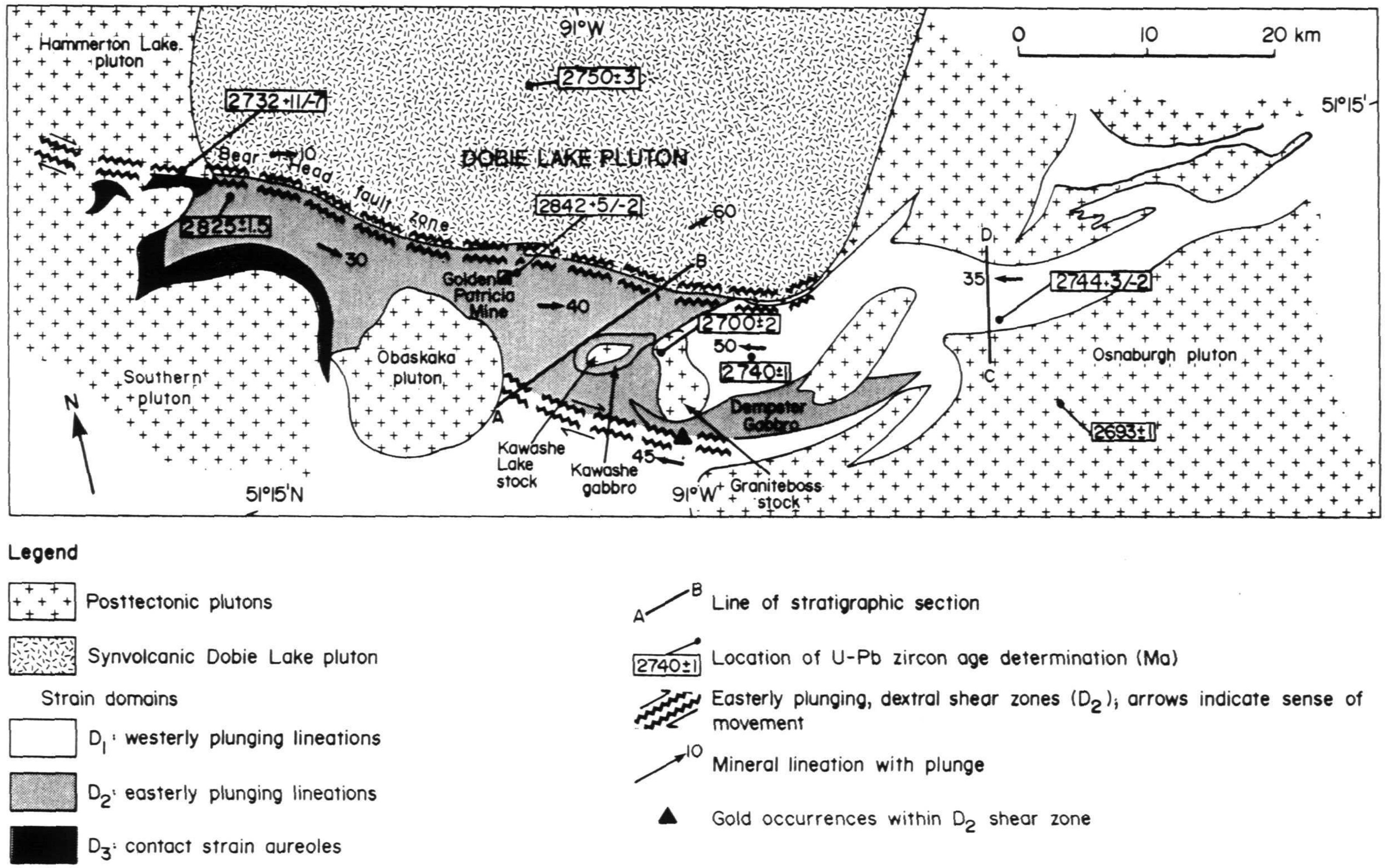

Hammerton Lake pluton
91°W
2750±3
2732+11/-7
DOBIE LAKE PLUTON
Bear Head fault zone
10
2825±1.5
2842+5/-2
60
30
Golden Patricia Mine
40
B
2700±2
50
2740±1
Obaskaka pluton
Southern pluton
N
A
Kawashe Lake stock
Kawashe gabbro
45
91°W
Graniteboss stock
Dempster Gabbro
51°15'N
0
10
20 km
51°15'
D
35
2744+3/-2
C
Osnaburgh pluton
2693±1
Legend
Posttectonic plutons
Synvolcanic Dobie Lake pluton
Strain domains
D1: westerly plunging lineations
D2: easterly plunging lineations
D3: contact strain aureoles
Line of stratigraphic section
Location of U-Pb zircon age determination (Ma)
Easterly plunging, dextral shear zones (D2); arrows indicate sense of movement
Mineral lineation with plunge
Gold occurrences within D2 shear zone

Figure 8

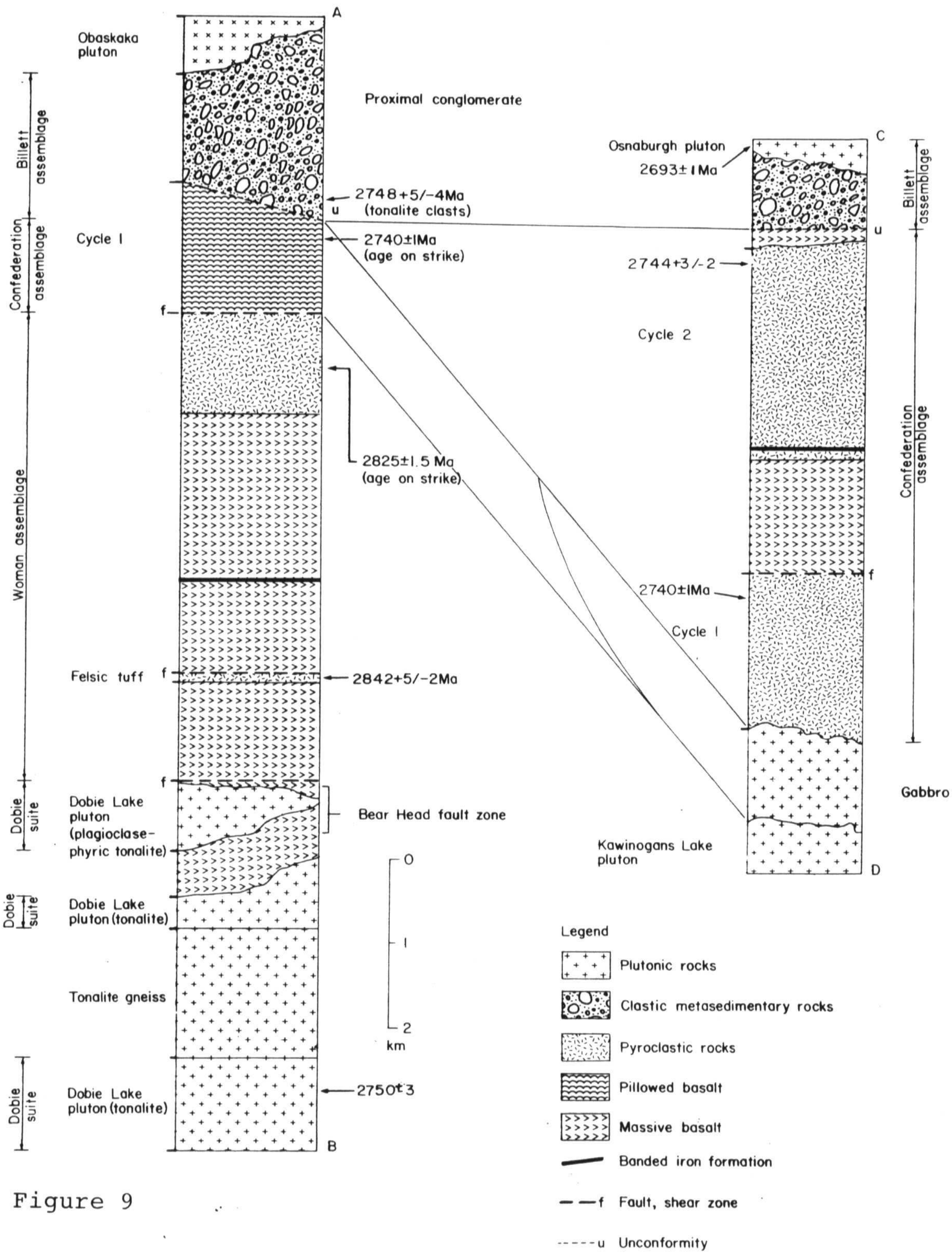

A
Obaskaka pluton
Proximal conglomerate
Billett assemblage
Confederation assemblage
Cycle I
2748+5/-4Ma (tonalite clasts)
u
2740±1Ma (age on strike)
f
Woman assemblage
2825±1.5 Ma (age on strike)
Felsic tuff
2842+5/-2Ma
Dobie suite
Dobie Lake pluton (plagioclase-phyric tonalite)
Bear Head fault zone
Dobie Lake pluton (tonalite)
Tonalite gneiss
0
1
2
km
2750±3
B
C
Osnaburgh pluton
2693±1Ma
2744+3/-2
Cycle 2
2740±1Ma
Cycle I
Gabbro
Kawinogans Lake pluton
D
Legend
Plutonic rocks
Clastic metasedimentary rocks
Pyroclastic rocks
Pillowed basalt
Massive basalt
Banded iron formation
f Fault, shear zone
u Unconformity

Figure 9

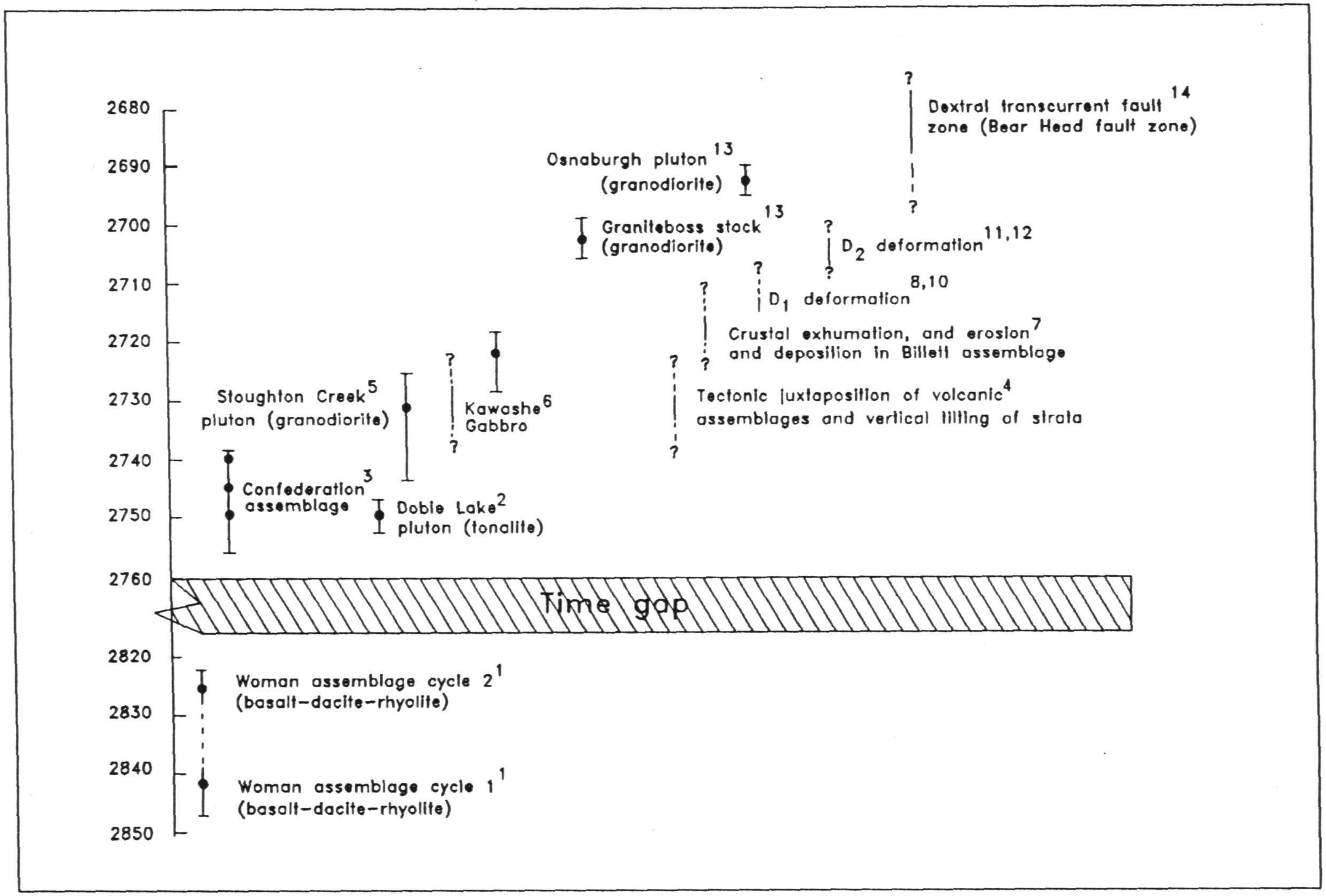

2680
2690
2700
2710
2720
2730
2740
2750
2760
2820
2830
2840
2850
Dextral transcurrent fault zone (Bear Head fault zone) 14
Osnaburgh pluton (granodiorite) 13
Graniteboss stock (granodiorite) 13
D2 deformation 11,12
D1 deformation 8,10
Crustal exhumation, and erosion and deposition in Billett assemblage 7
Tectonic juxtaposition of volcanic assemblages and vertical tilting of strata 4
Stoughton Creek pluton (granodiorite) 5
Kawashe Gabbro 6
Confederation assemblage 3
Doble Lake pluton (tonalite) 2
Time gap
Woman assemblage cycle 2 (basalt-dacite-rhyolite) 1
Woman assemblage cycle 1 (basalt-dacite-rhyolite) 1

Figure 10

14 Bear Head fault zone - dextral transcurrent movement postdates plutons typical of Williams suite (2700 Ma, granite-granodiorite) and other plutons during the late stage of Kenoran orogenesis (Stott and Corfu 1991); fault may be reactivation of earlier fault in north Meen-Dempster greenstone belt margin.

13 Crescent-shaped Osnaburgh pluton (2693±1 Ma) intruded between Meen-Dempster greenstone belt and foliated tonalite of Lake St. Joseph batholith; Graniteboss stock (2700±2 Ma) postdates D_2 deformation.

12 D_2 deformation locally affected by *circa* 2700 Ma plutons.

11 D_2 deformation domain postdates Kawashe Lake stock and predates Graniteboss stock: D_2 possibly related to Kenoran orogenic northwest-southeast shortening producing translation and clockwise rotation of Dobie Lake pluton, which in turn compressed the adjacent greenstone belt.

10 D_1 deformation fabric imposed on Billett assemblage.

9 Kawashe Lake stock (2722^{+6}_{-4} Ma) intruded Kawashe Gabbro and was later subjected to D_2 deformation.

8 Dempster Gabbro intruded Billett assemblage and itself is deformed later by D_1 and D_2 deformation.

7 Crustal exhumation, erosion and consequent Billett assemblage sedimentary deposition: interbedded conglomerate and graded sandstone; dominantly turbidite sequences unconformably overlie volcanic assemblages; some detritus evidently from erosion of Dobie Lake pluton (tonalite clast 2748^{+5}_{-4} Ma).

6 Kawashe Gabbro (ca. 2740 to 2722 Ma) stitches boundary between Woman and Confederation assemblages and itself is intruded by Kawashe Lake stock.

5 Stoughton Creek pluton (2732^{+11}_{-7} Ma) intruded north margin of Meen-Dempster greenstone belt; pluton is synchronous with volcanism in south half of Uchi Subprovince

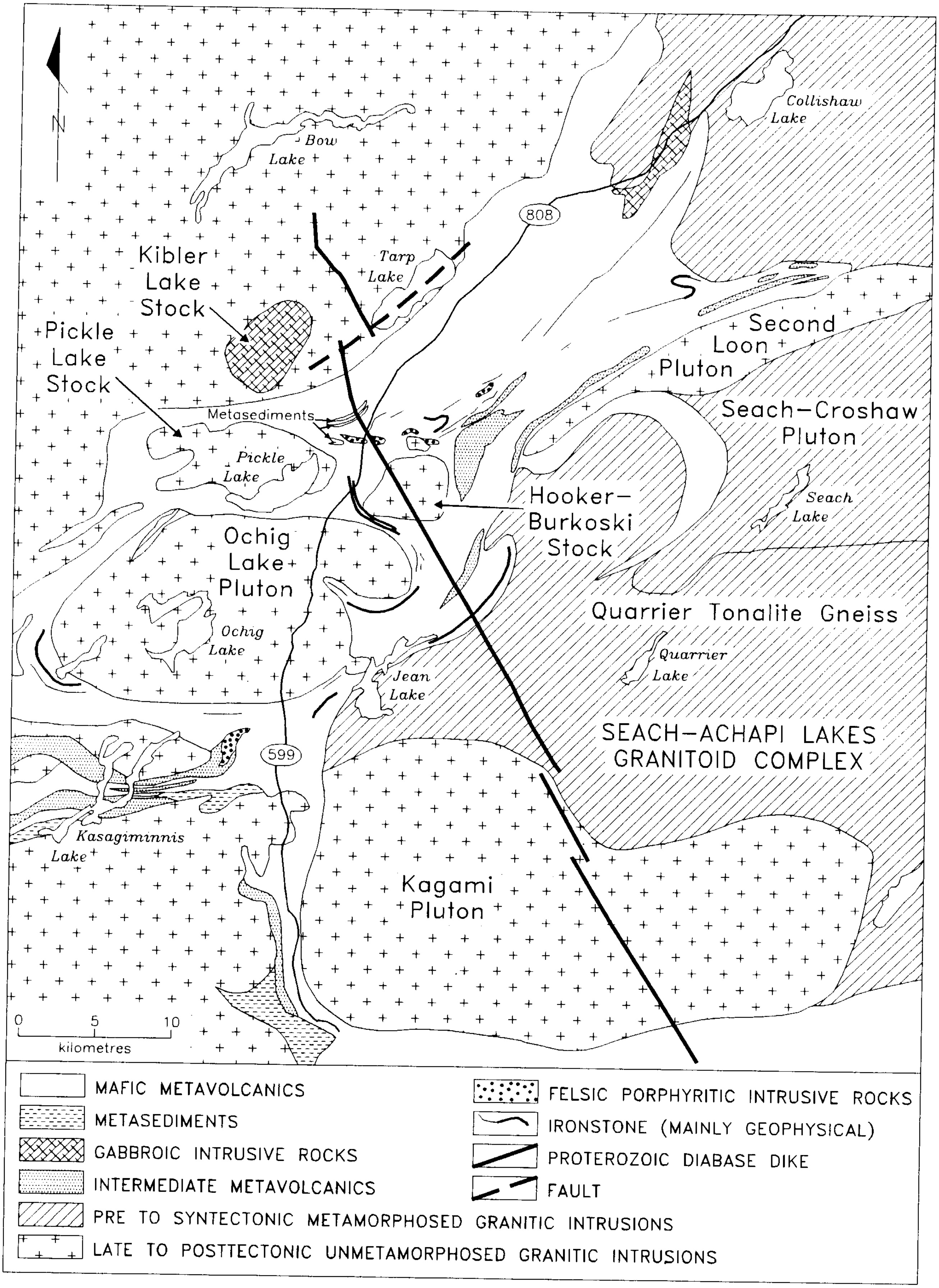
4 Local tectonic juxtaposition (by thrusting?) of Woman and Confederation assemblages bracketed between 2740 and 2722 Ma.

3 Confederation assemblage (2749 to 2740 Ma) volcanism; island arc or continental arc, bimodal tholeiitic basalt and calc-alkalic dacite.

2 Dobie Lake pluton (tonalite) (2750±3 Ma) intruded synchronously with Confederation volcanism; pluton imposed contact metamorphism on north margin of Meen-Dempster greenstone belt.

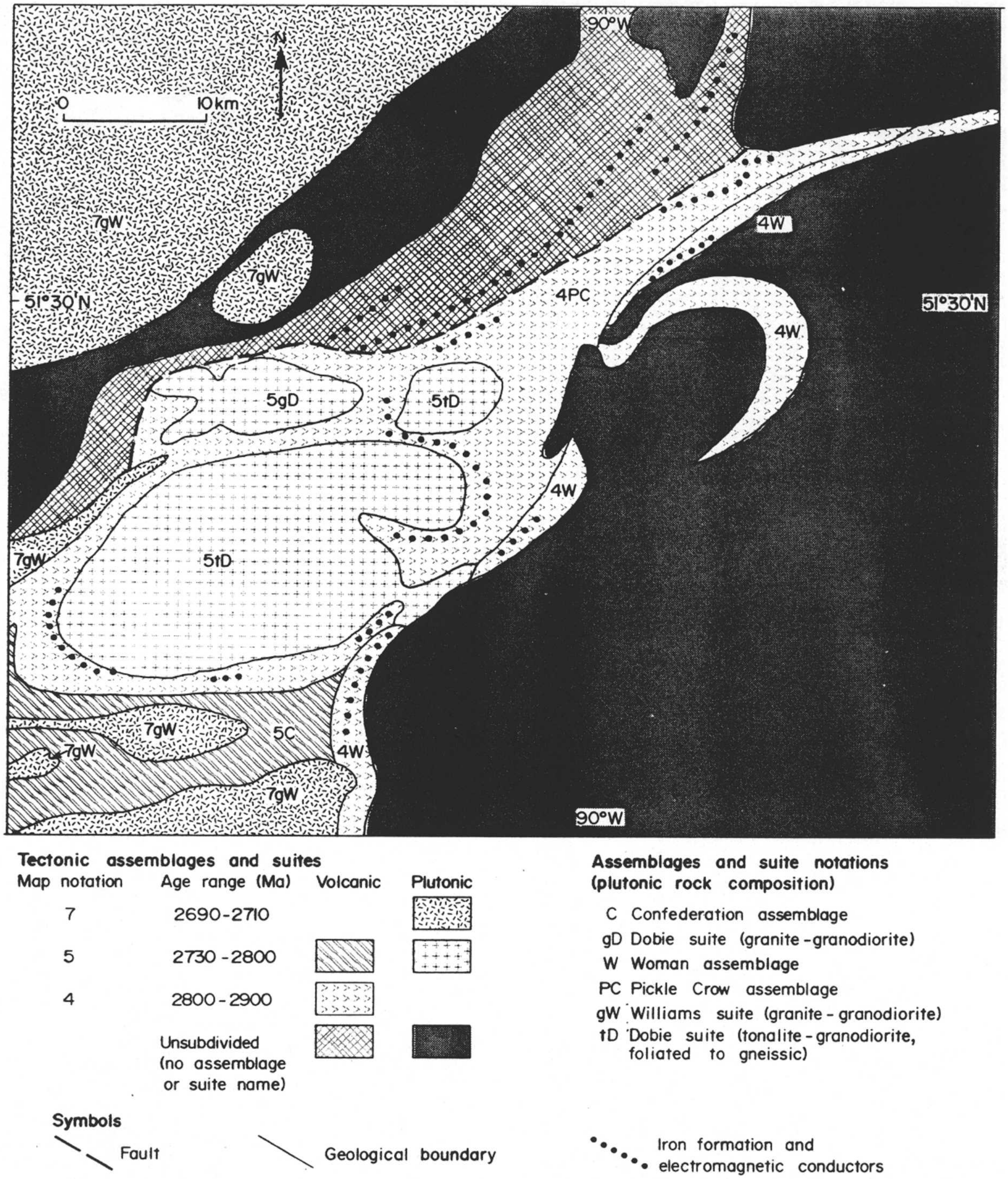
1 Woman assemblage (2842 to 2825 Ma) volcanism; continental margin island arc, bimodal tholeiitic basalt and calc-alkalic dacite to rhyolite.

Figure 10: The general sequence of magmatic and structural events in the Meen-Dempster greenstone belt.



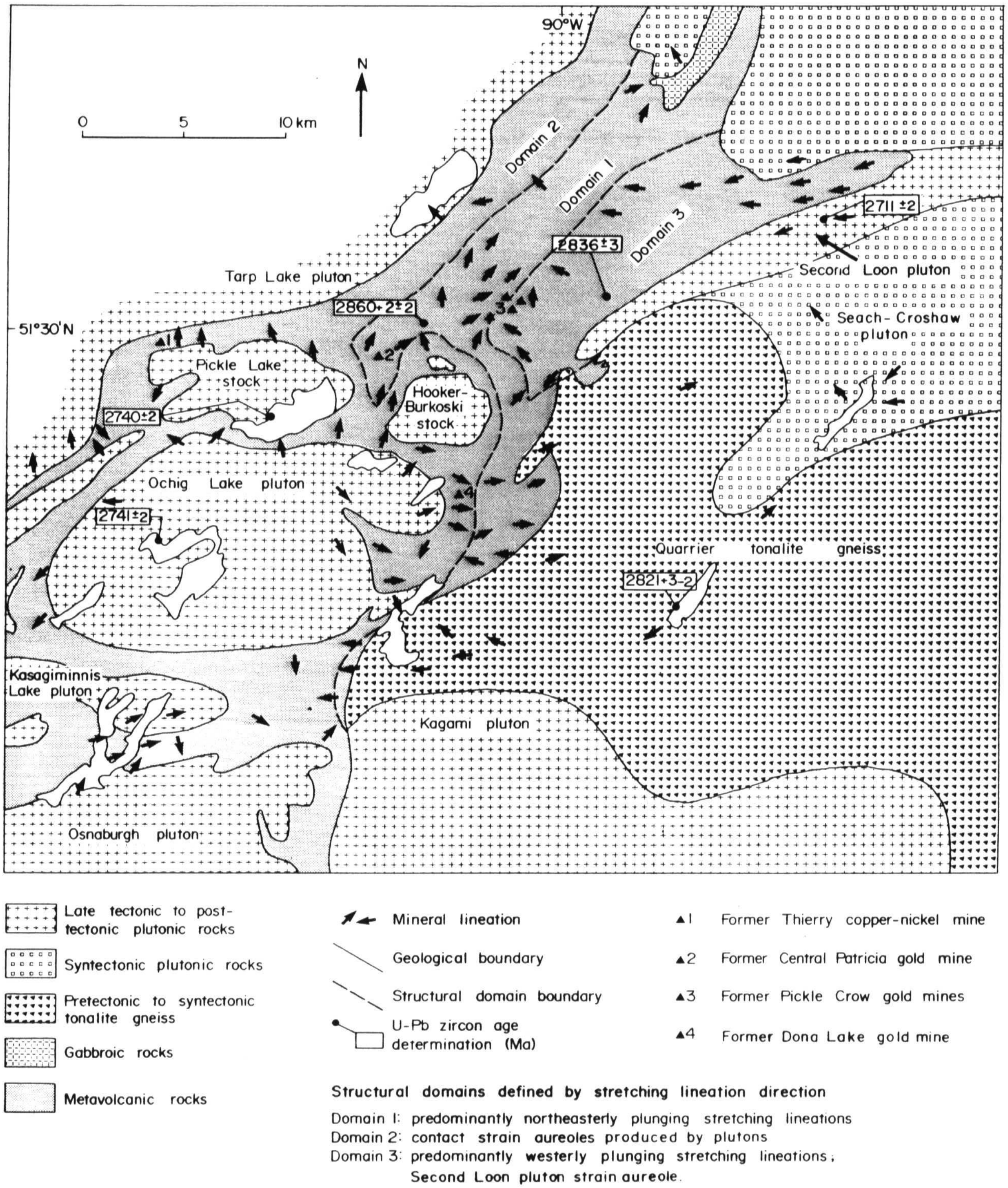
N
Collishaw Lake
Bow Lake
808
Tarp Lake
Kibler Lake Stock
Pickle Lake Stock
Second Loon Pluton
Seach-Croshaw Pluton
Metasediments
Pickle Lake
Hooker-Burkoski Stock
Seach Lake
Ochig Lake Pluton
Quarrier Tonalite Gneiss
Ochig Lake
Quarrier Lake
Jean Lake
SEACH-ACHAPI LAKES GRANITOID COMPLEX
599
Kasagiminnis Lake
Kagami Pluton
0 5 10
kilometres
MAFIC METAVOLCANICS
METASEDIMENTS
GABBROIC INTRUSIVE ROCKS
INTERMEDIATE METAVOLCANICS
PRE TO SYNTECTONIC METAMORPHOSED GRANITIC INTRUSIONS
LATE TO POSTTECTONIC UNMETAMORPHOSED GRANITIC INTRUSIONS
FELSIC PORPHYRITIC INTRUSIVE ROCKS
IRONSTONE (MAINLY GEOPHYSICAL)
PROTEROZOIC DIABASE DIKE
FAULT

Figure 11



90°W
N
0 10 km
7gW
7gW
51°30'N
4PC
4W
4W
51°30'N
5gD
5tD
5tD
4W
7gW
7gW
7gW
5C
4W
7gW
90°W
Tectonic assemblages and suites
Map notation
Age range (Ma)
Volcanic
Plutonic
7
2690-2710
5
2730-2800
4
2800-2900
Unsubdivided (no assemblage or suite name)
Assemblages and suite notations (plutonic rock composition)
C Confederation assemblage
gD Dobie suite (granite-granodiorite)
W Woman assemblage
PC Pickle Crow assemblage
gW Williams suite (granite-granodiorite)
tD Dobie suite (tonalite-granodiorite, foliated to gneissic)
Symbols
Fault
Geological boundary
Iron formation and electromagnetic conductors

Figure 12



90°W
N
0 5 10 km
Domain 2
Domain 1
Domain 3
2711 ±2
2836±3
Second Loon pluton
Tarp Lake pluton
2860+2±2
3
51°30'N
1
2
Seach-Croshaw pluton
Pickle Lake stock
Hooker-Burkoski stock
2740±2
Ochig Lake pluton
4
2741±2
Quarrier tonalite gneiss
2821+3-2
Kasagiminnis Lake pluton
Kagami pluton
Osnaburgh pluton
Late tectonic to post-tectonic plutonic rocks
Syntectonic plutonic rocks
Pretectonic to syntectonic tonalite gneiss
Gabbroic rocks
Metavolcanic rocks
Mineral lineation
Geological boundary
Structural domain boundary
U-Pb zircon age determination (Ma)
▲1 Former Thierry copper-nickel mine
▲2 Former Central Patricia gold mine
▲3 Former Pickle Crow gold mines
▲4 Former Dona Lake gold mine
Structural domains defined by stretching lineation direction
Domain 1: predominantly northeasterly plunging stretching lineations
Domain 2: contact strain aureoles produced by plutons
Domain 3: predominantly westerly plunging stretching lineations; Second Loon pluton strain aureole.

Figure 13

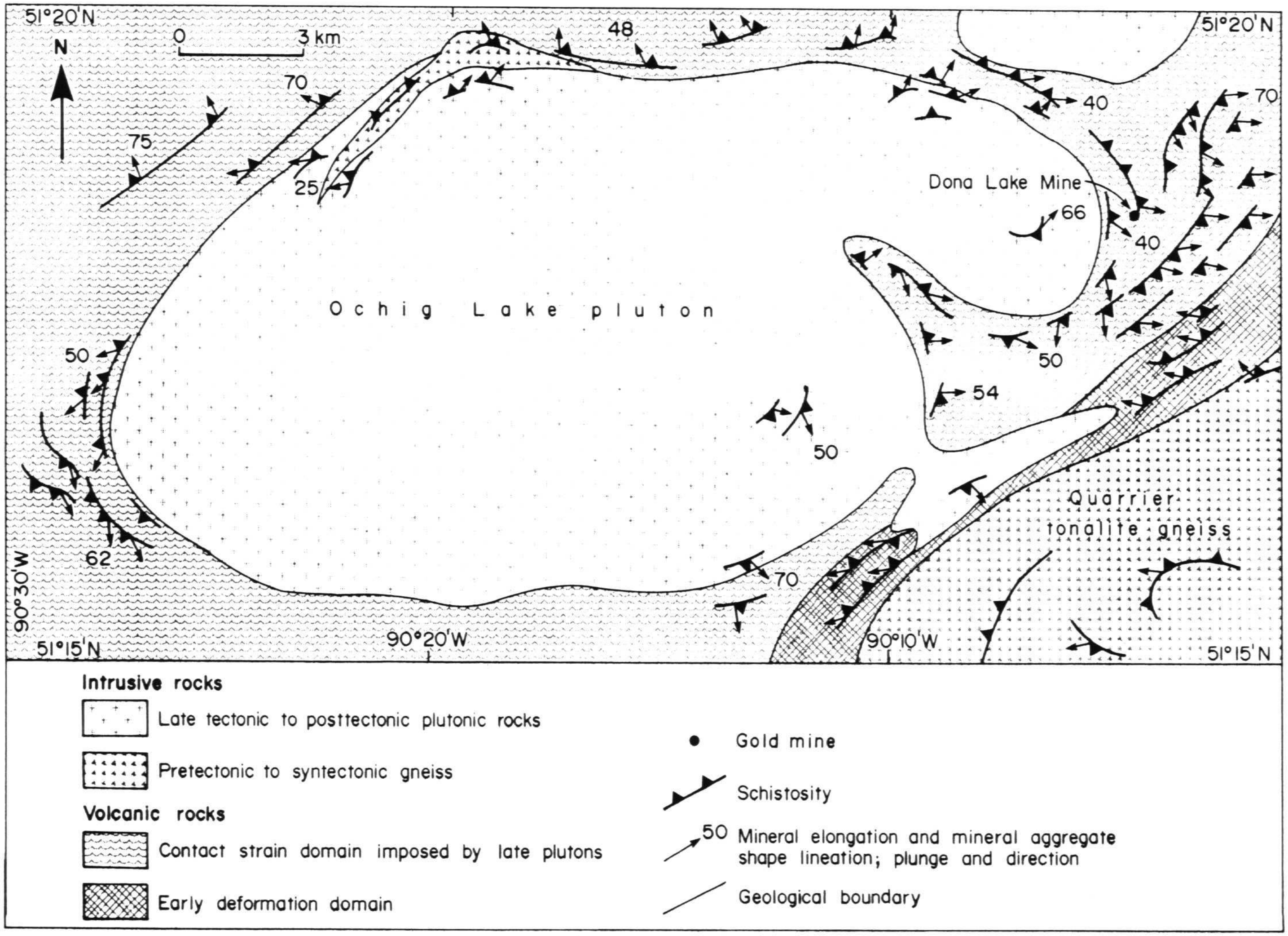

51°20'N
N
0 3 km
75
70
25
48
40
70
Dona Lake Mine
66
40
Ochig Lake pluton
50
54
50
50
62
70
Quarrier tonalite gneiss
90°30'W
51°15'N
90°20'W
90°10'W
51°15'N
51°20'N
Intrusive rocks
Late tectonic to posttectonic plutonic rocks
Pretectonic to syntectonic gneiss
Volcanic rocks
Contact strain domain imposed by late plutons
Early deformation domain
Gold mine
Schistosity
50 Mineral elongation and mineral aggregate shape lineation; plunge and direction
Geological boundary

Figure 14

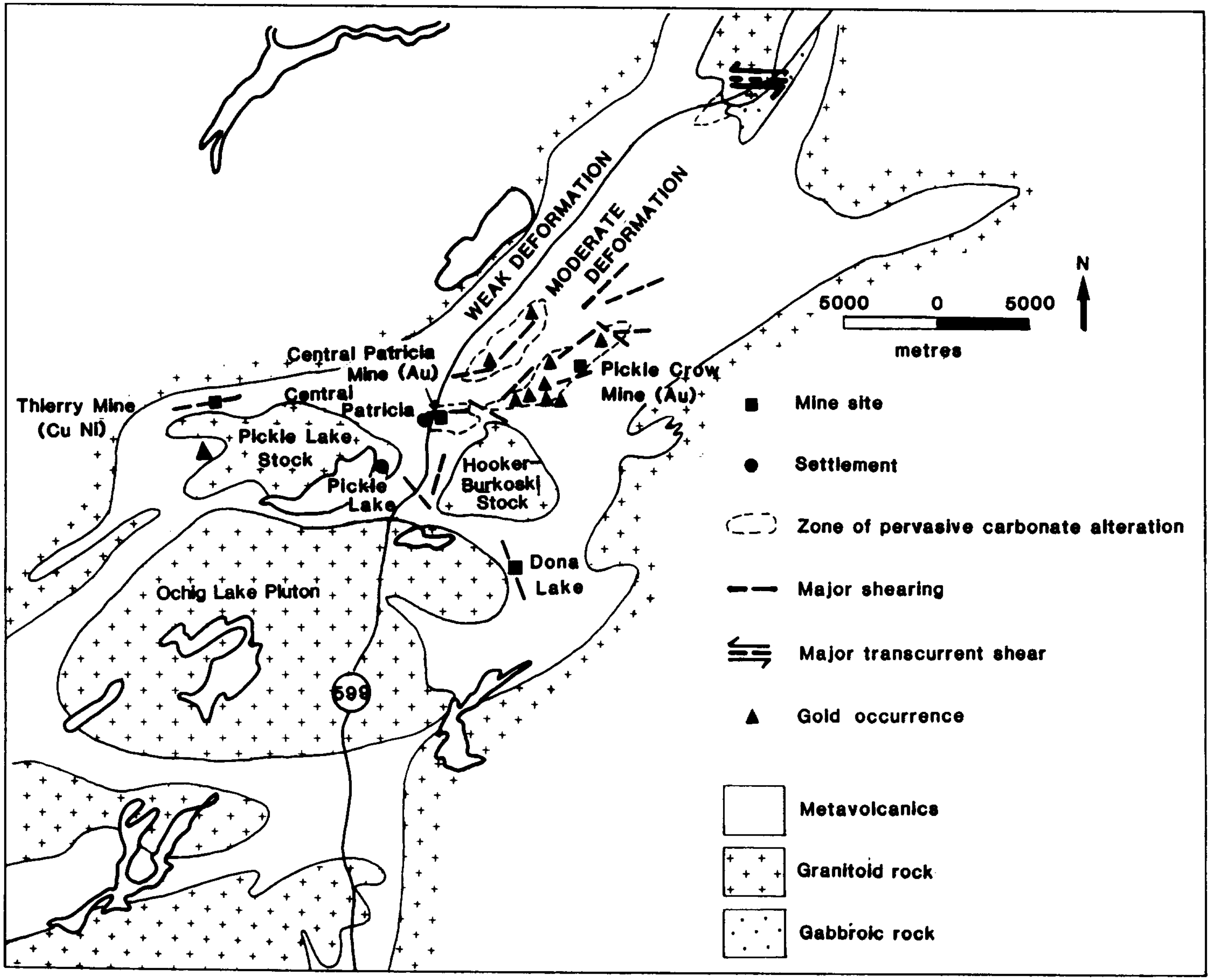

WEAK DEFORMATION
MODERATE DEFORMATION
Central Patricia Mine (Au)
Central Patricia
Thierry Mine (Cu Ni)
Pickle Lake Stock
Pickle Lake
Hooker-Burkoski Stock
Pickle Crow Mine (Au)
Dona Lake
Ochig Lake Pluton
599
N
5000 0 5000
metres
Mine site
Settlement
Zone of pervasive carbonate alteration
Major shearing
Major transcurrent shear
Gold occurrence
Metavolcanics
Granitoid rock
Gabbroic rock

Figure 15

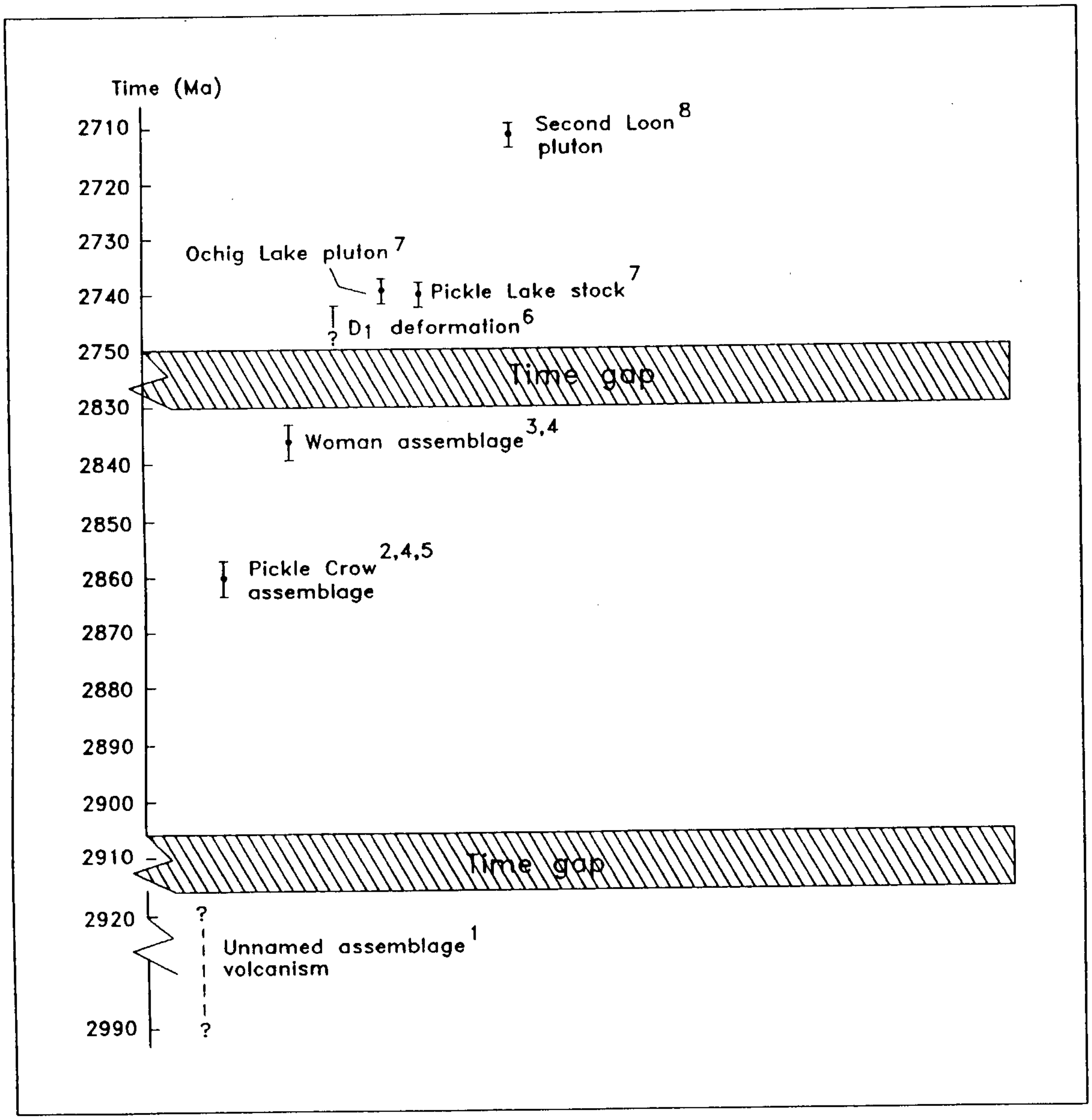

Time (Ma)
2710
2720
2730
2740
2750
2830
2840
2850
2860
2870
2880
2890
2900
2910
2920
2990
Second Loon 8
pluton
Ochig Lake pluton 7
Pickle Lake stock 7
D1 deformation 6
Time gap
Woman assemblage 3,4
Pickle Crow 2,4,5
assemblage
Time gap
Unnamed assemblage 1
volcanism
?
?

Figure 16

8 Granodioritic Second Loon pluton intruded (2711±2 Ma) along greenstone belt margin and produced contact strain aureole (D_3 domain) in Pickle Lake greenstone belt.

7 Ochig Lake pluton (2741±2 Ma), Pickle Lake (2740±2 Ma) and Hooker-Burkoski, stocks intruded and produced contact strain and metamorphic aureoles, forming part of D_2 strain domain in Pickle Lake greenstone belt.

6 D_1 domain deformation postdates volcanic assemblages and predates 2741 million-year-old plutons.

5 Tectonic accretion of north half of belt with Pickle Crow assemblage evident from juxtaposed strata; northern assemblage strata, including iron formation and electromagnetic conductor marker-units, transected by Pickle Crow assemblage at a small angle. Accretion at undefined time.

4 Disconformable contact between Pickle Crow and Woman assemblages at undefined time.

3 Woman assemblage volcanism (ca. 2836±3 Ma).

2 Pickle Crow assemblage volcanism (2860±2 Ma); island arc volcanism or rifted basin tholeiitic basalt and calc-alkalic rhyolite.

1 Possible correlation of north half of Pickle Lake volcanism with McGruer assemblage in North Caribou greenstone belt (North Caribou terrane); oceanic mafic plain volcanism with tholeiitic basalt, ultramafic sills and iron formation.

Figure 16: The general sequence of magmatic and structural events in the Pickle Lake greenstone belt.

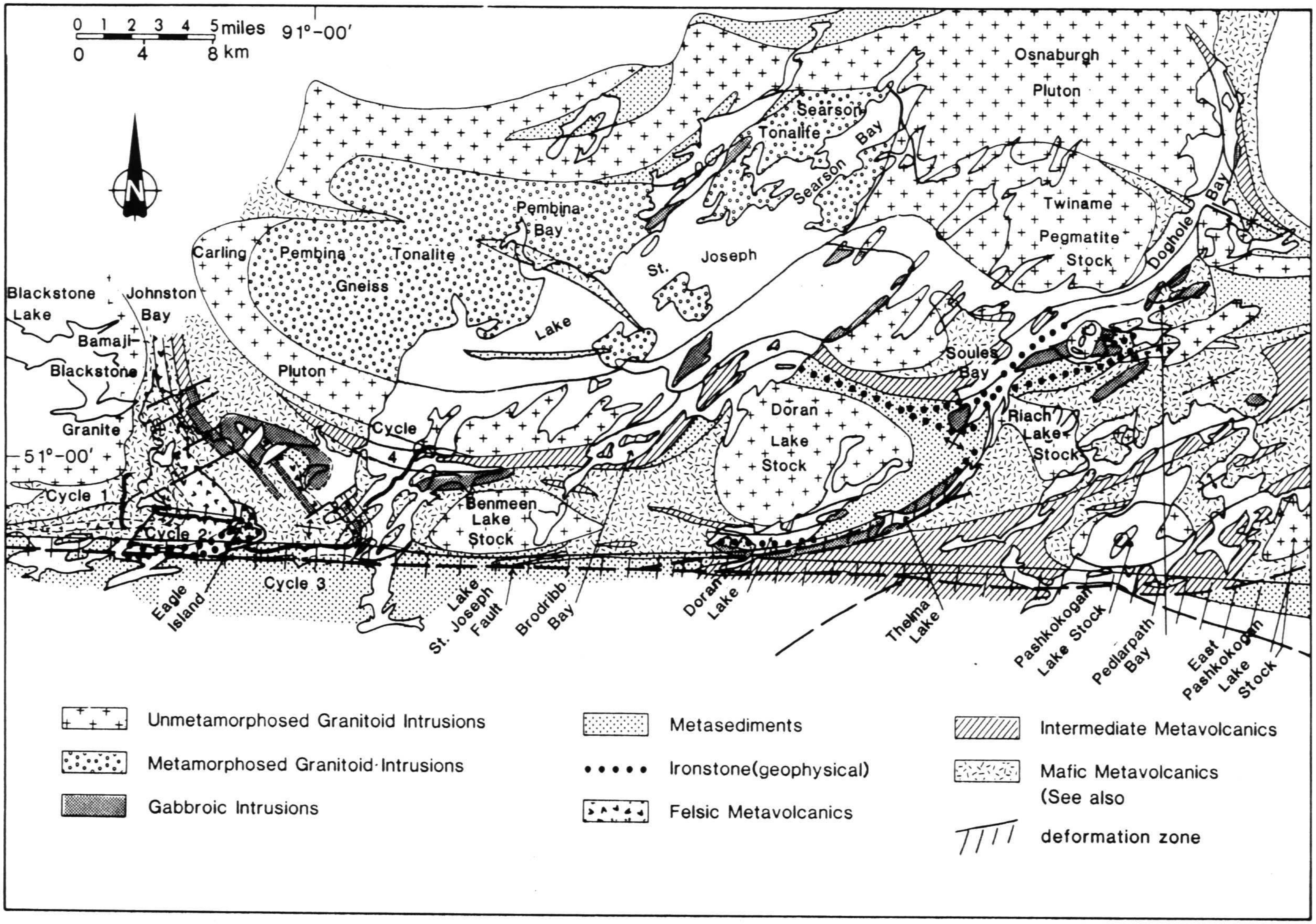
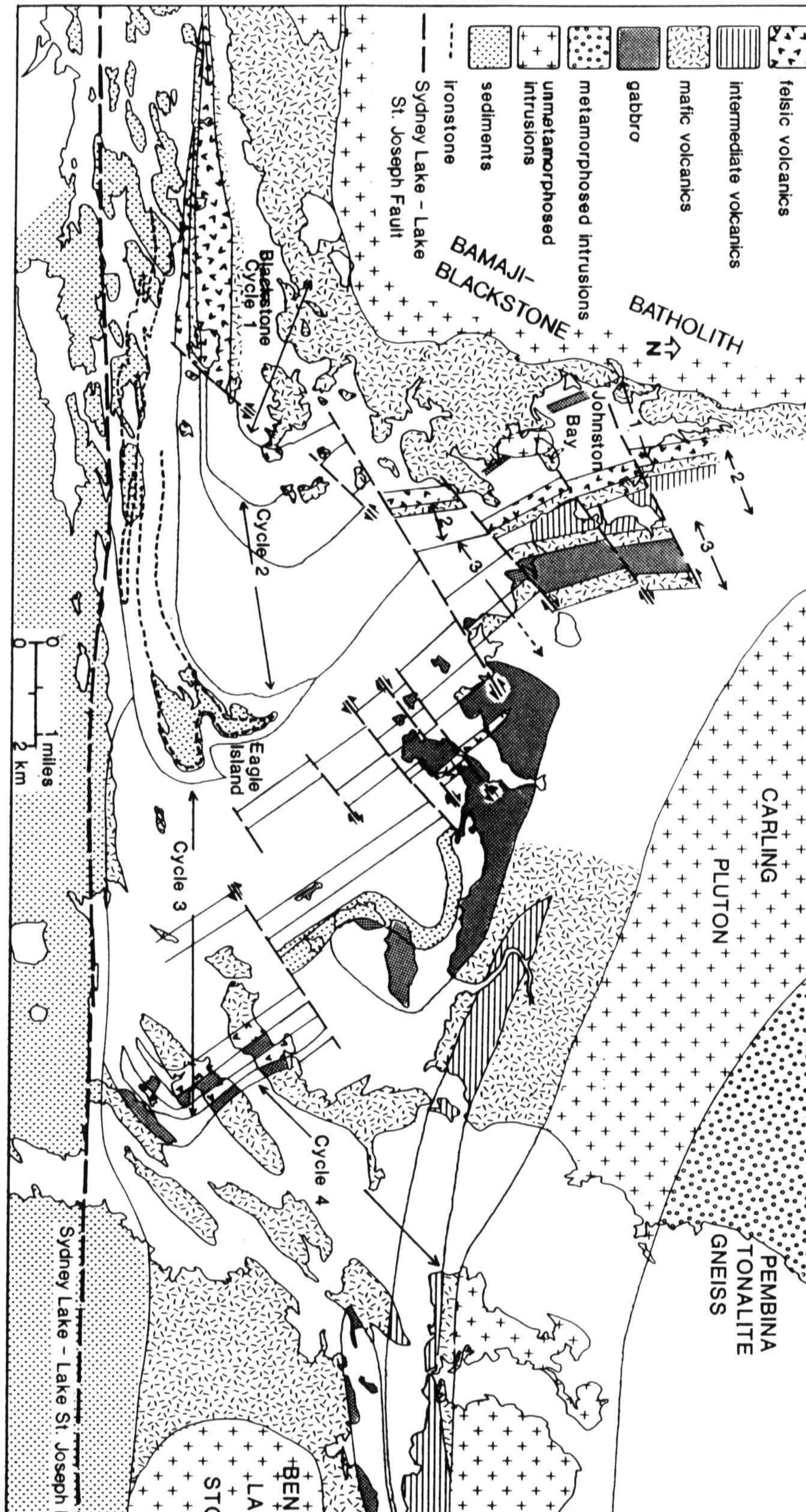

0 1 2 3 4 5 miles
0 4 8 km
91°-00′
51°-00′
N
Osnaburgh Pluton
Searson Tonalite
Searson Bay
Twiname Pegmatite Stock
Doghole Bay
Pembina Bay
Carling Pembina Gneiss Tonalite Pluton
St. Joseph Lake
Blackstone Lake
Johnston Bay
Bamaji-Blackstone Granite
Cycle 1
Cycle 2
Cycle 3
Cycle 4
Soules Bay
Doran Lake Stock
Riach Lake Stock
Benmeen Lake Stock
Eagle Island
Lake St. Joseph Fault
Brodribb Bay
Doran Lake
Thelma Lake
Pashkokogan Lake Stock
Pedlarpath Bay
East Pashkokogan Lake Stock
Unmetamorphosed Granitoid Intrusions
Metamorphosed Granitoid Intrusions
Gabbroic Intrusions
Metasediments
Ironstone(geophysical)
Felsic Metavolcanics
Intermediate Metavolcanics
Mafic Metavolcanics
(See also
deformation zone

Figure 17



felsic volcanics
intermediate volcanics
mafic volcanics
gabbro
metamorphosed intrusions
unmetamorphosed intrusions
sediments
ironstone
Sydney Lake - Lake St. Joseph Fault
BAMAJI-BLACKSTONE BATHOLITH
N
Johnston Bay
Blackstone Cycle 1
Cycle 2
Cycle 3
Cycle 4
Eagle Island
0 1 miles
0 2 km
CARLING PLUTON
PEMBINA TONALITE GNEISS
BENMEEN LAKE STOCK
Sydney Lake - Lake St. Joseph Fault

Figure 18

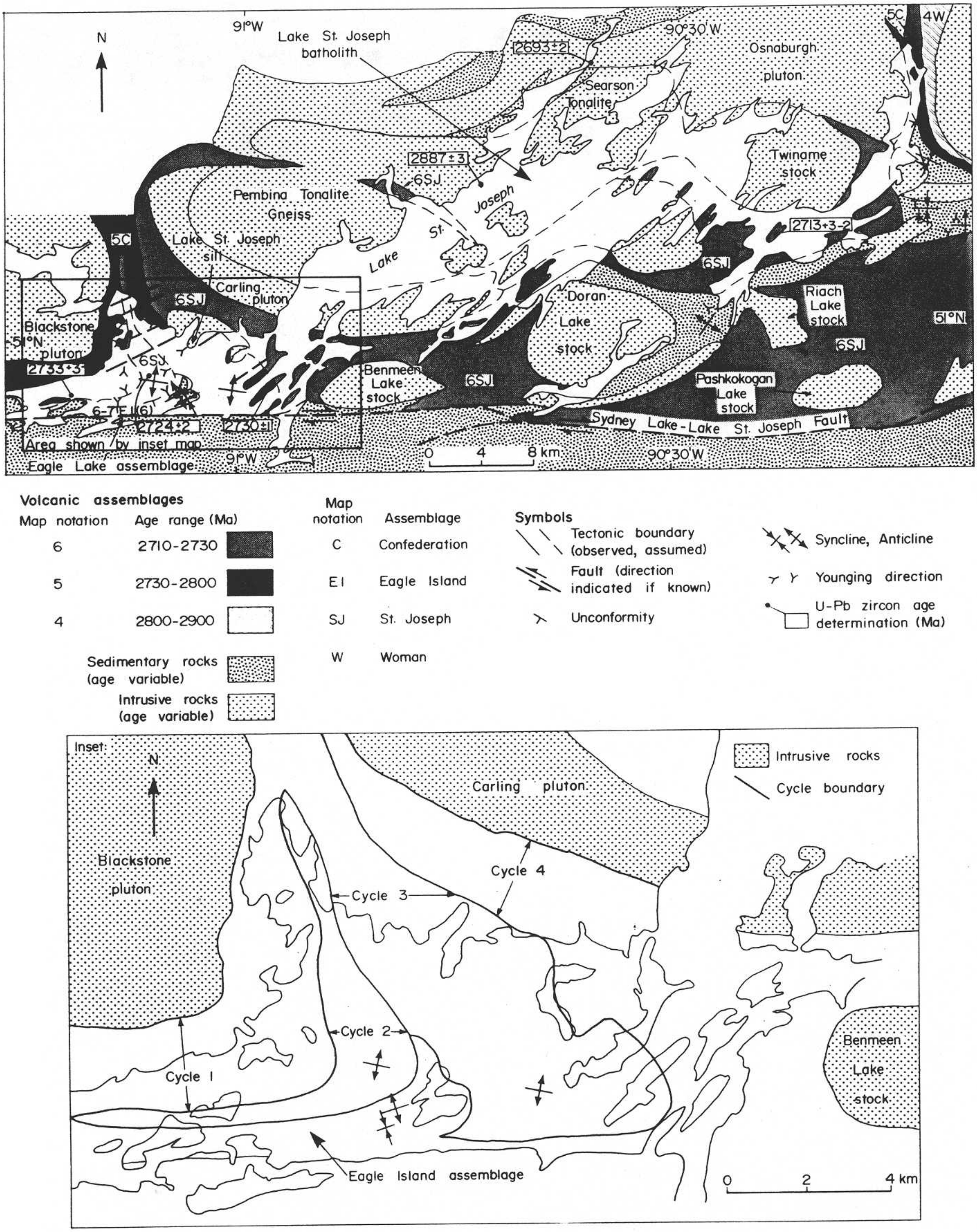

N
91°W
Lake St. Joseph batholith
2693±2
90°30'W
Osnaburgh pluton
5C
4W
Searson Tonalite
Twiname stock
2887±3
6SJ
Joseph
Pembina Tonalite Gneiss
St.
Lake
5C
Lake St. Joseph sill
2713+3-2
6SJ
Carling pluton
6SJ
Doran Lake stock
Riach Lake stock
Blackstone pluton
51°N
51°N
6SJ
2733+3
6SJ
Benmeen Lake stock
6SJ
Pashkokogan Lake stock
6-7EI(6)
2724±2
2730±1
Sydney Lake-Lake St. Joseph Fault
Area shown by inset map
Eagle Lake assemblage
91°W
0 4 8 km
90°30'W
Volcanic assemblages
Map notation
Age range (Ma)
6 2710-2730
5 2730-2800
4 2800-2900
Sedimentary rocks (age variable)
Intrusive rocks (age variable)
Map notation
Assemblage
C Confederation
EI Eagle Island
SJ St. Joseph
W Woman
Symbols
Tectonic boundary (observed, assumed)
Fault (direction indicated if known)
Unconformity
Syncline, Anticline
Younging direction
U-Pb zircon age determination (Ma)
Inset:
N
Carling pluton
Intrusive rocks
Cycle boundary
Blackstone pluton
Cycle 4
Cycle 3
Cycle 2
Cycle 1
Benmeen Lake stock
Eagle Island assemblage
0 2 4 km

Figure 19

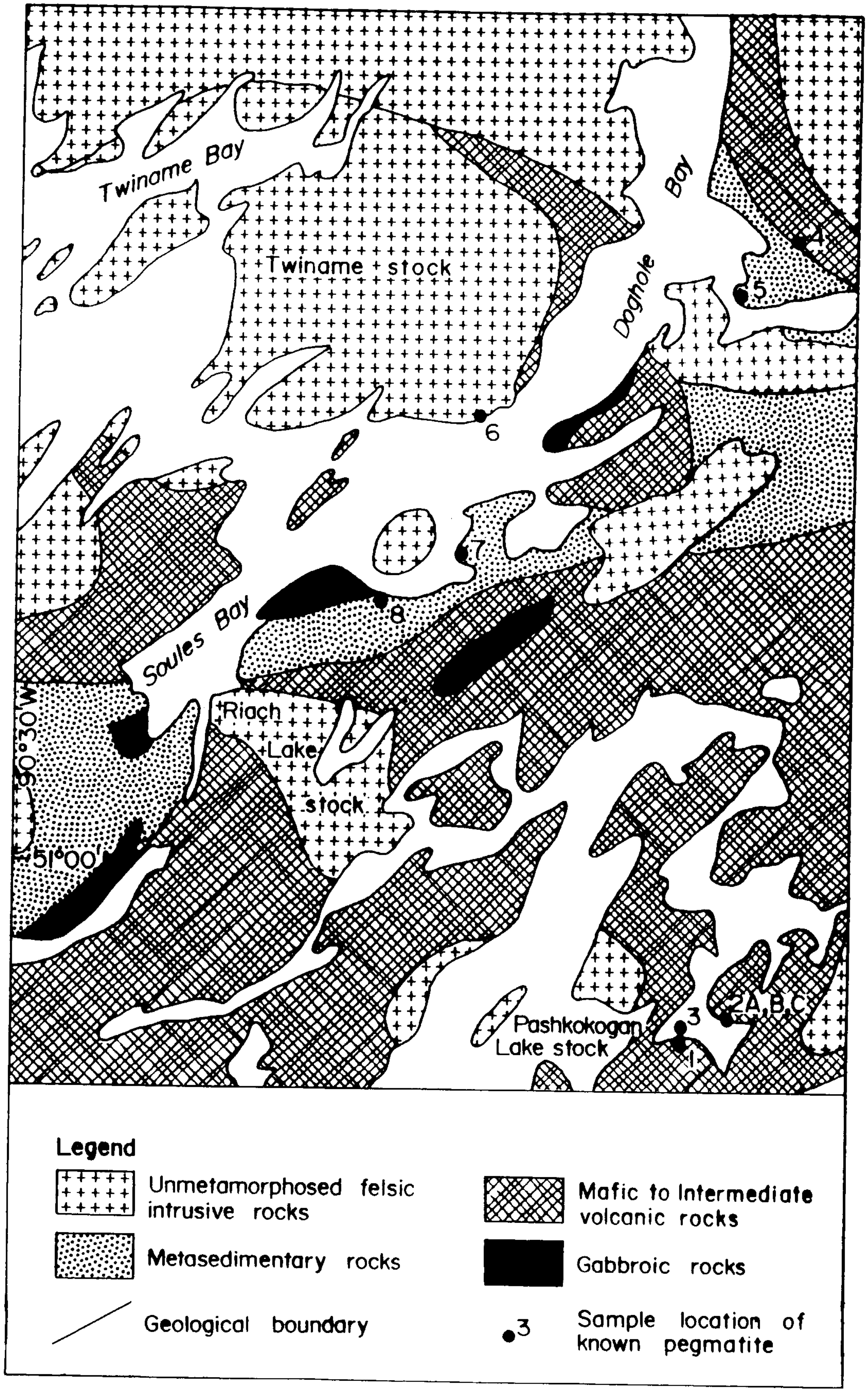

Twiname Bay
Twiname stock
Doghole Bay
Soules Bay
Riach Lake stock
Pashkokogan Lake stock
90°30'W
51°00'
1
2A,B,C
3
4
5
6
7
8
Legend
Unmetamorphosed felsic intrusive rocks
Metasedimentary rocks
Geological boundary
Mafic to Intermediate volcanic rocks
Gabbroic rocks
3 Sample location of known pegmatite

Figure 20

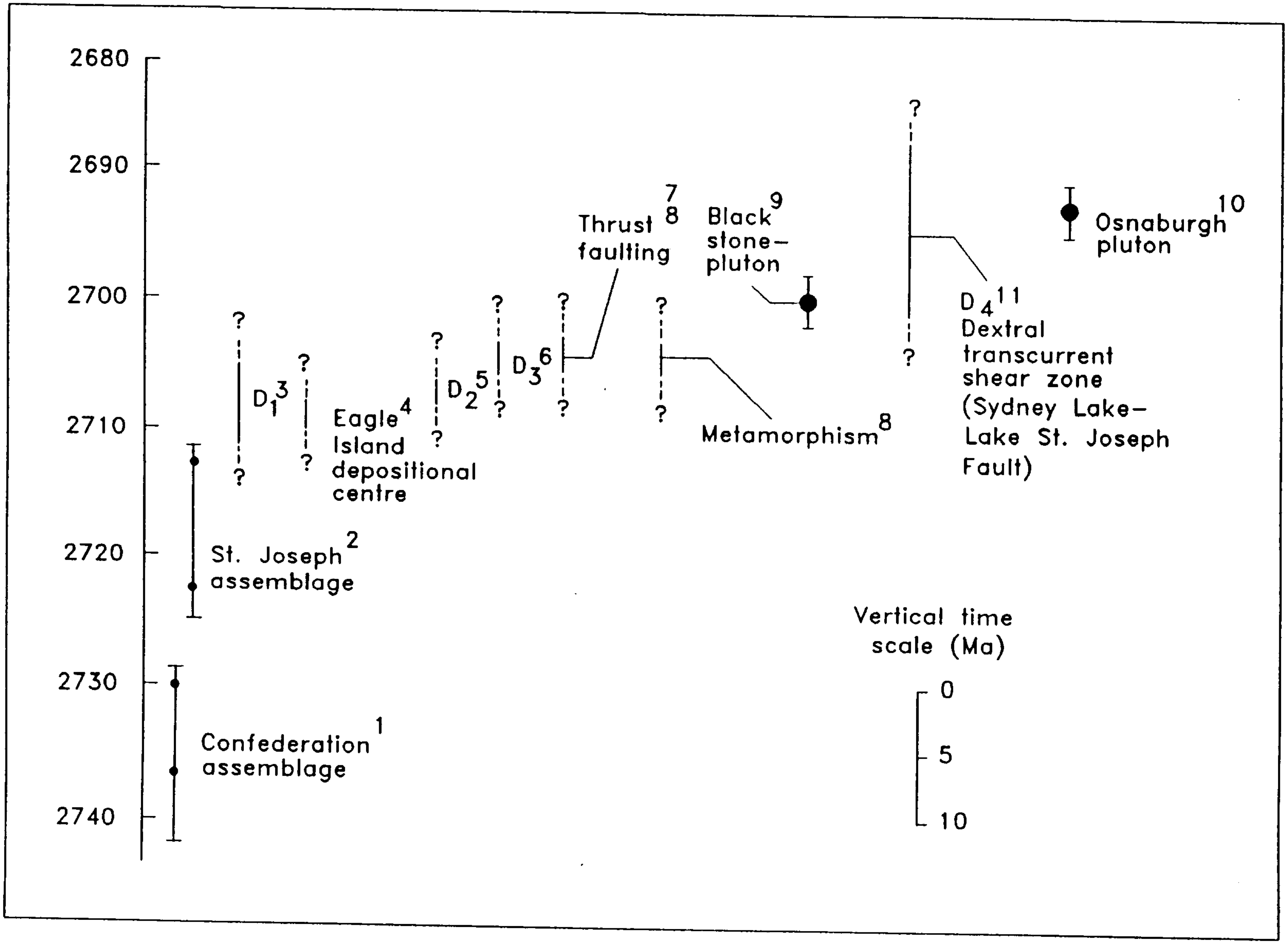

2680
2690
2700
2710
2720
2730
2740
Confederation assemblage 1
St. Joseph assemblage 2
D1 3
Eagle Island depositional centre 4
D2 5
D3 6
Thrust faulting 7 8
Metamorphism 8
Black stone-pluton 9
Osnaburgh pluton 10
D4 11 Dextral transcurrent shear zone (Sydney Lake-Lake St. Joseph Fault)
Vertical time scale (Ma)
0
5
10
?

Figure 21

11 D_4 deformation; transpressive deformation within 1.3 km of subprovince boundary to produce dextral transcurrent shear zone with abundant kinematic indicators; followed by development of brittle, conjugate and asymmetric kink bands (D_3 of Clifford 1969).

10 Intrusion of crescent-shaped Carling pluton and Osnaburgh pluton (2693±1 Ma).

9 Intrusion of granodioritic Blackstone pluton (2702±1 Ma).

8 Metamorphism of Pembina Tonalite Gneiss of unknown duration (2704±2 Ma, titanite).

7 Initial thrust faulting (Sydney Lake-Lake St. Joseph Fault) accompanying or subsequent to D_3 deformation.

6 D_3 deformation (D_2 of Clifford 1969); north-south shortening of Uchi-Sachigo microcontinent forming south-verging upright anticlinal fold.

5 D_2 deformation (D_1 of Clifford 1969); subsidence, slumping and infolding of Eagle Island depositional centre (restricted to depositional basin).

4 Crustal exhumation, erosion and deposition forming Eagle Island depositional centre; unconformably upon the east-facing upper felsic unit of the St. Joseph assemblage; basin accumulated wacke-arenite submarine fan delta and thick banded magnetite beds; basin may be a syntectonic proximal channel fill on margin of English River fore-arc basin.

3 D_1 deformation; tectonic stacking of Confederation and St. Joseph assemblages to form east-facing, steeply dipping sequences in west Lake St. Joseph.

2 St. Joseph assemblage (2724 to 2713 Ma) volcanism; continental margin, island arc; tholeiitic basalt to calc-alkalic andesite-dacite-rhyolite.

1 Confederation assemblage (2737 to 2730 Ma) volcanism; continental margin, island arc, bimodal tholeiitic basalt and rhyolite to dacite.

Figure 21: The general sequence of magmatic and structural events in the Lake St. Joseph greenstone belt

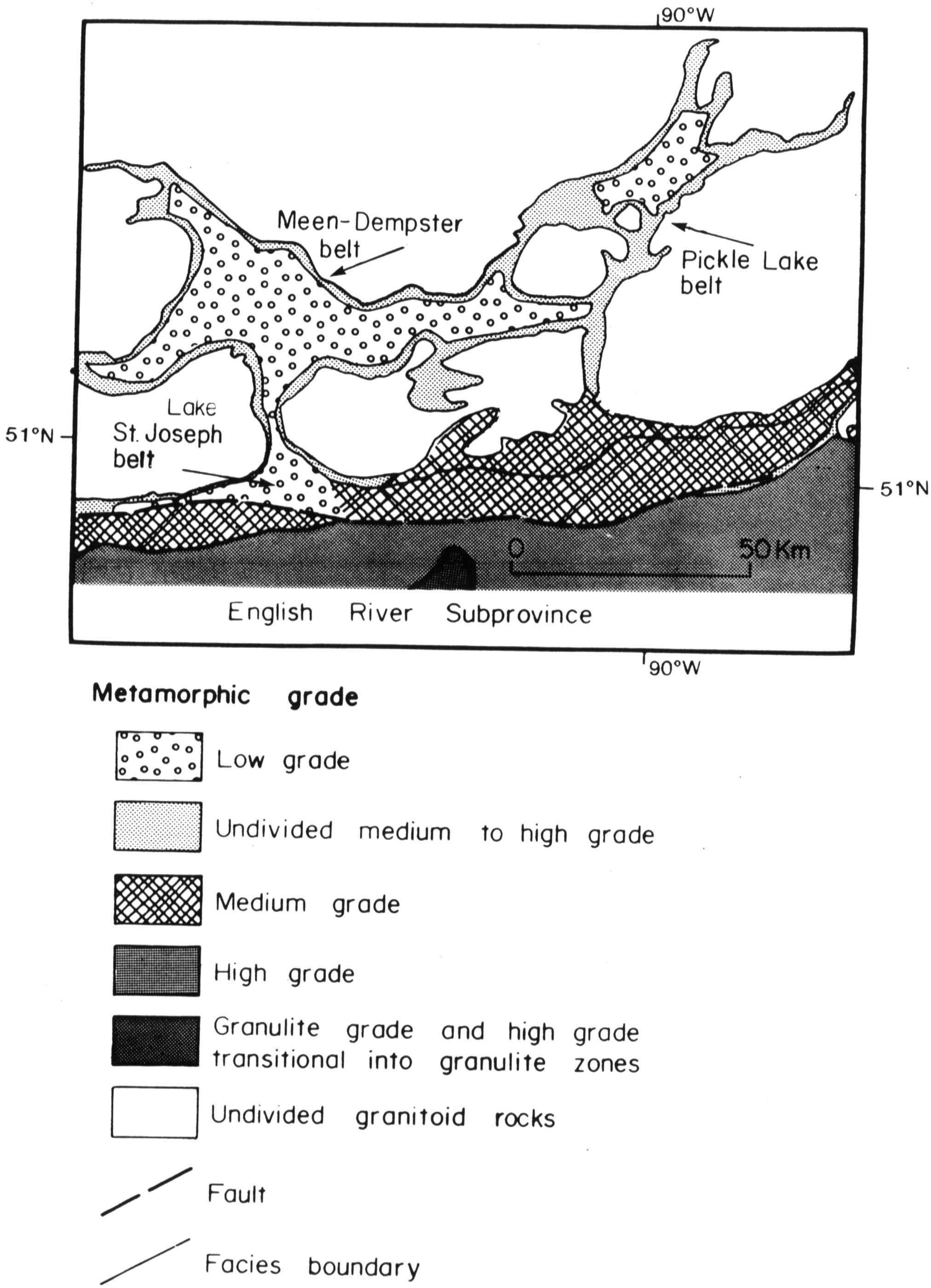

90°W
Meen-Dempster belt
Pickle Lake belt
Lake St. Joseph belt
51°N
51°N
0
50Km
English River Subprovince
90°W
Metamorphic grade
Low grade
Undivided medium to high grade
Medium grade
High grade
Granulite grade and high grade transitional into granulite zones
Undivided granitoid rocks
Fault
Facies boundary

Figure 22

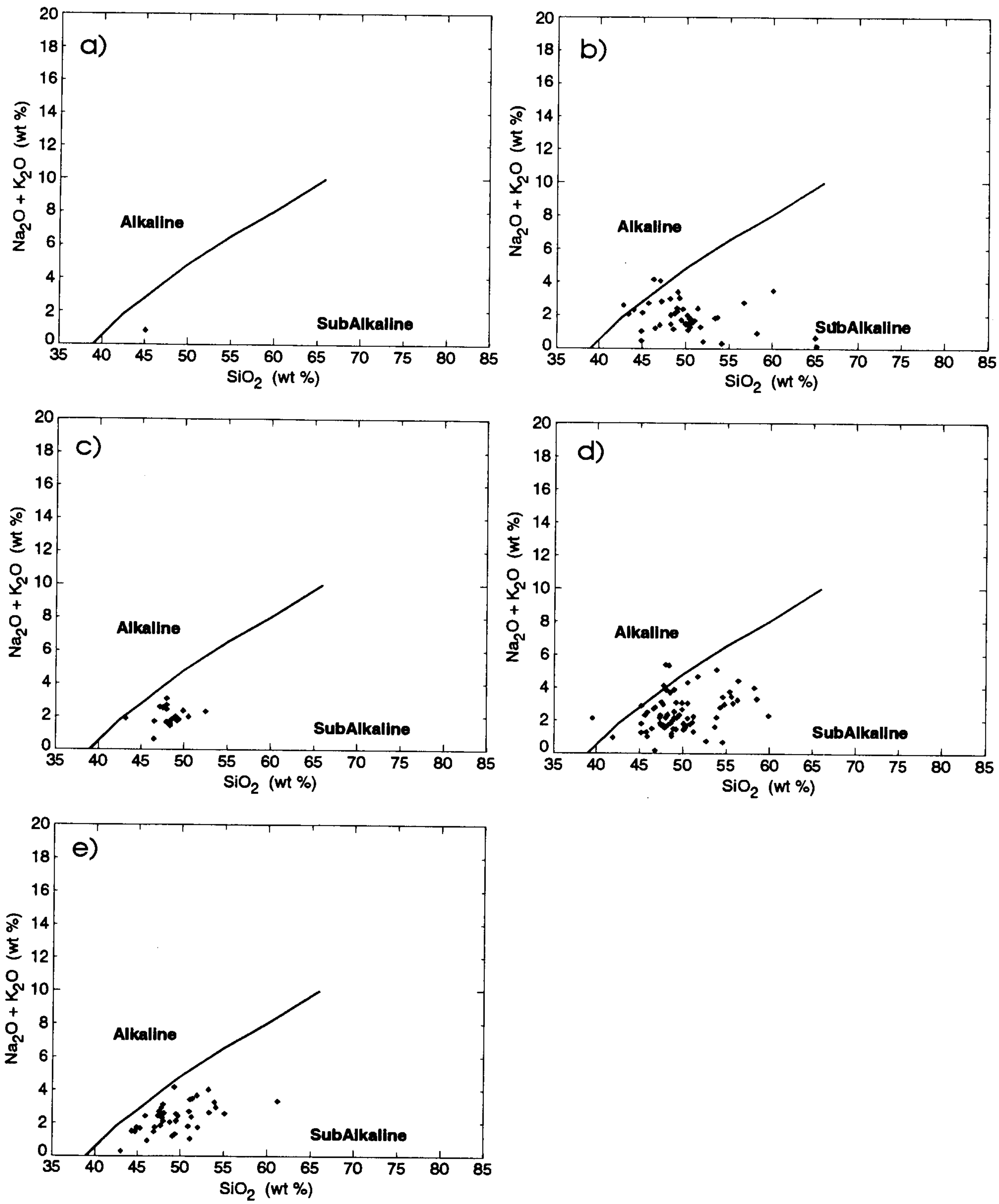


Figure 23, la to e

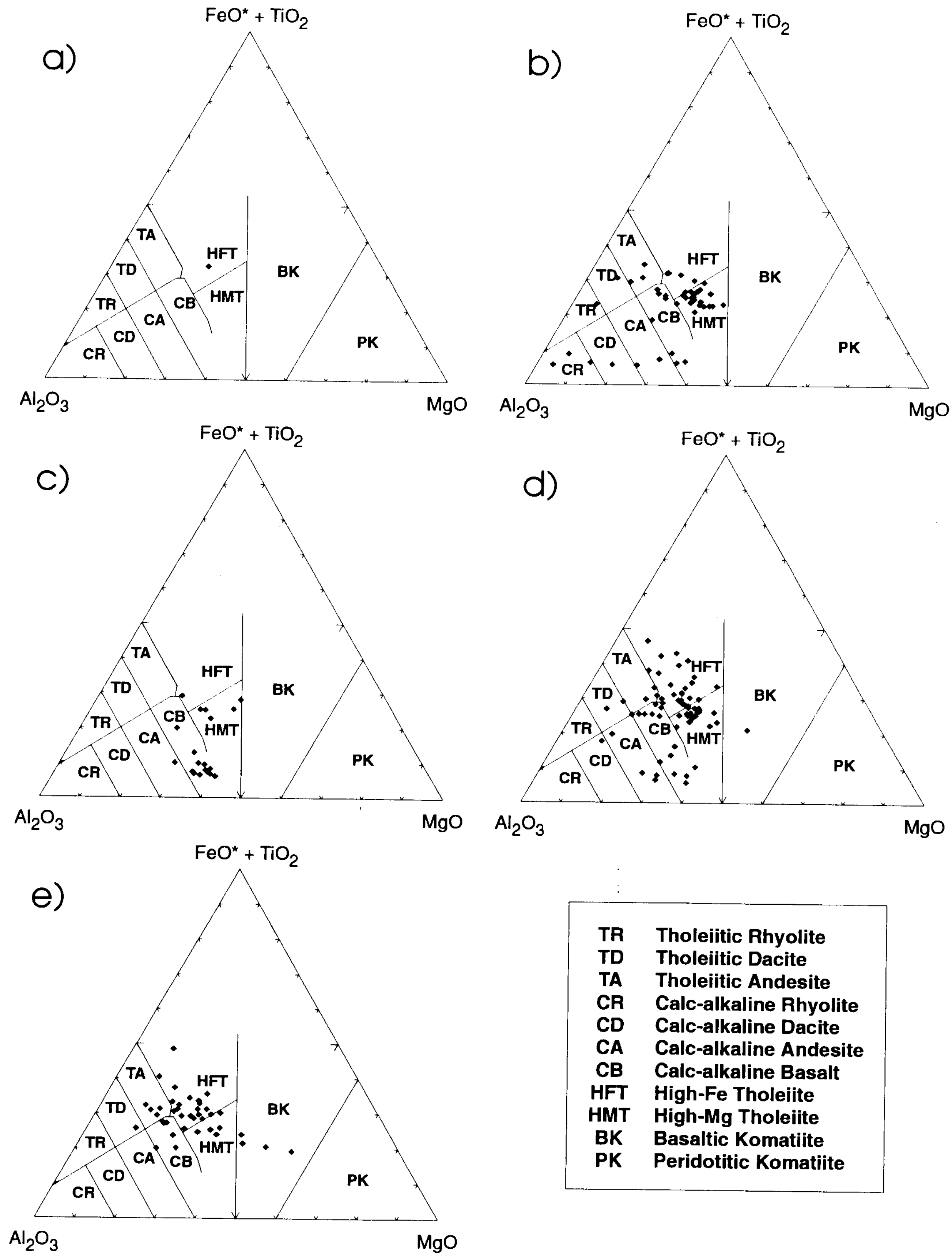


Figure 23, 2a to e

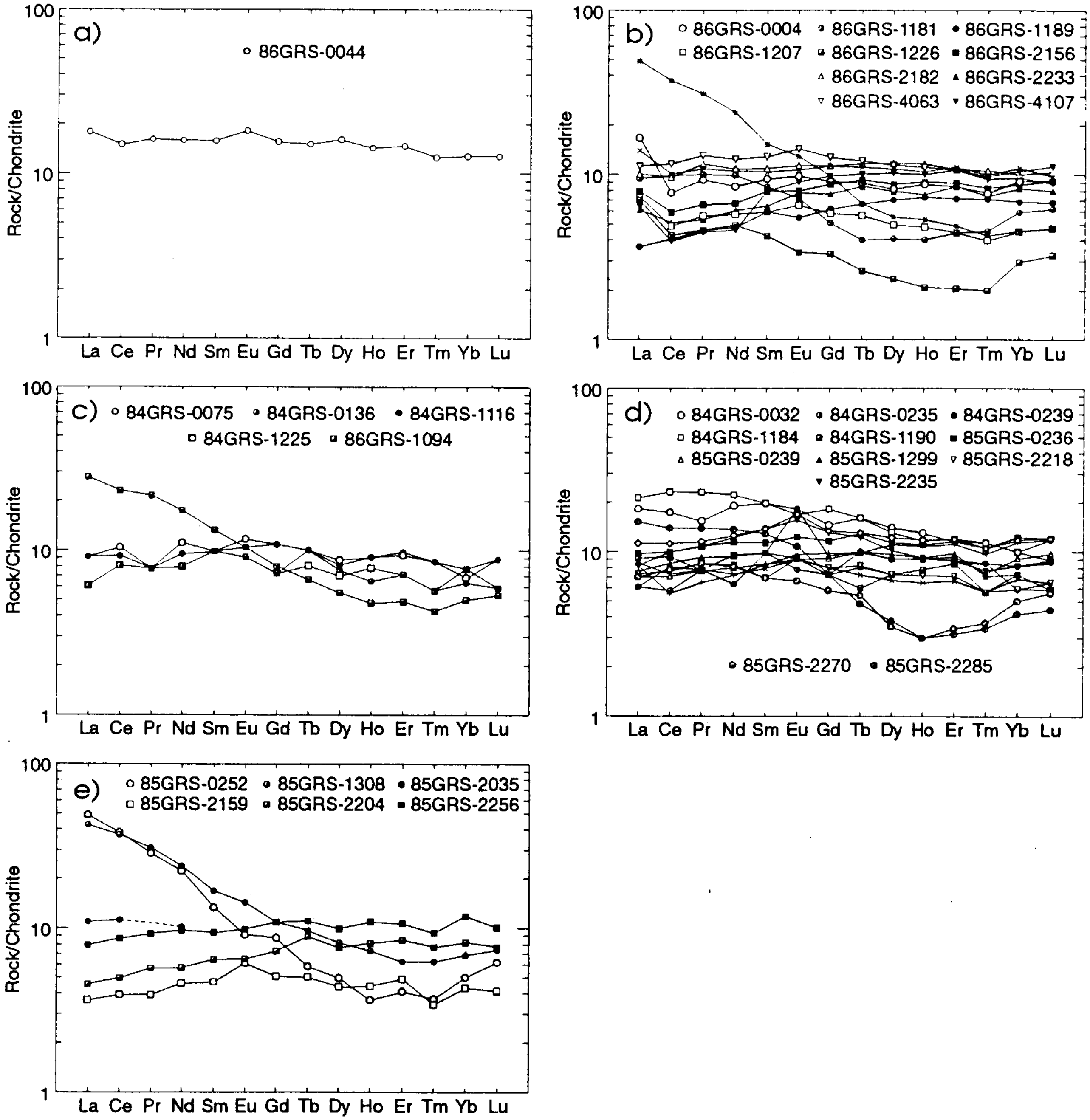


Figure 23, 3a to e

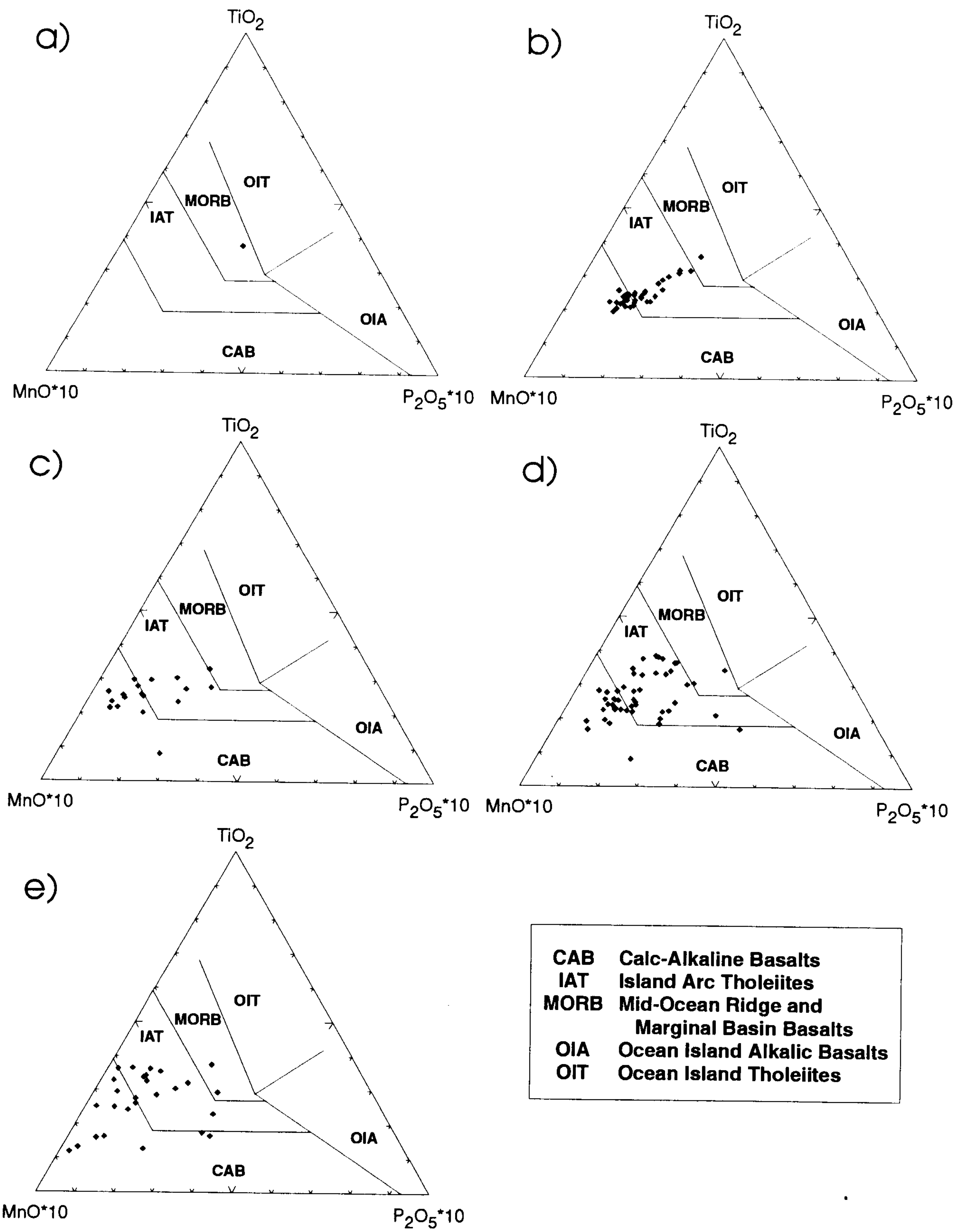


Figure 23, 4a to e

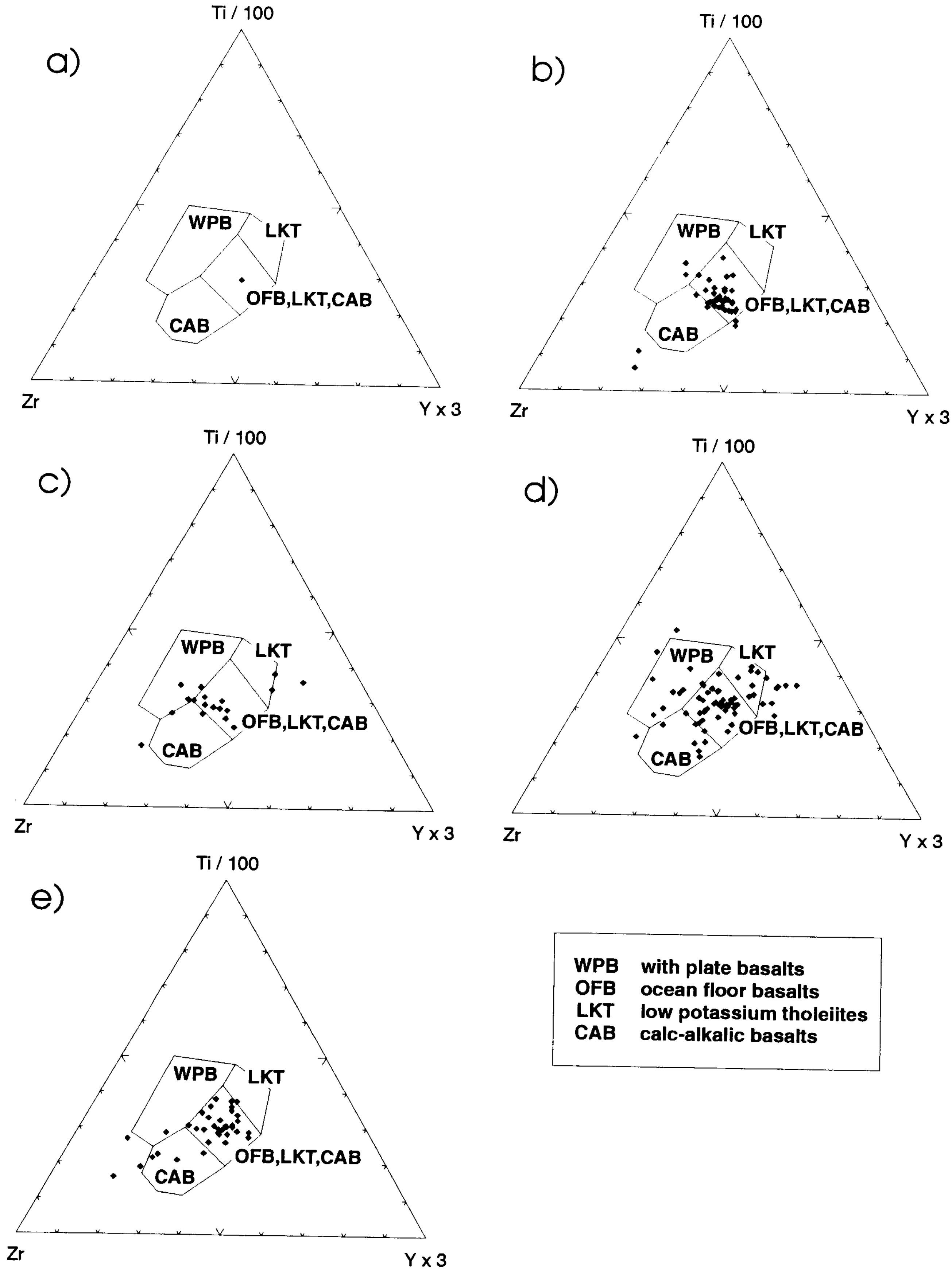


Figure 23, 5a to e

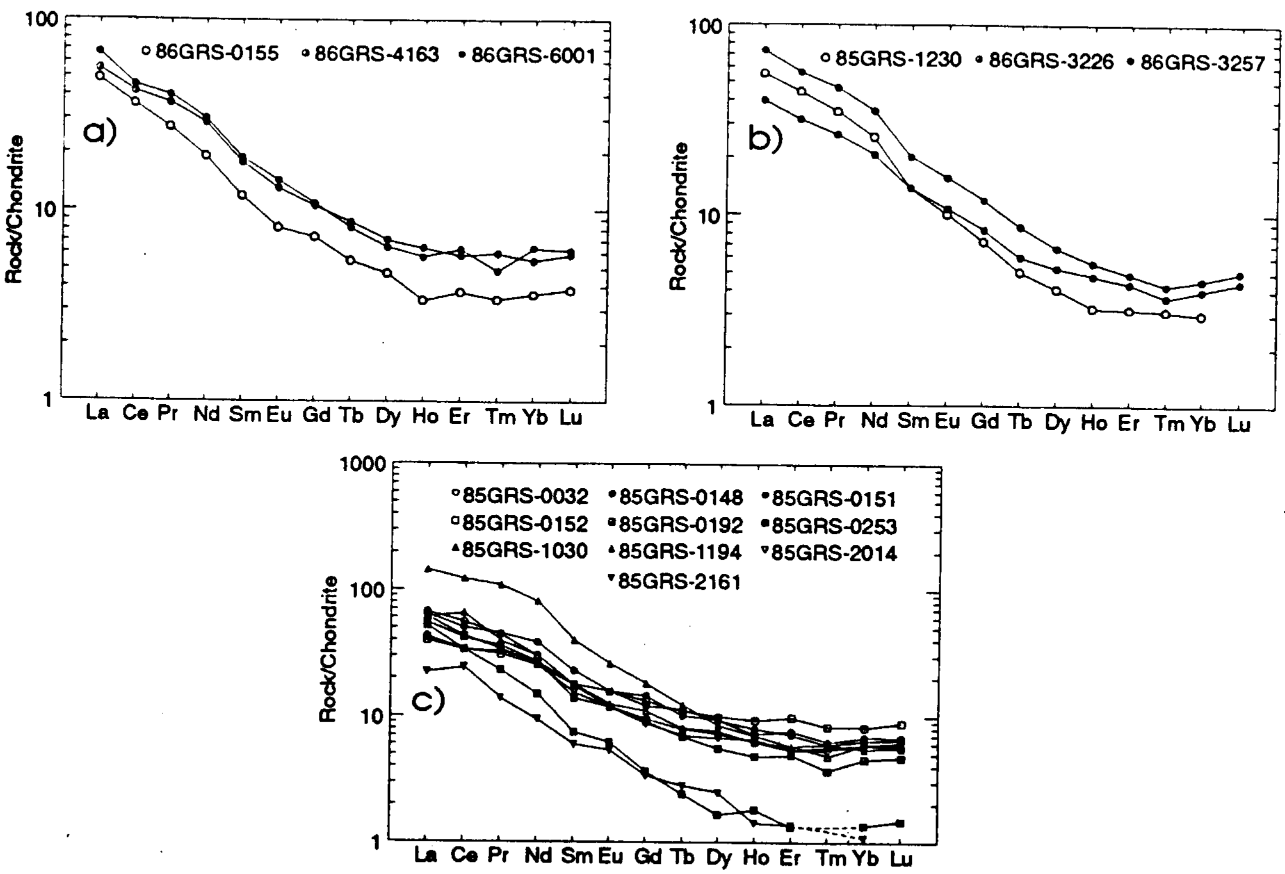
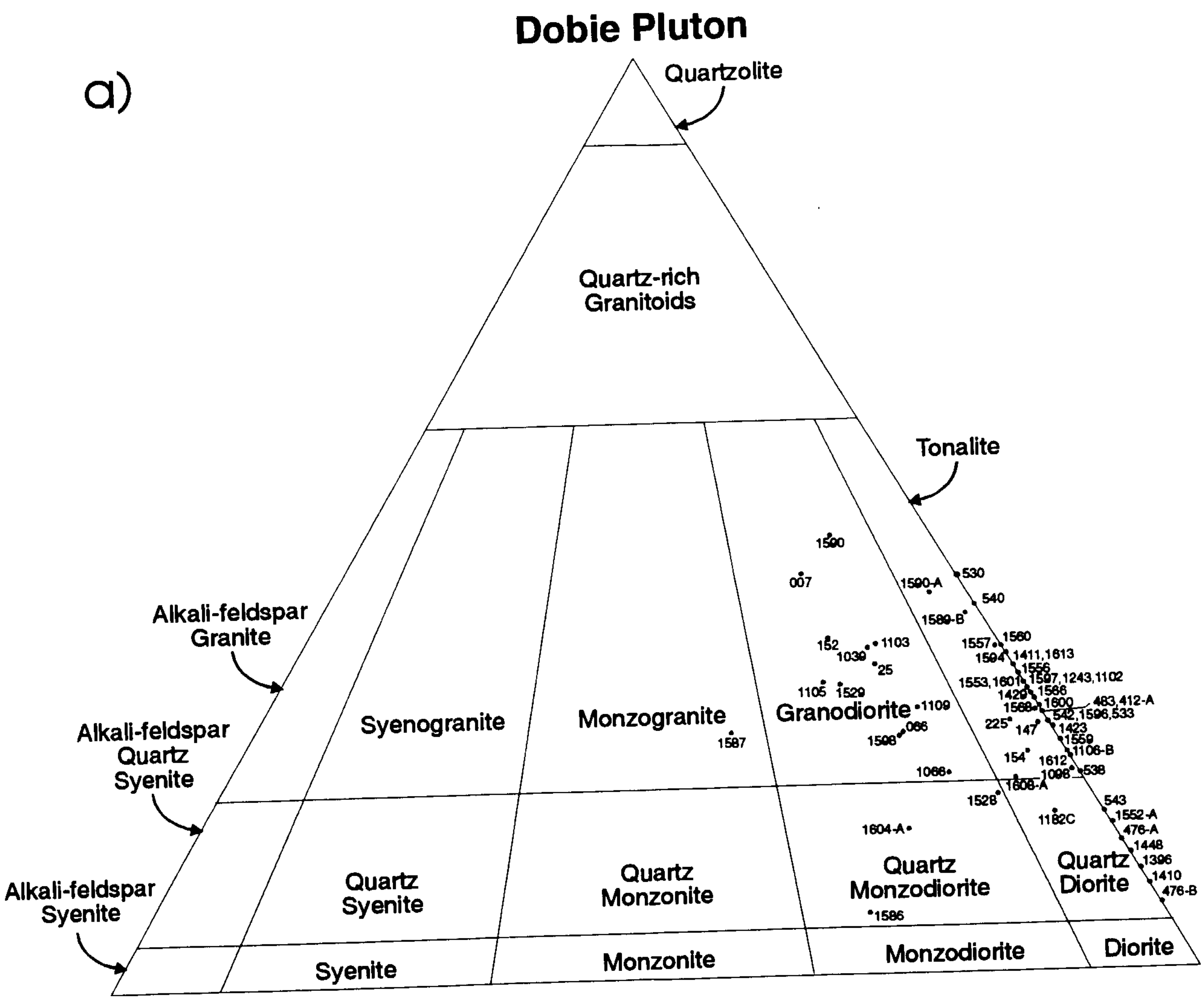
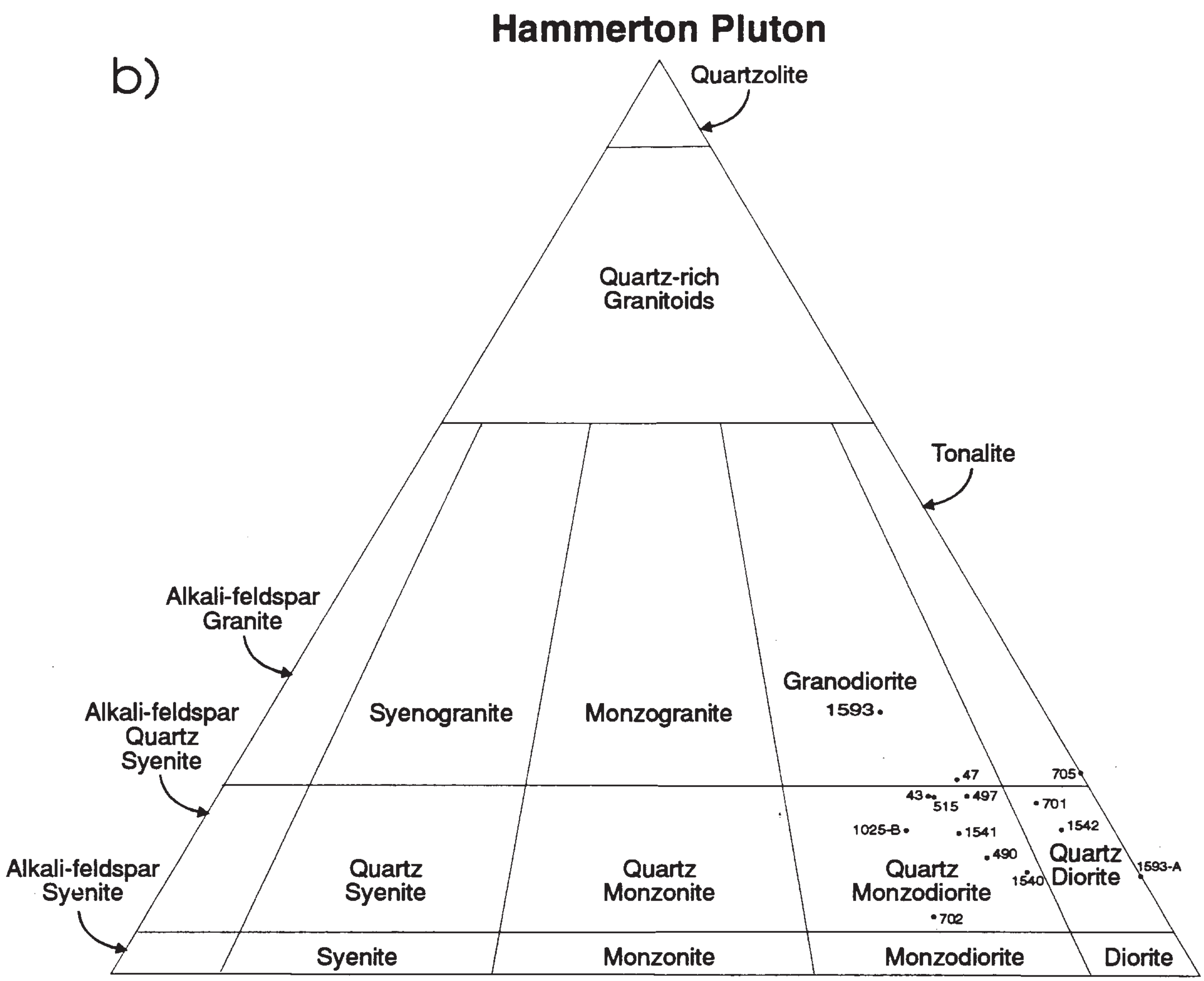


Figure 23, 6a to c



Dobie Pluton
a)
Quartzolite
Quartz-rich
Granitoids
Tonalite
Alkali-feldspar
Granite
Alkali-feldspar
Quartz
Syenite
Alkali-feldspar
Syenite
Syenogranite
Monzogranite
Granodiorite
Quartz
Syenite
Quartz
Monzonite
Quartz
Monzodiorite
Quartz
Diorite
Syenite
Monzonite
Monzodiorite
Diorite

Figure 23, 7a



Hammerton Pluton
b)
Quartzolite
Quartz-rich
Granitoids
Tonalite
Alkali-feldspar
Granite
Alkali-feldspar
Quartz
Syenite
Syenogranite
Monzogranite
Granodiorite
1593
47
705
43
515
497
701
1025-B
1541
1542
490
Quartz
Diorite
1593-A
Alkali-feldspar
Syenite
Quartz
Syenite
Quartz
Monzonite
Quartz
Monzodiorite
1540
702
Syenite
Monzonite
Monzodiorite
Diorite

Figure 23, 7b

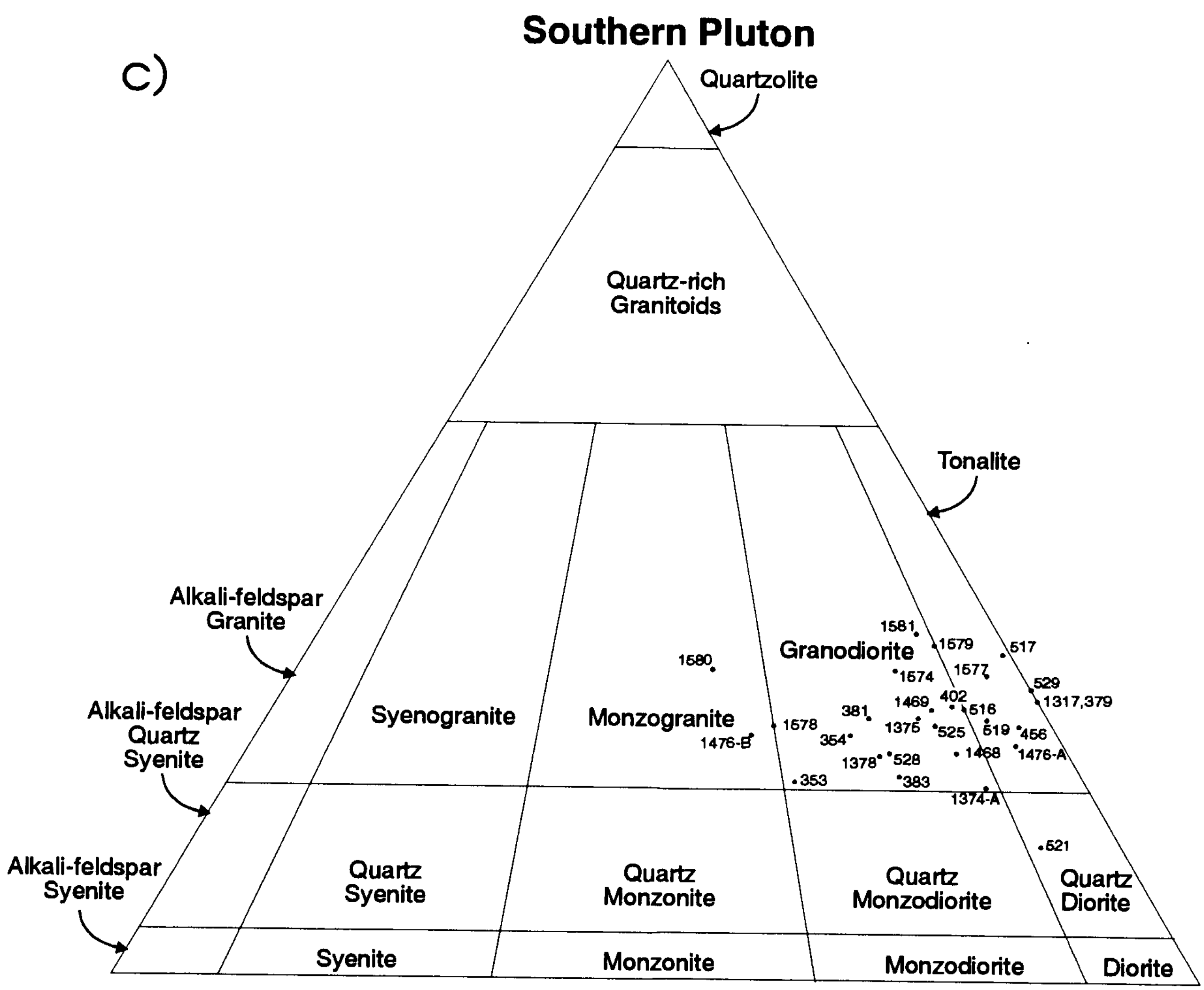

c)
Southern Pluton
Quartzolite
Quartz-rich
Granitoids
Tonalite
Alkali-feldspar
Granite
Alkali-feldspar
Quartz
Syenite
Alkali-feldspar
Syenite
Syenogranite
Monzogranite
Granodiorite
Quartz
Syenite
Quartz
Monzonite
Quartz
Monzodiorite
Quartz
Diorite
Syenite
Monzonite
Monzodiorite
Diorite
1580
1476-B
1578
1581
1579
517
1574
1577
529
1317,379
381
1469
402
516
1375
525
519
456
354
1378
528
1468
1476-A
353
383
1374-A
521

Figure 23, 7c

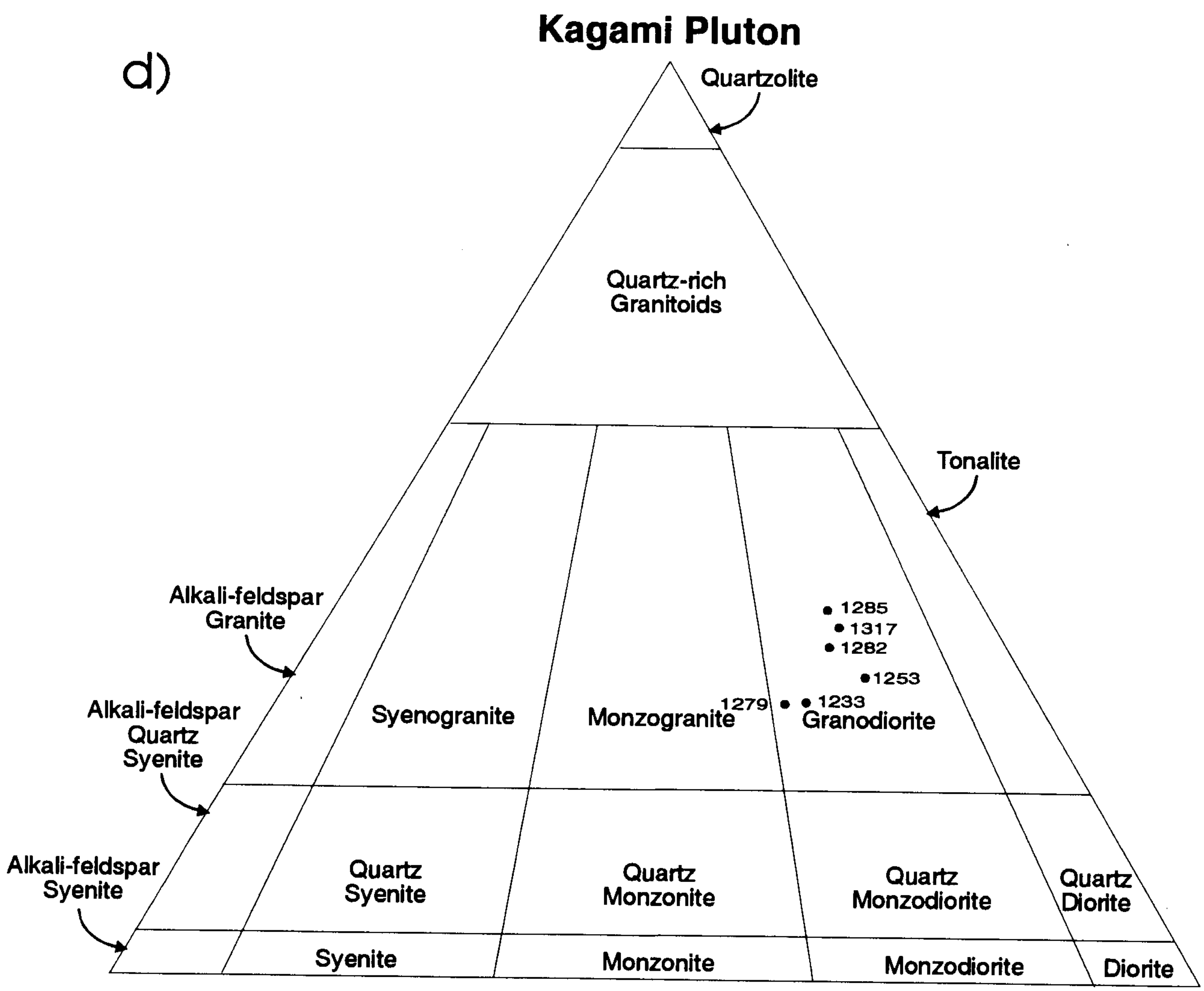
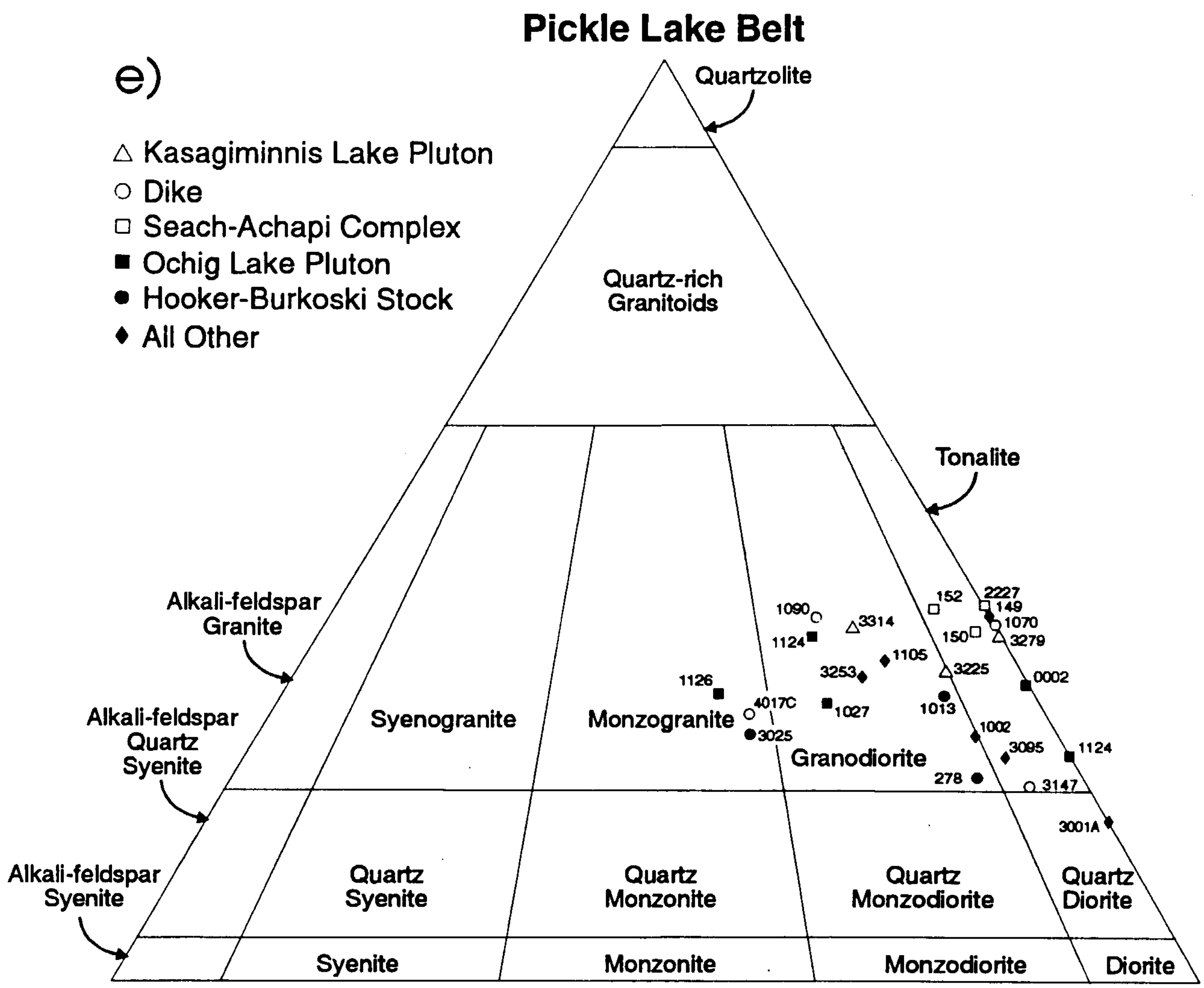

Kagami Pluton
d)
Quartzolite
Quartz-rich
Granitoids
Tonalite
Alkali-feldspar
Granite
Alkali-feldspar
Quartz
Syenite
Alkali-feldspar
Syenite
Syenogranite
Monzogranite
Granodiorite
1285
1317
1282
1253
1279
1233
Quartz
Syenite
Quartz
Monzonite
Quartz
Monzodiorite
Quartz
Diorite
Syenite
Monzonite
Monzodiorite
Diorite

Figure 23, 7d



Pickle Lake Belt
e)
Kasagiminnis Lake Pluton
Dike
Seach-Achapi Complex
Ochig Lake Pluton
Hooker-Burkoski Stock
All Other
Quartzolite
Quartz-rich Granitoids
Tonalite
Alkali-feldspar Granite
Alkali-feldspar Quartz Syenite
Alkali-feldspar Syenite
Syenogranite
Monzogranite
Granodiorite
Quartz Syenite
Quartz Monzonite
Quartz Monzodiorite
Quartz Diorite
Syenite
Monzonite
Monzodiorite
Diorite

Figure 23, 7e

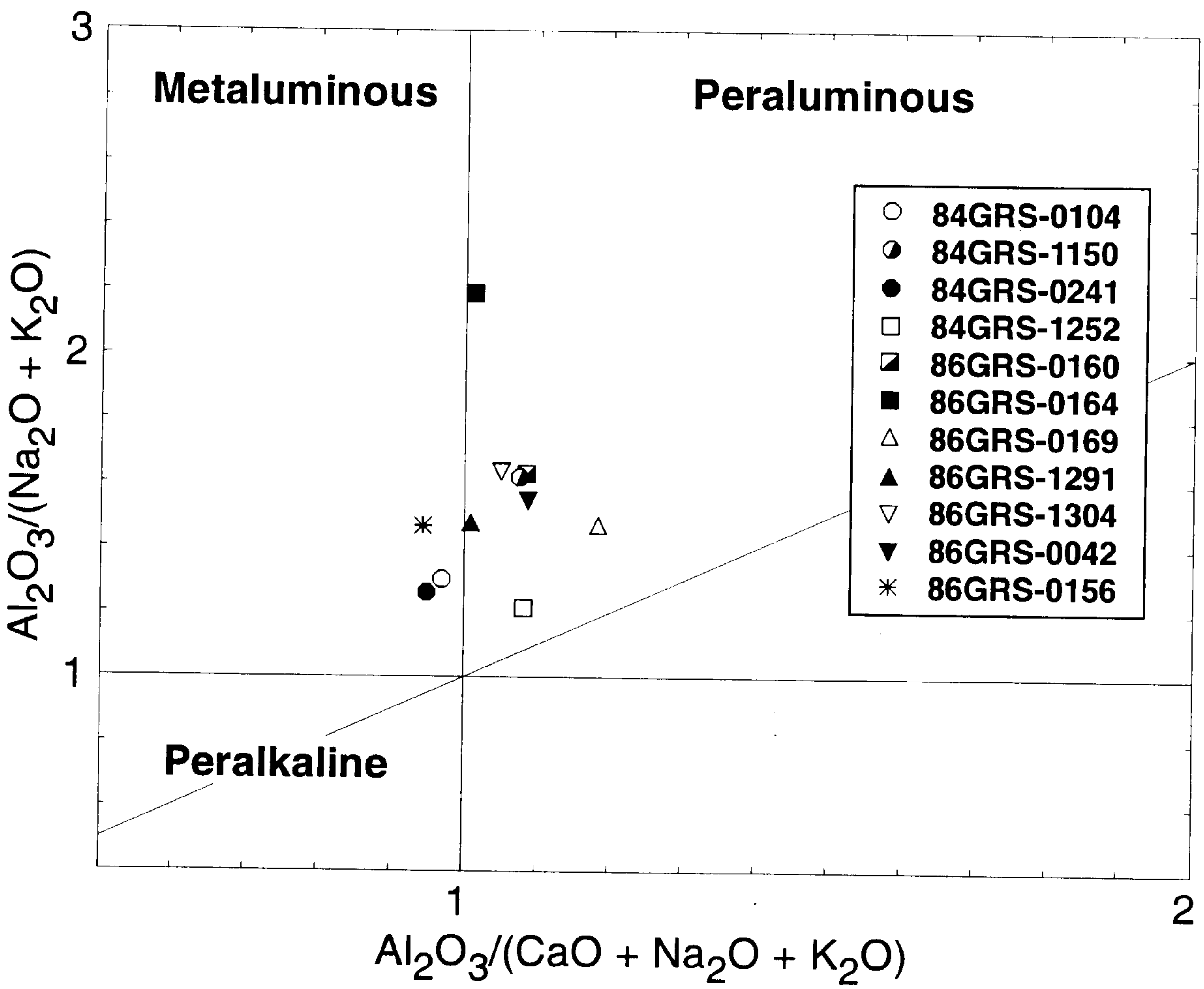

Metaluminous
Peraluminous
Peralkaline
84GRS-0104
84GRS-1150
84GRS-0241
84GRS-1252
86GRS-0160
86GRS-0164
86GRS-0169
86GRS-1291
86GRS-1304
86GRS-0042
86GRS-0156
3
2
1
1
2
$Al_2O_3/(Na_2O + K_2O)$
$Al_2O_3/(CaO + Na_2O + K_2O)$

Figure 23,8

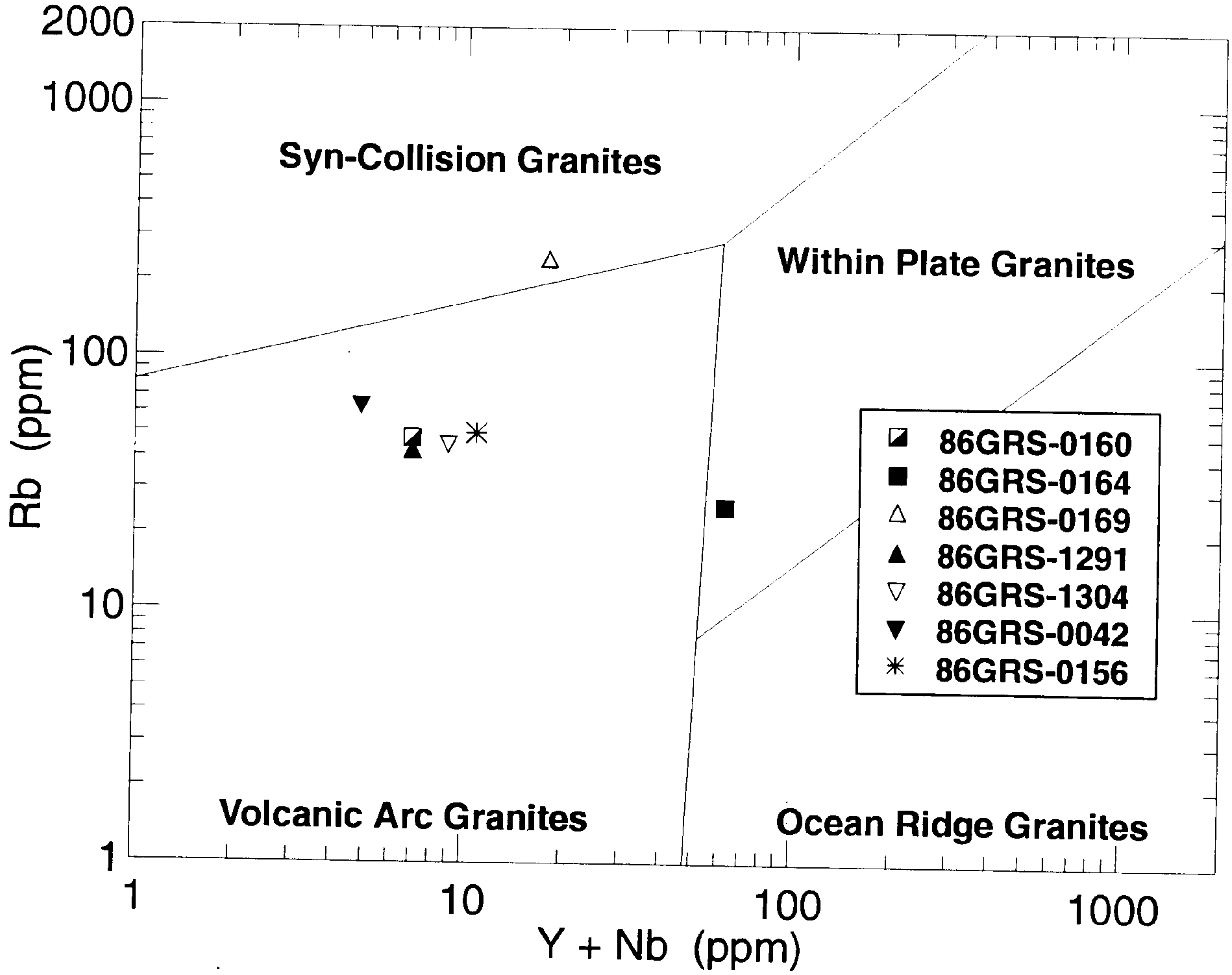

2000
1000
100
10
1
1
10
100
1000
Rb (ppm)
Y + Nb (ppm)
Syn-Collision Granites
Within Plate Granites
Volcanic Arc Granites
Ocean Ridge Granites
86GRS-0160
86GRS-0164
86GRS-0169
86GRS-1291
86GRS-1304
86GRS-0042
86GRS-0156

Figure 23, 9

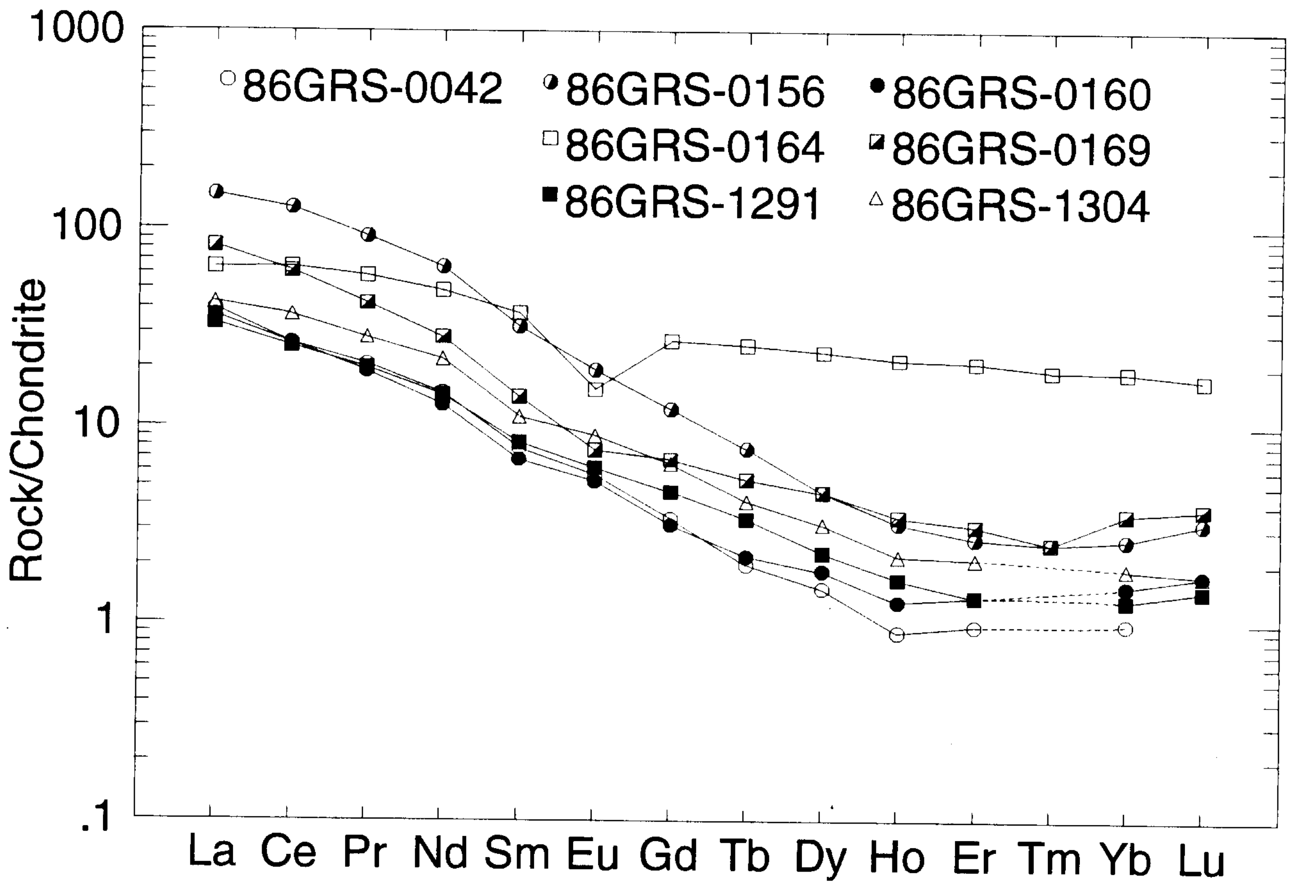

86GRS-0042
86GRS-0156
86GRS-0160
86GRS-0164
86GRS-0169
86GRS-1291
86GRS-1304
Rock/Chondrite
1000
100
10
1
.1
La
Ce
Pr
Nd
Sm
Eu
Gd
Tb
Dy
Ho
Er
Tm
Yb
Lu

Figure 23, 10

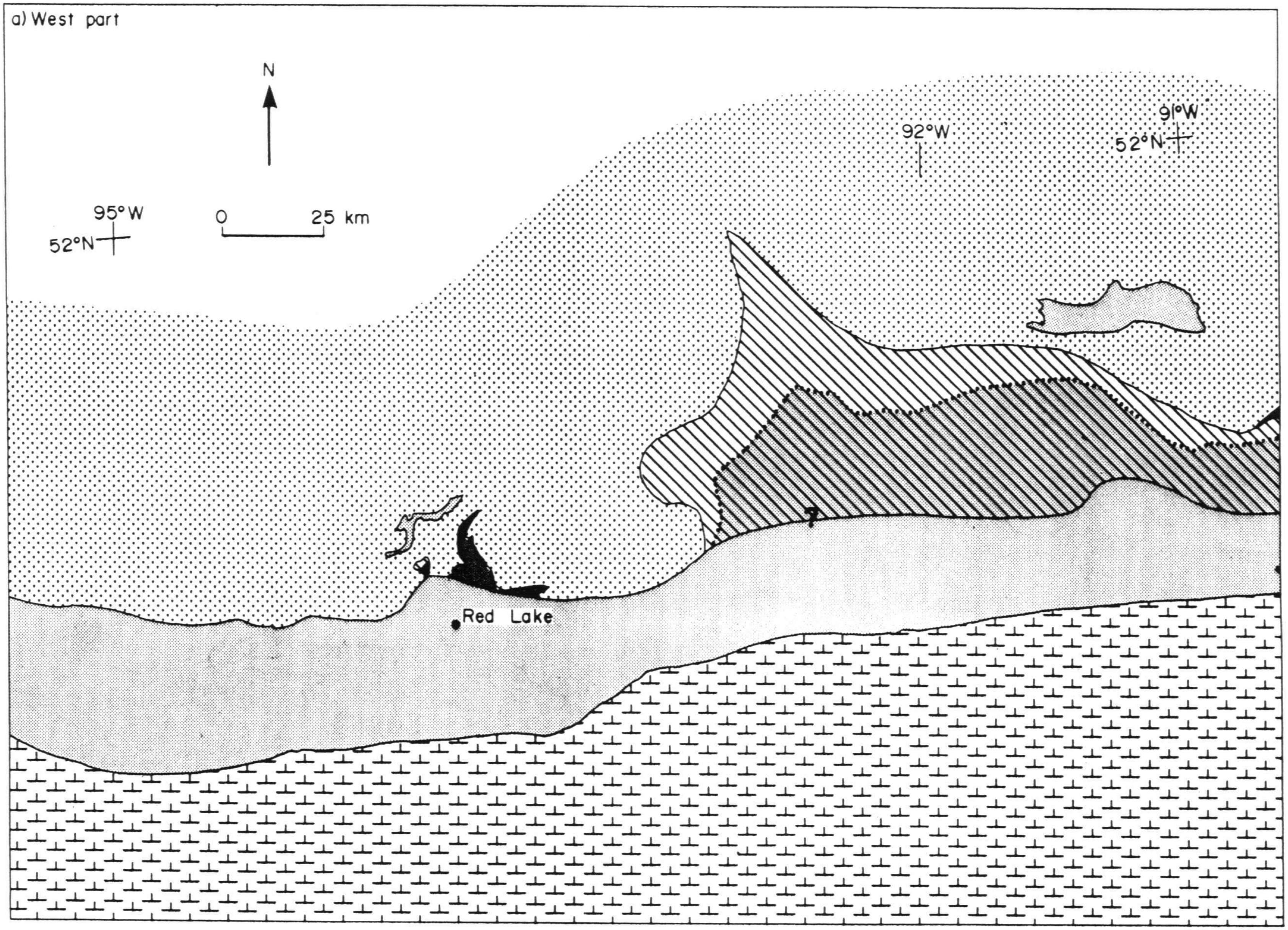


Figure 24a

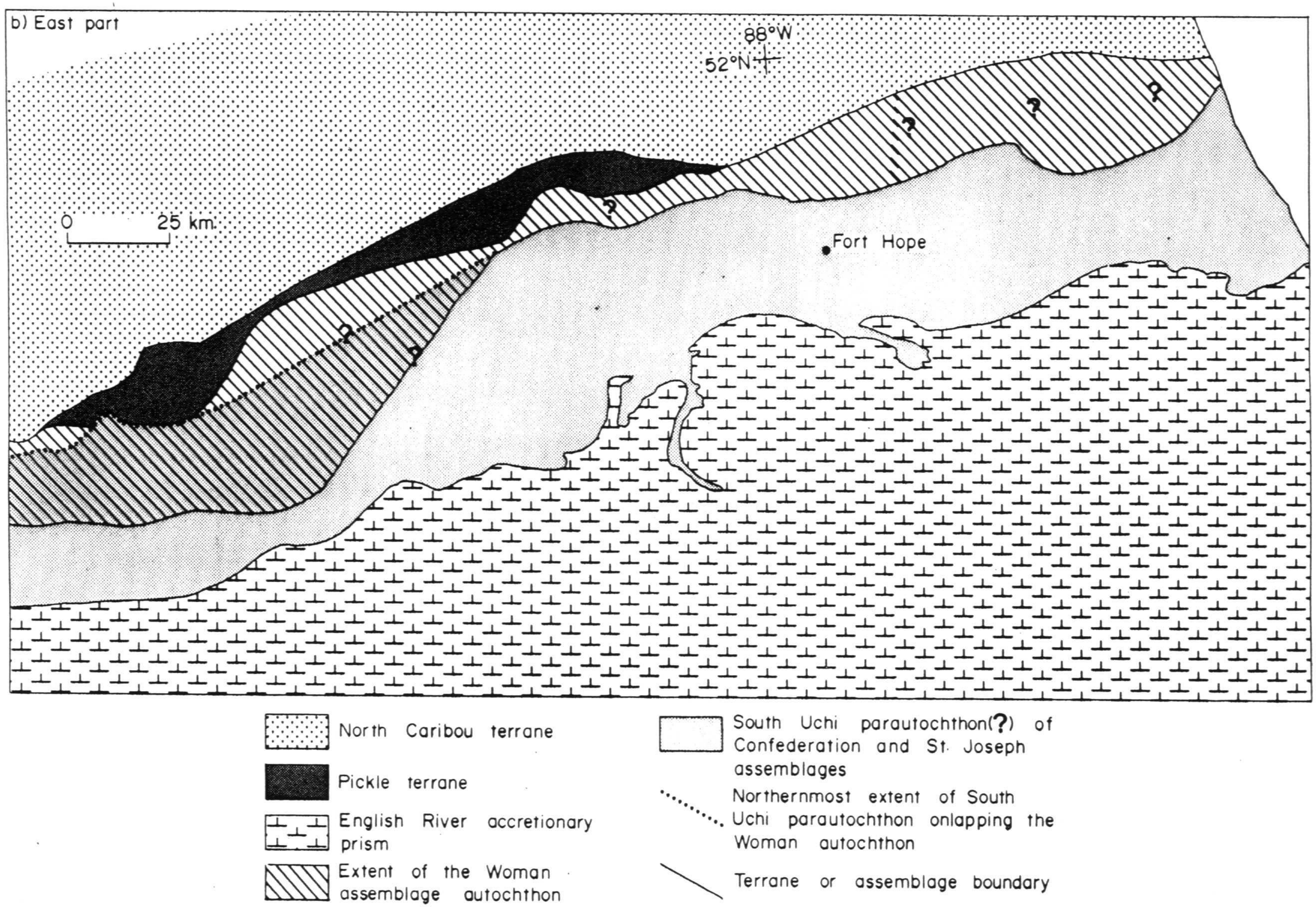

b) East part
88°W
52°N
0
25 km
Fort Hope
?
North Caribou terrane
Pickle terrane
English River accretionary prism
Extent of the Woman assemblage autochthon
South Uchi parautochthon(?) of Confederation and St. Joseph assemblages
Northernmost extent of South Uchi parautochthon onlapping the Woman autochthon
Terrane or assemblage boundary

Figure 24b

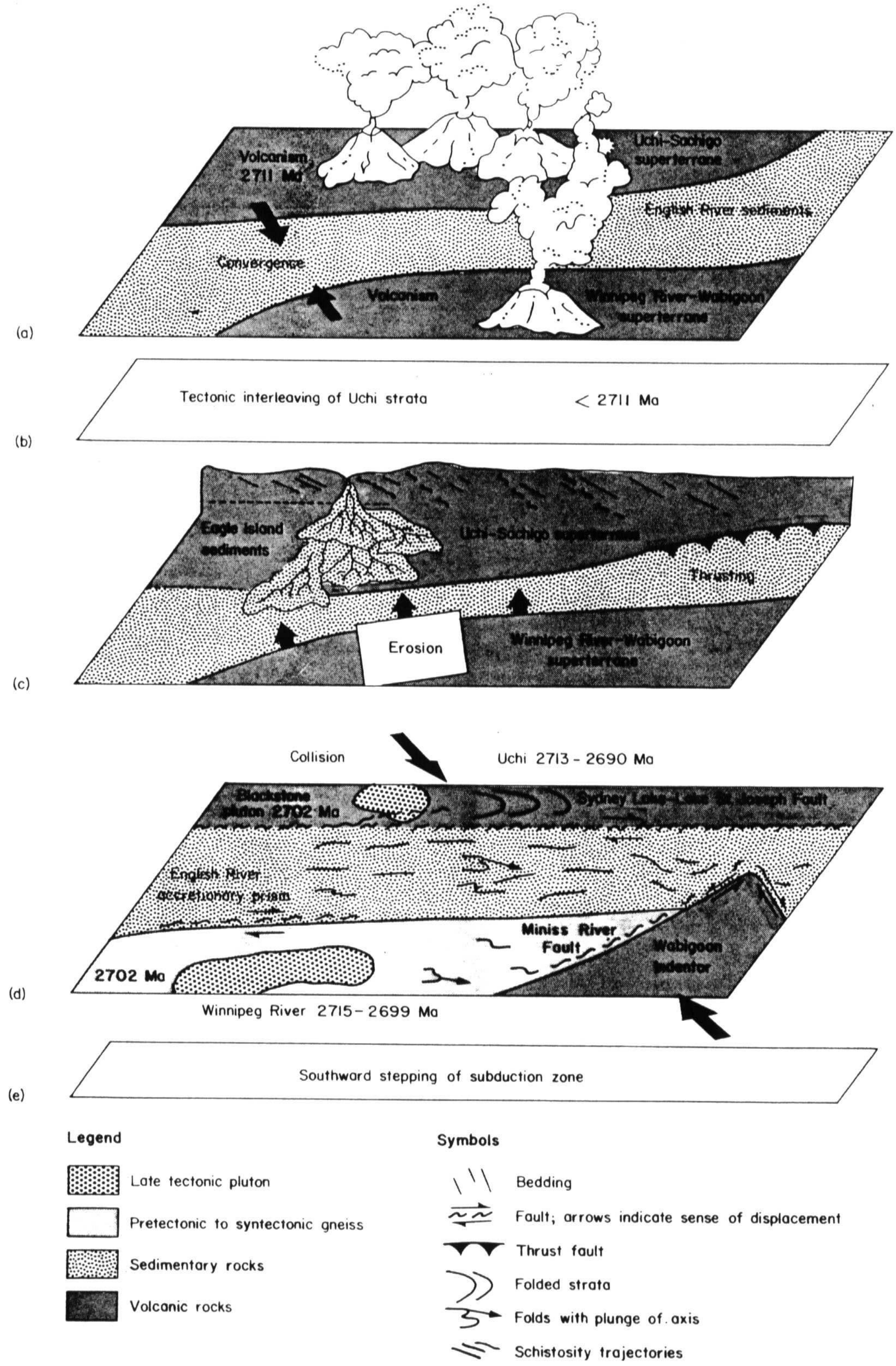


Figure 25a to e

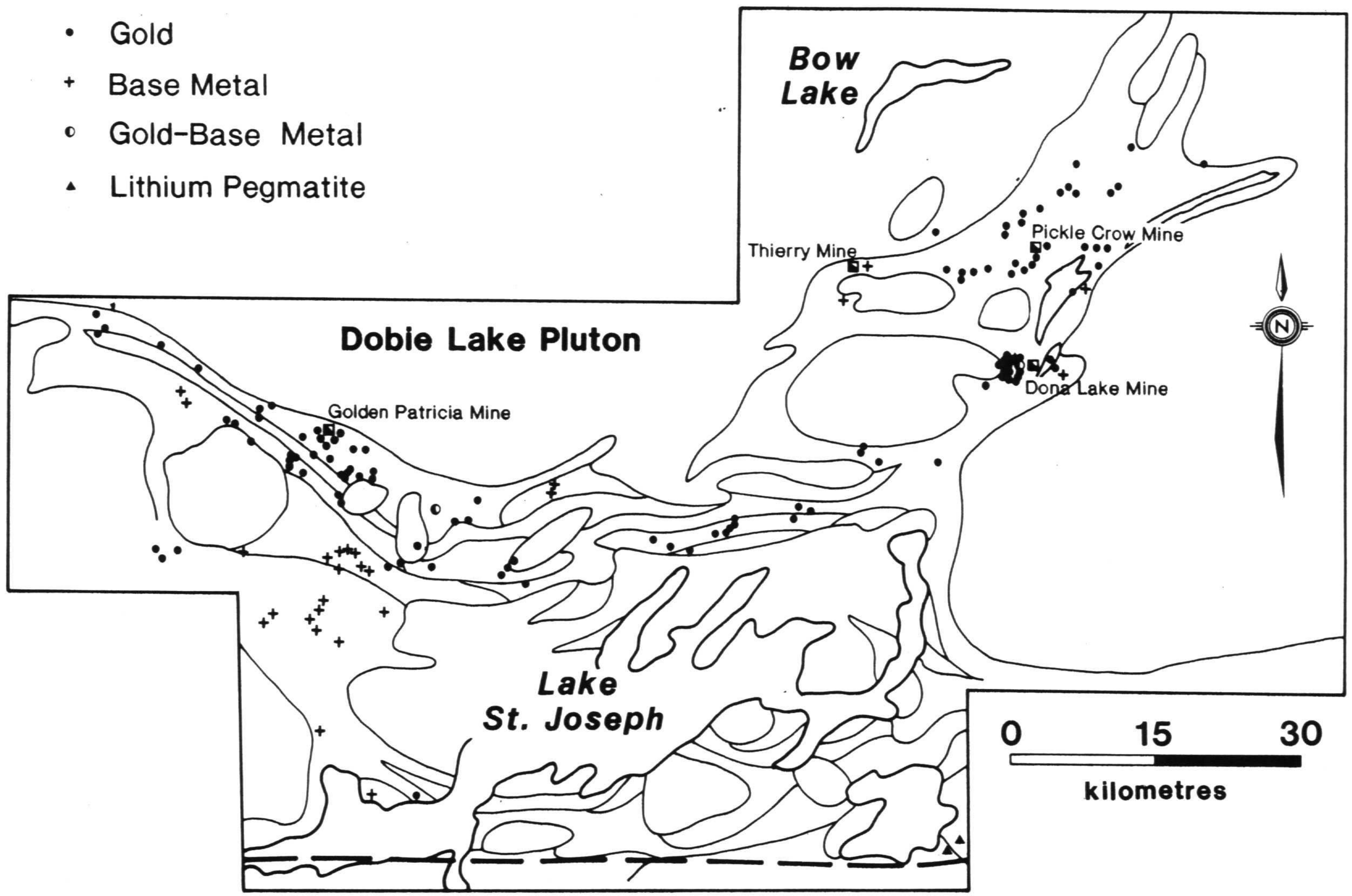

Gold
Base Metal
Gold-Base Metal
Lithium Pegmatite
Bow Lake
Thierry Mine
Pickle Crow Mine
Dobie Lake Pluton
Golden Patricia Mine
Dona Lake Mine
Lake St. Joseph
0
15
30
kilometres
N

Figure 26

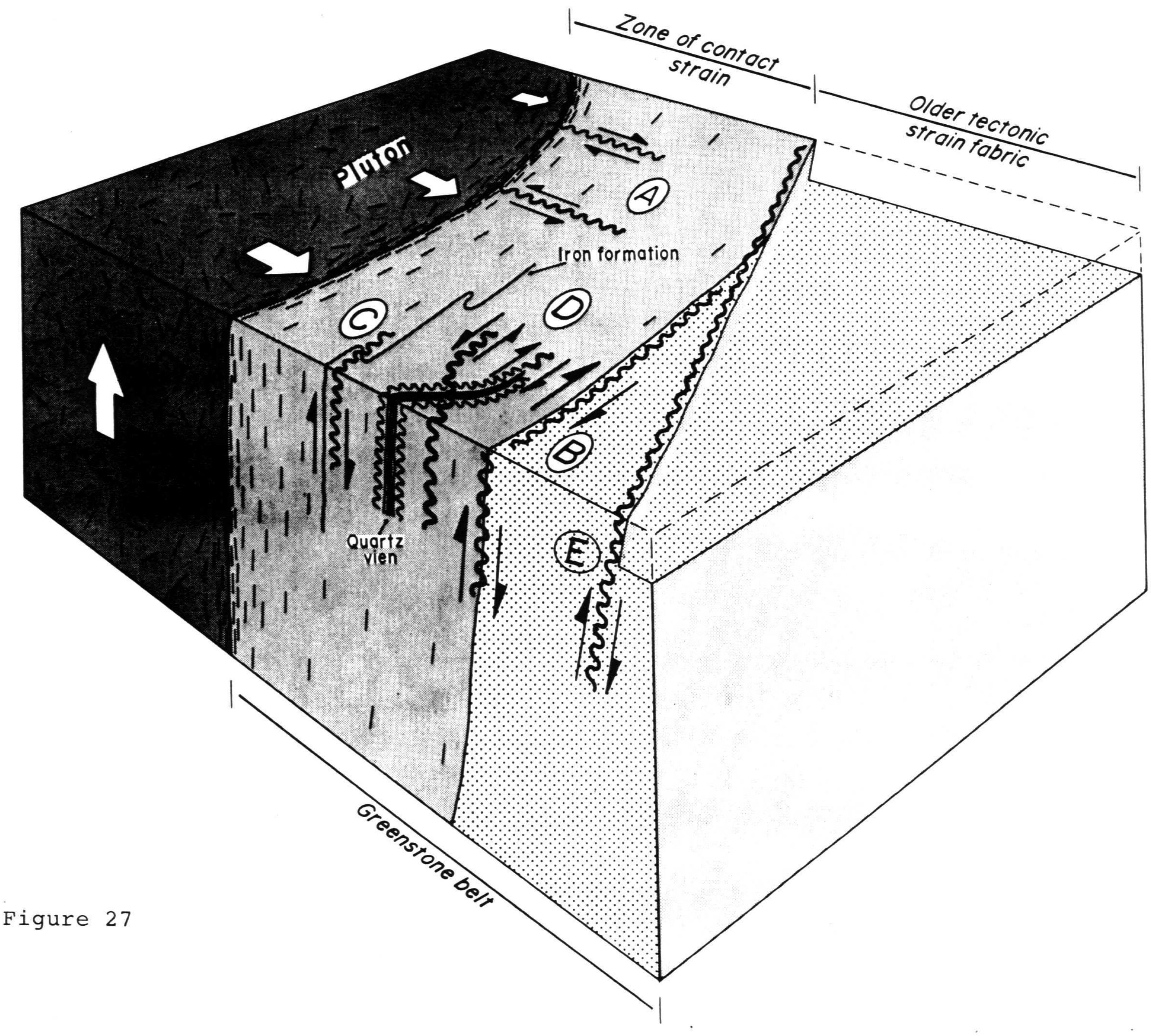

Zone of contact strain
Older tectonic strain fabric
Pluton
A
Iron formation
C
D
B
Quartz vien
E
Greenstone belt

Figure 27

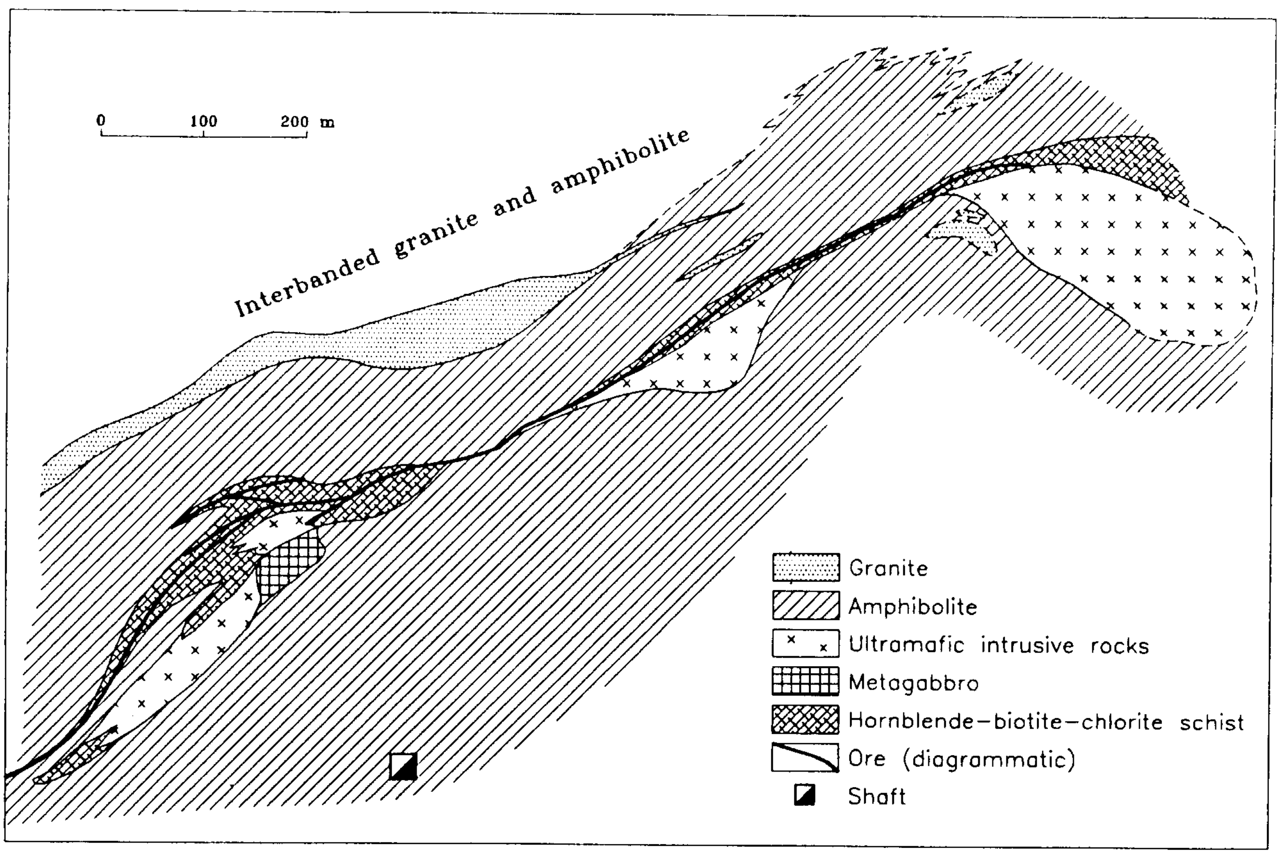

0
100
200 m
Interbanded granite and amphibolite
Granite
Amphibolite
Ultramafic intrusive rocks
Metagabbro
Hornblende–biotite–chlorite schist
Ore (diagrammatic)
Shaft

Figure 28

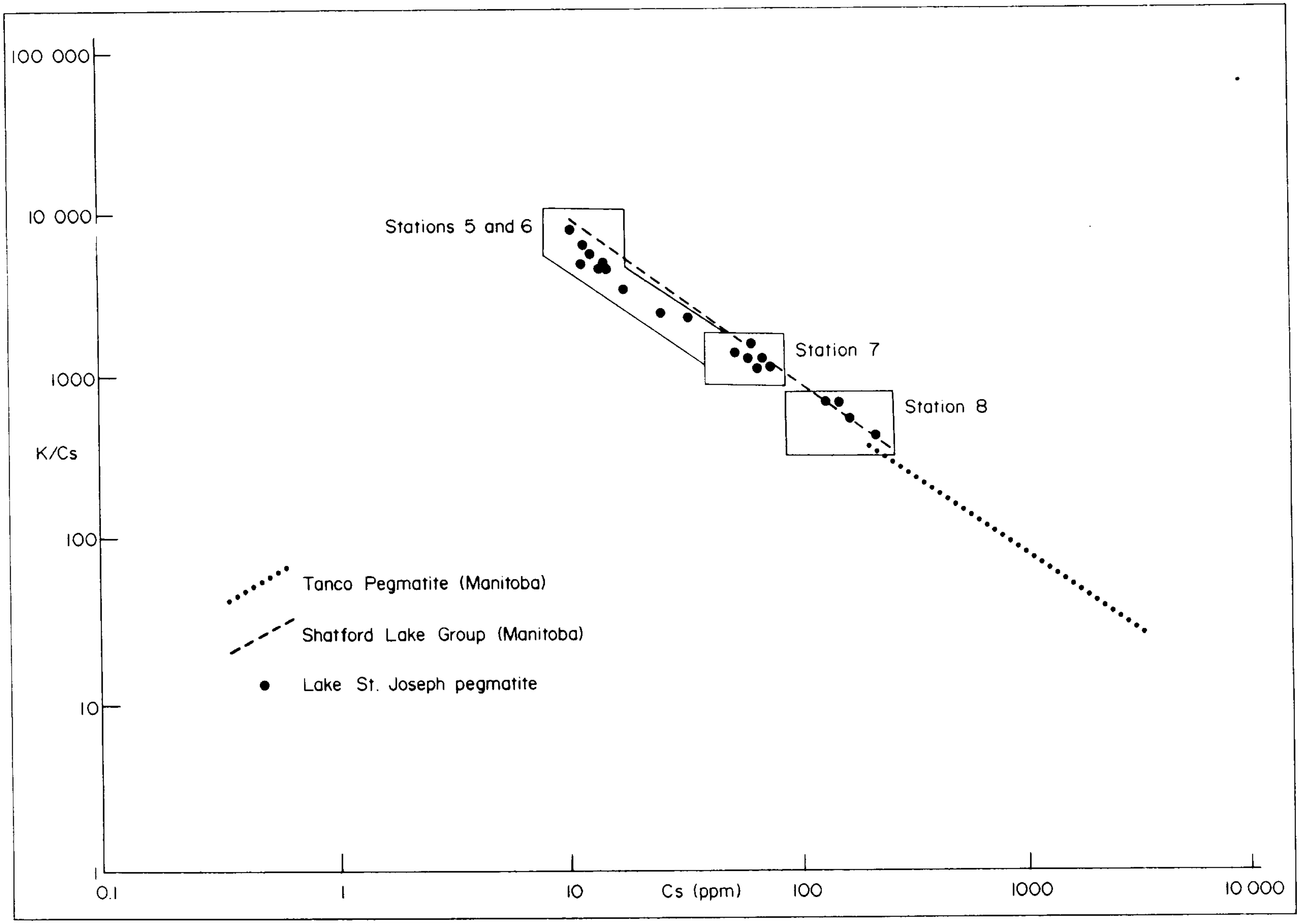

100 000
10 000
1000
K/Cs
100
10
1
0.1
1
10
Cs (ppm)
100
1000
10 000
Stations 5 and 6
Station 7
Station 8
Tanco Pegmatite (Manitoba)
Shatford Lake Group (Manitoba)
Lake St. Joseph pegmatite

Figure 29

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

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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