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JOINT ANNUAL MEETING
27-29 MAY/MAI 1996
RÉUNION ANNUELLE CONJOINTE
THE UNIVERSITY OF MANITOBA

# LITHOSTRATIGRAPHIC ASSEMBLY AND STRUCTURAL SETTING OF GOLD MINERALIZATION IN THE EASTERN RICE LAKE GREENSTONE BELT, MANITOBA (FIELD TRIP A4)

by

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Recommended citation: Poulsen, K.H., Weber, W., Brommecker, R. and Seneshen, D.N., 1996. Lithostratigraphic Assembly and Structural Setting of Gold Mineralization in the Eastern Rice Lake Greenstone Belt, Manitoba - Field Trip Guidebook A4, Geological Association of Canada/Mineralogical Association of Canada Annual Meeting, Winnipeg, Manitoba, May 27-29, 1996.

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## ABSTRACT

This field trip will examine the main lithostratigraphic assemblages and structural settings of gold deposits in the Rice Lake greenstone belt in Uchi Subprovince. A circa 2.93 Ga quartzite-bearing continental platform assemblage and a circa 2.87 Ga komatiite-bearing mafic plain assemblage will be examined near Wallace and Garner Lakes respectively. An arc assemblage of circa 2.73 Ga mafic flows, intermediate volcanic rocks and synvolcanic intrusions of the Rice Lake Group, host to most gold deposits in the district, will be viewed in the Wadhope and Bissett areas. A slightly younger and more felsic, shallow-water volcanic assemblage composed of ignimbrites, tuffs and mafic flows will be visited near the Manigotagan River where it is overlain by turbidites of the Edmunds Lake Formation, possibly representing a fore-arc assemblage. The youngest rocks in the belt, cross-bedded arenites of the San Antonio Formation, will be examined in the Bissett area where they unconformably overlie the Rice Lake Group. The settings of San Antonio, Central Manitoba and Gunnar gold deposits will receive particular attention during the trip.

## INTRODUCTION

The Archean Rice Lake greenstone belt (Fig. 1) is Manitoba's most important lode gold district, accounting for nearly two million ounces (approximately 60 tonnes) of past gold production. The largest deposit is at the San Antonio Mine, located in the northwestern part of the belt, which yielded almost 42 t of gold (Whiting and Sinclair, 1990): this mine has undergone considerable re-evaluation recently and, at the time of writing, is about to re-open with a reserve of approximately 32 t (Northern Miner, Aug. 28, 1995). A concentration of smaller mines, with a combined production of approximately 10 t (Stephenson, 1971) occurs in the southeastern part of the belt and numerous occurrences are known throughout.

Prospecting in the Rice Lake greenstone belt dates back to 1911 after a gold discovery near the San Antonio mine. Numerous geological studies of the region accompanied the early stages of mining and exploration (e.g. Moore, 1912; Davies, 1963) and, in particular, the reports of Stockwell (1935) and Stockwell and Lord (1939) contain valuable accounts of the geology in the vicinity of the past gold producers, since they were able to examine the underground workings, many of which have now been closed for over forty years. They also had opportunities to examine excellent exposures that resulted from

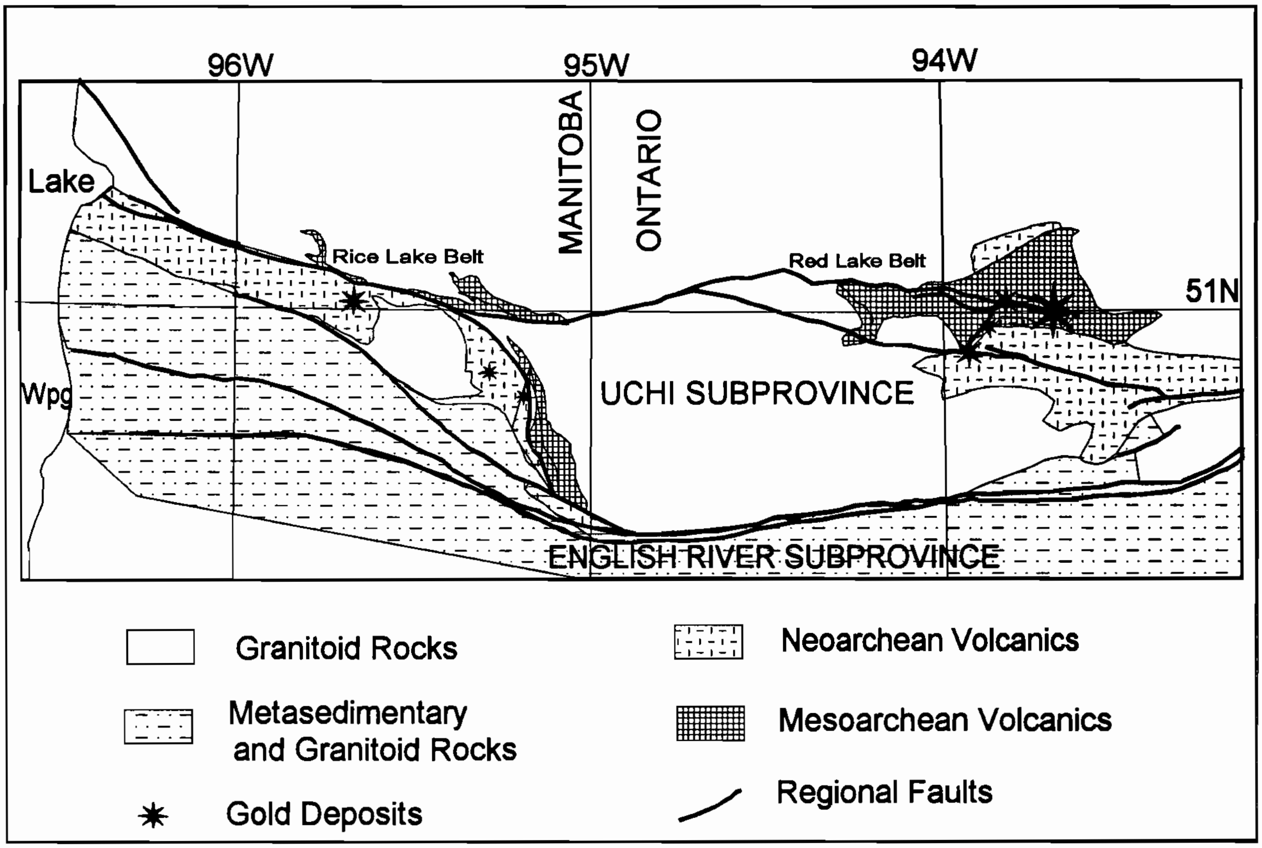



Figure 1: Setting of the Rice Lake Greenstone Belt in the western part of Uchi Subprovince.

frequent forest fires in this region. Since then, however, the multidisciplinary study by the Manitoba Mines Branch called "Geology and Geophysics of the Rice Lake Region, South-eastern Manitoba (Project Pioneer), 1971" represents the most comprehensive work available that addresses geological problems in and around the area.

With the revitalization of gold exploration and the implementation of the Canada-Manitoba Mineral Development Agreements from 1984-89 and 1989-93, new initiatives were undertaken by the Geological Survey of Canada and Manitoba Energy and Mines to further improve the level of geoscience documentation in this area, particularly as it pertains to the occurrence of gold. Designed to complement a concurrent mineral inventory by Manitoba Energy and Mines (Theyer and Yamada, 1989; Theyer and Ferreira, 1990; Theyer, 1991, 1994a,b) , recent geological studies have focused on regional and local features that are directly related to known gold deposits in the Bissett and Beresford Lake areas. The relationships between gold-bearing structures and regional generations of deformation, the recurring stratigraphic affiliations as a guide to ore, and the role of hydrothermal alteration, principally carbonatization, in the ore-forming process are all important topics relevant to this region. D.W. Davis (Poulsen et al., 1994; unpublished data) and A. Turek (Turek et al., 1989; Turek and Weber, 1991) have provided valuable geochronological data in support to the geological studies.

## REGIONAL GEOLOGY

The Rice Lake greenstone belt is located about 170km northeast of Winnipeg, Manitoba, in the Uchi Subprovince of the Superior Province (Fig. 1). It is composed mainly of Archean mafic to felsic volcanic rocks flanked on the north by the Wanipigow River Plutonic Complex and to the south by the Manigotagan Gneissic Belt, which is part of the English River Subprovince (Fig. 2). The centre of the volcanic terrane is intruded by the Ross River tonalitic pluton. The felsic to intermediate volcanic rocks and syn-volcanic intrusive rocks of the Rice Lake belt are unconformably overlain by arenite and conglomerate of the San Antonio Formation. The greenstone belt is bounded by two major faults, the Wanipigow fault on the north and the Manigotagan fault on the south, both of which show large apparent dextral offsets. Most of the rocks in the southeastern Rice Lake greenstone belt have been metamorphosed to greenschist facies, although some amphibolite facies assemblages occur around the plutons. Primary textures are usually preserved so the prefix "meta" has been omitted from rock names for simplicity, and rocks are classified principally by their primary textures.

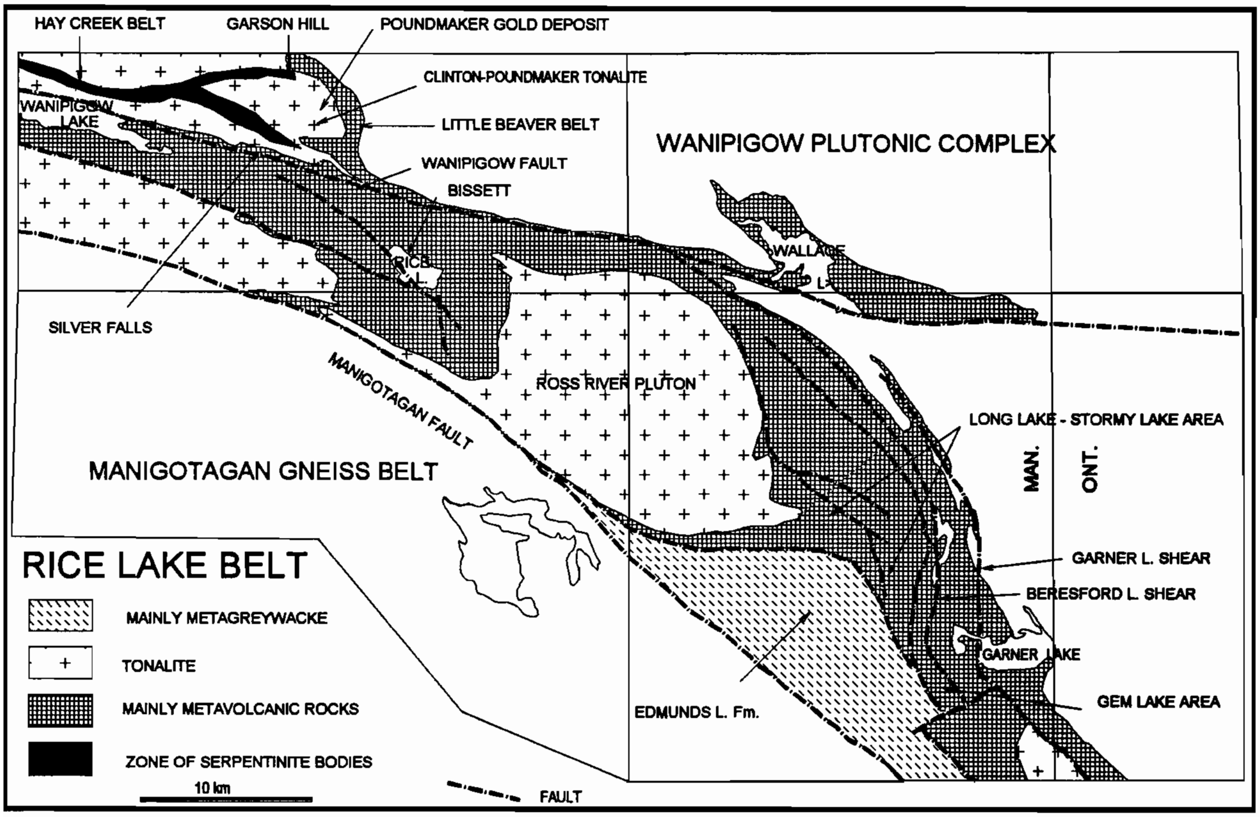



Figure 2: Main geological elements of Rice Lake Belt and locations of specific areas discussed in text.

## REGIONAL GEOPHYSICS

A further appreciation of the overall setting and structure of the area is given by available geophysical data. In addition to regional one-mile to one-inch aeromagnetic coverage, there are in excess of 150 non-confidential files that contain ground and airborne geophysical data on the region (Hosain et al., 1993). The Geological Survey of Canada has also completed airborne gradiometer of the Bissett area (GSC, 1988), as well as recent aeromagnetic and airborne radiometric surveys that cover the entire eastern part of the belt (Hetu and Holman, 1995).

A synthesis of the aeromagnetic data (Fig. 3) reveals several important features:

1. The most striking feature on the aeromagnetic maps ( McRitchie, 1971c; Hetu and Holman, 1995; GSC, 1988, for the Bissett area only) are discontinuous strings of linear, very strong positive anomalies along the northern and eastern margin of the Rice Lake belt, northwest of Bissett along the Wanipigow River, in the Wallace Lake-Siderock Lake area and between Moore Lake and Garner Lake. They are caused by oxide facies banded iron-formation. The absence of similar anomalies elsewhere in the supracrustal belt sets these sedimentary and the associated rocks apart from the remainder of the belt. As described below these iron-formations and the associated rocks are part of a pre-2.8 Ga platformal assemblage, predating and largely in fault contact with the younger dominantly volcanogenic assemblages of the Rice Lake Group.

2. A second order of regional, but lower amplitude, positive anomalies marks the larger younger ( < 2.73 Ga) granitic intrusions in the greenstone belt and the metasedimentary gneiss belt to the south. Particularly their margins are magnetically defined, e. g. the belt-central Ross River pluton, because of contrasts with adjacent volcanic rocks.

3. Strings of distinctly oval positive anomalies along the northern margin of the belt between Lake Winnipeg and Bissett are caused by serpentinites. These are spatially associated with the Wanipigow Fault. The textures of these bodies do not definitively indicate their origin but it is possible that they represent komatiites which have been tectonically re-intruded along late fault structures.

4. A large strong magnetic anomaly in the Garner Lake area is caused by the Garner Lake layered mafic/ultramafic intrusion.

5. A feature that is particularly noticeable on the 1:20,000 map (GSC, 1988) is the weakening, or disappearance, of positive magnetic anomalies in a northerly trending strip, extending from approximately 5 km west of Bissett to the eastern shore of Rice Lake. This termination appears to be in part related to the disappearance (or discontinuity) of iron formation, but the regional feature may be an expression of the breakdown of magnetite during impregnation with reducing fluids. There is some

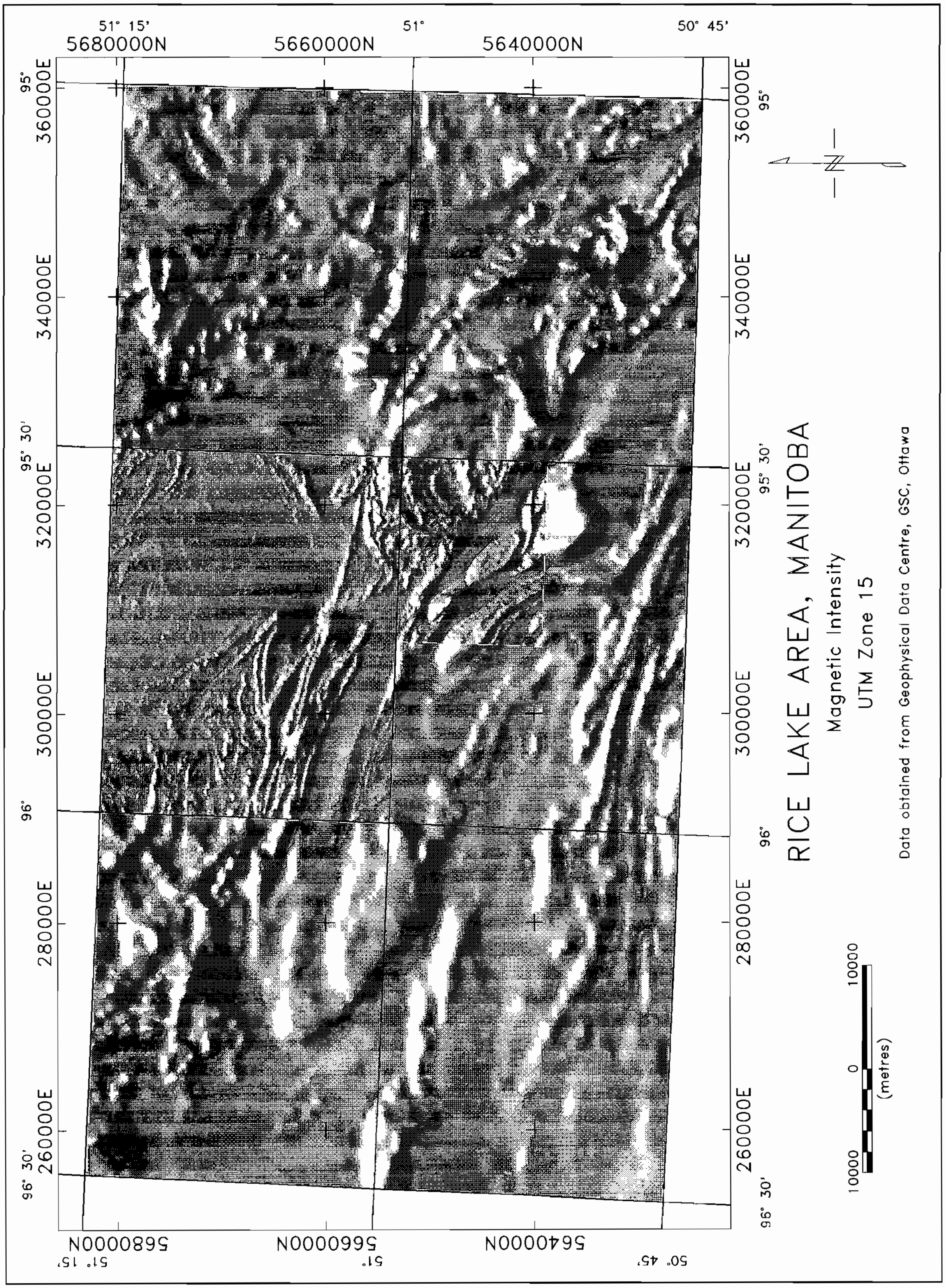



Figure 3: Aeromagnetic total field relief map of the Rice Lake area. Data processing by R. Tykajlo, WMC using data provided by the Geological Survey of Canada.

evidence for this in the Bissett area where similar gabbros lose much of their magnetic signature in the vicinity of the San Antonio Mine, where intense carbonate alteration has been documented (Ames et al., 1990).

## LOCAL GEOLOGY

Stockwell (1941) and other early workers coined the term Rice Lake Group to identify all of the supracrustal rocks in Rice Lake belt. A more detailed lithostratigraphic stratigraphic nomenclature was subsequently developed for the Rice Lake greenstone belt in Project Pioneer (Weber, 1971; McRitchie, 1971a; Campbell, 1971). In particular, the volcanic rocks of the Rice Lake Group were divided into the Bidou Lake and Gem Lake Subgroups and these in turn into formations: sedimentary rocks were also subdivided into formations. In addition, many of the important subdivisions of the plutonic rocks of the region were established by McRitchie (1971b) and Scoates (1971). Much of this early nomenclature is still useful in describing the local geology in specific areas within the Rice Lake belt (Fig. 2) even though some of the earlier correlations can no longer be sustained in the face of new structural and geochronological data. Table 1 combines the historically accepted stratigraphic nomenclature for the region with new data by introducing only one new term, “Garner Lake Subgroup”, for a volcanic sequence east of the Beresford River which was formerly portrayed partly as Gem Lake Subgroup and partly as Edmunds Lake Formation. In addition, there is new evidence (see below) that the Conley Formation (McRitchie, 1971) is both right-way-up and the oldest supracrustal unit in the belt, contrary to the views of earlier workers. Table 1 also illustrates that some units are present only in certain areas and that definitive correlation from area to area is hampered by intervening faults.

### Bissett Area

As demonstrated by previous workers, the stratigraphic succession in the Bissett area (Fig. 4) dips and faces northward with the exception of the arenite of the San Antonio Formation that occurson the overturned limb of a major syncline southwest of Rice Lake. North and east of the contact with the arenite, volcanic and epiclastic rocks of the Bidou Lake Subgroup, principally of dacitic composition, are intruded by sills of fine to medium grained gabbro.

The epiclastic rocks that underlie much of Rice Lake are primarily volcanic conglomerates and sandstones, interpreted to be braided fluvial deposits derived from unconsolidated pyroclastic debris on the slopes of a stratovolcano (Tirschmann, 1987). The stratigraphically younger porphyritic dacite that occurs north of Rice Lake is composed of euhedral to broken plagiocalse crystals, lithic fragments, pumice-like fragments, amygdaloidal spherulitic fragments and irregular to rounded quartz crystals in a fine grained matrix. The presence of brecciated zones, intercalated tuffs and relict clastic textures favour a subaqueous pyroclastic origin for this unit (Tirschmann,1987).

## Table 1 - Regional Stratigraphic Nomenclature of Rice Lake Group

| Bissett Area | Long Lake-Stormy Lake Area | Gem Lake Area | Garner Lake Area | Wallace Lake Area | Wanipigow - Little Beaver Lake Area |
|---|---|---|---|---|---|
| San Antonio Fm. | | | | | |
| | Granodiorite Intrusions<br>Edmunds Lake Fm. | Granodiorite Intrusions<br>Edmunds Lake Fm. | | | Unnamed metasediments and iron-formation at Silver Falls |
| | Dove Lake Dyke?? | Synvolcanic Porphyry<br>Gem Lake Subgroup<br>- Rathall Lake Fm.<br>- Banksian Lake Fm. | | | |
| Ross River Pluton and related Synvolcanic gabbro to tonalite | Ross River Pluton and related Synvolcanic gabbro to tonalite | Synvolcanic tonalite ? | tonalite | Tonalite and Granodiorite of Wanipigow Plutonic Complex | Tonalite and Granodiorite of Wanipigow Plutonic Complex |
| Bidou Lake Subgroup<br>- Round Lake fm.<br>- Townsite fm.<br>- Hare's Island fm. | Bidou Lake Subgroup<br>- Manigotagan River Fm.<br>- The Narrows Fm.<br>- Stormy Lake Fm.<br>- Gunnar Fm.<br>- Dove Lake Fm.<br>- Tinney Lake Fm.<br>- Stovel Fm.<br>- Unnamed Basalt | Bidou Lake Subgroup<br>- The Narrows Fm. | | | |
| | | | Layered Intrusions:<br>- peridotite-pyroxenite<br>- gabbro, quartz diorite<br>Serpentinite | Serpentinite<br>Jeep Granodiorite and Gabbro | Serpentinite |
| | | | Garner Lake Subgroup | Unnamed Volcanics (possible equivalents of Garner Lake or Bidou Lake Subgroups ?)<br>mafic to felsic dykes | Unnamed Volcanics (possible equivalents of Garner Lake Subgroup ?) |
| | | | | Conley Fm. | |
| | | | | massive tonalite - trondhjemite | |

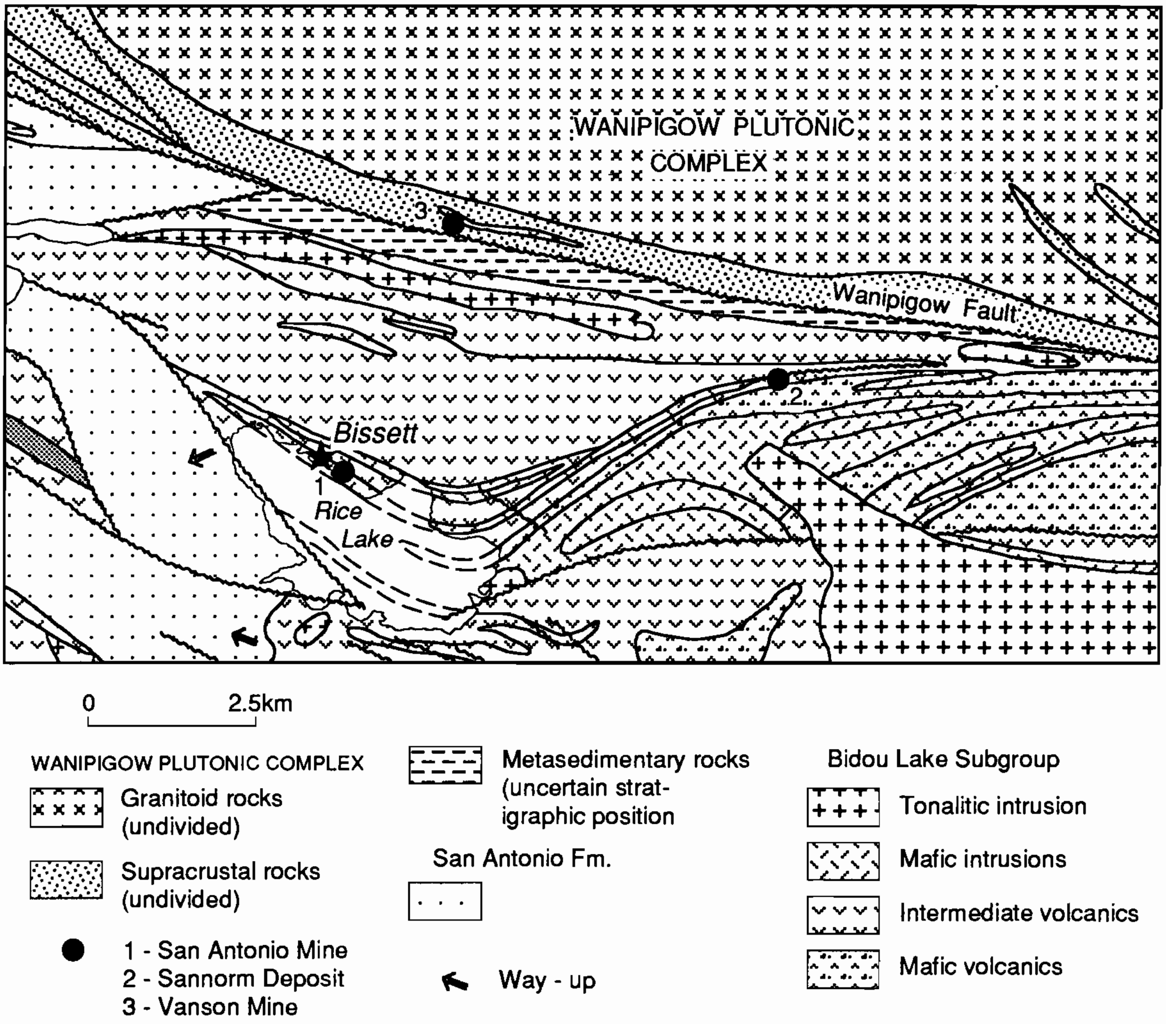



Figure 4: Geological sketch map of the Bissett area (adapted from Poulsen et al., 1986).

The gabbroic sills that intrude the epiclastic sequence are all compositionally layered. Ames (1988) used petrographic and geochemical data to show that the sill which hosts the San Antonio deposit is composed of three different types of gabbro: fine grained gabbro of normal basaltic composition occupies the upper and lower margins of the sill; melagabbro, enriched in MgO, FeO and Ni, comprises approximately the lower one-third of the sill; and, leucogabbro that is relatively enriched in $Al_2O_3$ and $TiO_2$ occupies the upper two-thirds. Similar patterns of magmatic differentiation were noted in a sill south of the Mine and in a large body of gabbro east of Rice Lake (Fig. 4).

**Long Lake- Stormy Lake Area**

The volcanic and sedimentary rocks of the Rice Lake Group in this area were divided into the Bidou Lake subgroup and the younger Gem Lake subgroup (Weber, 1971a). The Bidou Lake subgroup is characterized by a bimodal basalt-dacite and sedimentary rock assemblage whereas the Gem Lake subgroup to the southeast is characterized by a basalt-andesite-rhyolite and sedimentary rock assemblage.

The dominant structure in the Long Lake-Stormy Lake area is a major northwest trending anticlinorium (Fig. 5) which consists of the Beresford anticline and the Beresford syncline (Campell, 1971a). The oldest rocks in the core of the anticlinorium are mafic volcanic flows and intercalated tuffaceous and sedimentary rocks of the Bidou Lake subgroup that are extensively intruded by voluminous gabbro sills. Campell (1971a) divided the Bidou Lake subgroup in this area into (from oldest to youngest): Unnamed Basalt, Stovel Lake, Tinney Lake, Dove Lake, Gunnar, Stormy Lake , The Narrows and Edmunds Lake Formations (Table 1). A U-Pb age of 2730.7±12.6 Ma for a quartz-feldspar porphyry dyke is a minimum age for the host Gunnar Formation and a U-Pb age of 2731±3.2 Ma for a Narrows Formation dacite dates the upper part of the Bidou Lake subgroup volcanism (Turek et al., 1989).

Seneshen and Owens (1985) recognized a distinct supracrustal sequence, the Manigotagan River Formation, between The Narrows and Edmunds Lake Formations. It consists of epiclastic rocks, mafic flows and mafic to felsic tuffs and Seneshen (1990) interpreted it to have formed in nearshore environment. The Manigotagan River Formation may actually be part of the Gem Lake Subgroup because it contains felsic tuffs which contain fragments likely derived from Gem Lake Subgroup rhyolites (Seneshen, 1990). The overlying Edmunds Lake Formation is either in transgressive or in structural contact with both the Gem Lake and Bidou Lake Subgroups.

Abundant intrusions occur in the Long Lake - Stormy Lake area, including (from oldest to youngest): mafic sills, in part differentiated; anorthositic gabbro or gabbro with distinct glomeroporphyritic phases; tonalite-granodiorite, such as the Ross River pluton; numerous felsic to intermediate dykes, particularly near the Ross River pluton; and a unique differentiated ultramafic intrusion, the Dove Lake Dyke (Scoates, 1971).

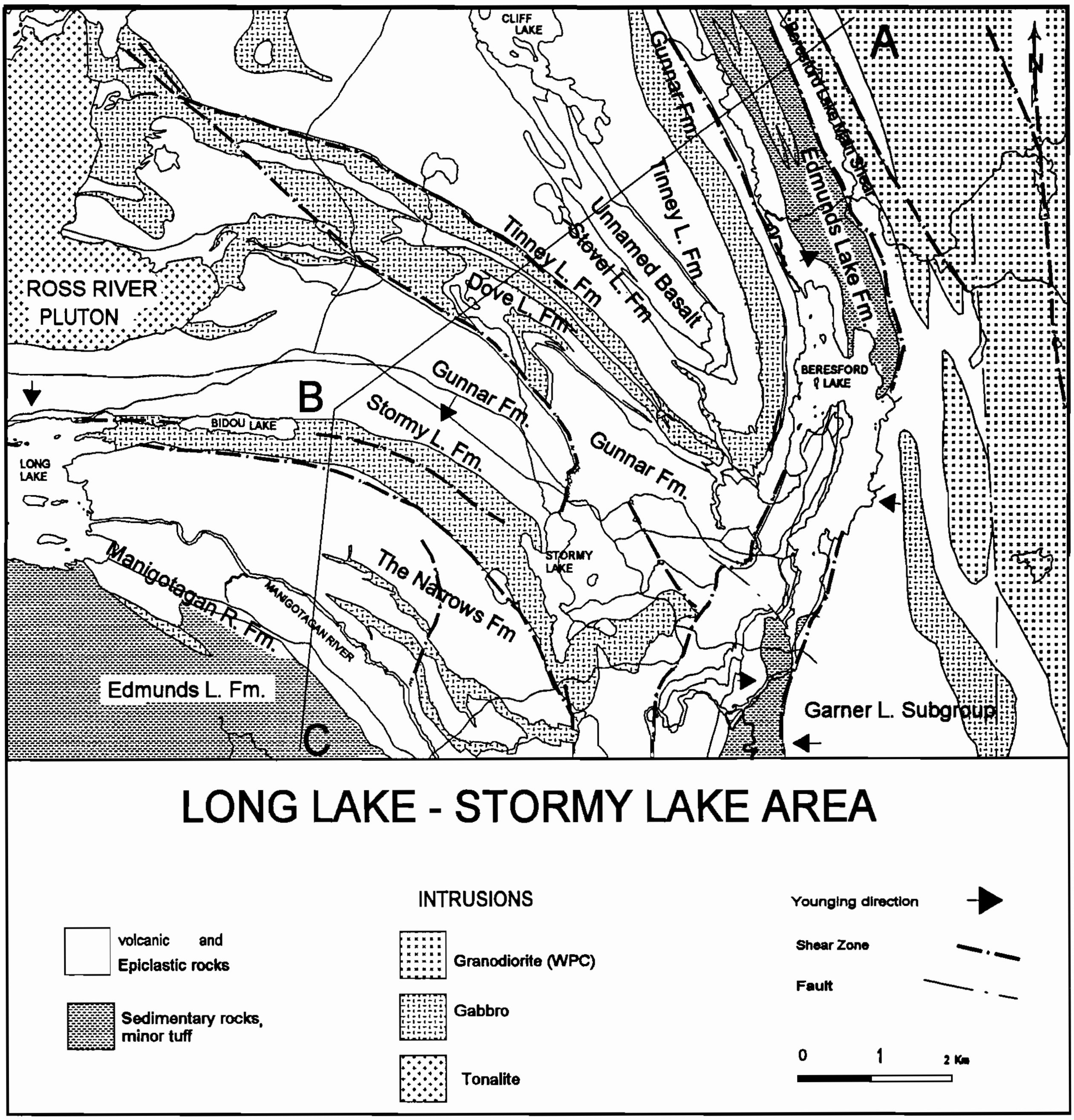



Figure 5: Geological sketch map of the Long Lake - Stormy Lake area. (adapted from Brommecker, 1991).

This body intruded along a fault, the South Carbonate Shear, which formed after intrusion of the intermediate-felsic dykes in the same area. It is likely that intermediate-felsic intrusive rocks and the volcanic rocks of the Bidou and possibly also of the Gem Lake subgroup are part of a essentially single volcano-plutonic event at about 2730±10 Ma (Turek et al., 1989).

## Gem Lake Area

The Gem Lake Subgroup occurs mainly in the Gem Lake area southeast of the Long Lake - Stormy Lake area and its relationship to the rocks of the Bidou Lake Subgroup is only weakly established. Originally postulated to be younger than the Bidou Lake subgroup based on structural grounds (Weber, 1971b), a U-Pb age of 2721.7±2 Ma for the proximal vent facies rhyolite (Davis, unpublished) supports this interpretation. However, it does not rule out that the two subgroups are essentially co-magmatic and only spatially separated, because the youngest units in the Long Lake-Stormy Lake area may have been eroded. The rocks of the Gem Lake Subgroup consist of a lower mafic Banksian Lake Formation and a upper felsic Rathall Lake Formation. Like the Bidou Lake Subgroup, the Gem Lake Subgroup is overlain in apparent conformity by the metaturbidites of the Edmunds Lake Formation.

## Garner Lake Area

This is one of the most geologically complex parts of the Rice Lake belt. One of the contributing factors is likely the fact that the area is transected by numerous northerly-striking shear zones that, along with north-northwest D2 cleavage and folds, results in large-scale transposition of east-west striking primary units. The Beresford Lake Shear Zone separates a western package of eastward facing rocks belonging to the Bidou Lake Subgroup and Edmunds Lake Formation from an eastern package of westerly facing supracrustal rocks east of Beresford Lake and northerly facing rocks around Garner Lake. The Garner Lake Shear Zone further divides the second package into geologically eastern and western parts ( Fig. 6) which themselves possess some differences.

The eastern part of the Garner Lake area contains a relatively coherent east-west stratigraphic package of supracrustal and intrusive rocks that is at least 5 km thick as measured in a north-south direction whereas the western part is more deformed. The entire sequence, for which we propose the term “Garner Lake Subgroup” has been metamorphosed to amphibolite facies assemblages and includes:

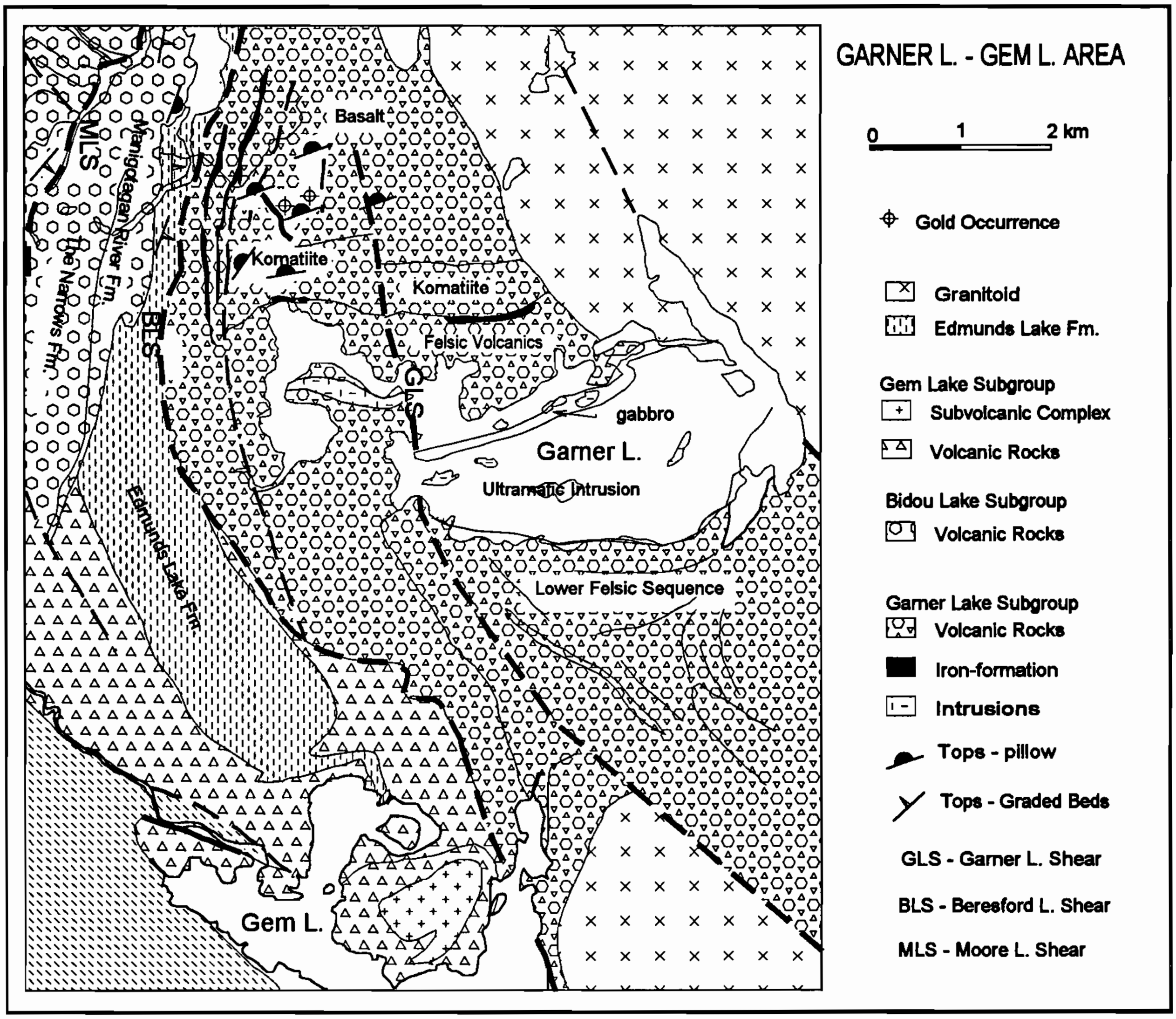



Figure 6: Geolgical sketch map of the Gem Lake and Garner Lake areas (Adapted from Weber, 1971; Brommecker et al., 1993).

1) a lowermost unit of banded intercalated felsic and mafic metamorphic rocks of uncertain origin that occur south of Garner Lake: fine-grained felsic biotite-bearing rocks dominate; these have either rhyolite or arenite protoliths but a strong foliation precludes a convincing interpretation even though the felsites locally contain clasts. The mafic component of this rock unit is strongly foliated homogenous amphibolite which is consistent with a gabbroic protolith.

2) The Garner Lake ultramafic intrusion consists of alternating layers of serpentinite and pyroxenite (Scoates, 1971) which, by their disposition,suggests their fractionation within a sill (or series of sills) that have tops to the north. The pyroxenite locally contains metre-wide gabbroic dykes that yielded circa 2870 Ma zircons ( Poulsen et al., 1993).

3) Gabbro, approximately 200 m thick, with minor pyroxenite layers occurs directly north of the ultramafic rocks and, west of the Garner Lake Shear Zone, equivalent rocks include quartz diorite. It is not known whether the gabbro and quartz diorite are more fractionated phases of the Garner Lake layered intrusion or parts of a separate body.

4) Overlying the gabbro are units of felsic tuff and volcanic breccia that were hydrothermally altered prior to regional metamorphism. Mineral assemblages are typified by biotite, anthophyllite (and possibly cordierite). Previously these rocks were mapped as sediments, probably based on their biotite content. An exhalite unit containing pyrite and traces of chalcopyrite occurs locally near the top of this unit.

5) The felsic volcanic rocks are overlain to the north by a north-facing sequence of intercalated pillowed basalt and komatiitic basalt, and spinifex-textured komatiite. This sequence locally contains interflow banded magnetite iron formation and a thin cap of iron-formation.

6) The komatiitic section of the Garner Lake Subgroup is overlain by intercalated Mg-tholeiitic and calc-alkalic basalt which, near the Beresford Lake Shear Zone, contains units of banded oxide and sulphide iron-formation and related metasedimentary rocks.

## Wallace Lake area

McRitchie (1971) produced the most detailed stratigraphic framework of the area. Re-examination of the area after recent forest fires and in view of new geochronological data (Turek and Weber, 1991, Turek et al., 1989; D.W. Davis , unpublished) revealed that the metasedimentary rocks of the Wallace Lake area, shown as relatively young on the previous maps are among the oldest, if not the oldest, of the Rice Lake belt. A well-exposed section of the Conley formation in the vicinity of the Conley shaft (Fig.7) demonstrates that quartz arenite was successively intruded by

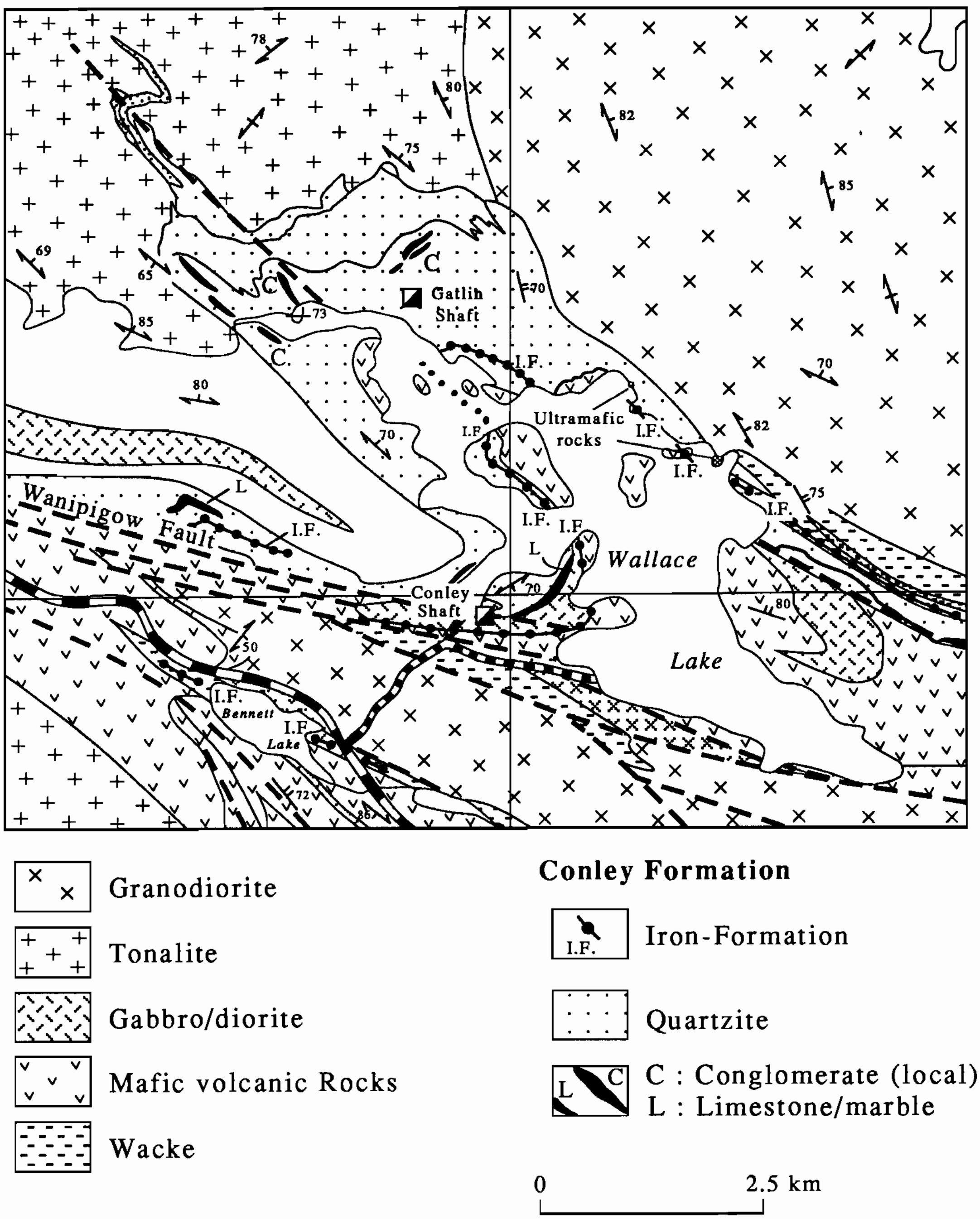



Figure 7: Geological sketch map of the Wallace Lake area (adapted from Weber and McRitchie, 1971).

gabbro, diorite, feldspar porphyry and finally by 2.92 Ga quartz-feldspar porphyry prior to regional deformation. Similar age relationships have been observed near the Jeep Mine where 2880 Ma pre-deformational granodiorite intruded the Wallace Lake assemblage.

This old gabbro-granitoid magmatism both predates and postdates the Conley Formation and has been traditionally included in the Wanipigow Plutonic Suite (Marr, 1971). The term Wanipigow Plutonic Complex is more appropriate however because the term "suite" implies co-magmatic plutons whereas available geochronology data indicate that the granitoid belt north of the Rice Lake belt is a complex of intrusions of variable composition and ranging in age from 3.0 Ga to 2.73 Ga (Ermanovics and Wanless, 1983; Turek et al., 1989; Turek and Weber, 1994).

Ultramafic rocks also are present at Wallace Lake of which there are two distinct varieties: serpentinite and actinolite schist. Serpentinite had been recorded at one locality on the north shore of Garner Lake (Scoates, 1971) but Theyer (1983) noted that this was but part of a more extensive body. It is likely, based on chemical composition and on field characteristics, that this serpentinite is of the same type as found along the Hay Creek Belt and north of Garner Lake. The actinolite schists (McRitchie, 1971) also occur in association with the Conley Formation as thin concordant lenses. They have been regarded as either unusual clay-rich magnesian metasedimentary rocks or as varieties of ultramafic rocks but this is not easy to resolve.

### Wanipigow River - Little Beaver Lake Area

A belt containing ultramafic rocks has also been recently identified within the Wanipigow Plutonic Complex northeast of Wanipigow Lake (Poulsen et al., 1994). Coincident with a well defined airborne gradiometer anomaly (GSC,1988), this belt is the northernmost of two branches which split from the Hay Creek Serpentinite Belt (Fig. 8). Massive serpentinite is exposed in several outcrops (Garson Hill) but cannot be traced any farther eastward suggesting a fault contact between the east-west ultramafic belt and a prominent northeast-southwest belt of mafic-felsic volcanic rocks though Little Beaver Lake. The contact between these supracrustal rocks of the Little Beaver belt and the tonalite to the west is intrusive but pre-tectonic as evidenced by the local tectonic transposition of rocks in the contact zone. Although the supracrustal rocks of the Little Beaver belt are portrayed on some existing maps as metagreywacke, at least some of them are actually intermediate to felsic volcanic rocks that have been metamorphosed to the amphibolite facies, resulting in their high biotite content. Patchy gossan zones within some felsic volcanic units are suggestive of synvolcanic sulphidic stockworks and the local presence of garnets may reflect a precursor synvolcanic hydrothermal alteration such as is known to occur in the vicinity of volcanogenic massive sulphide deposits.

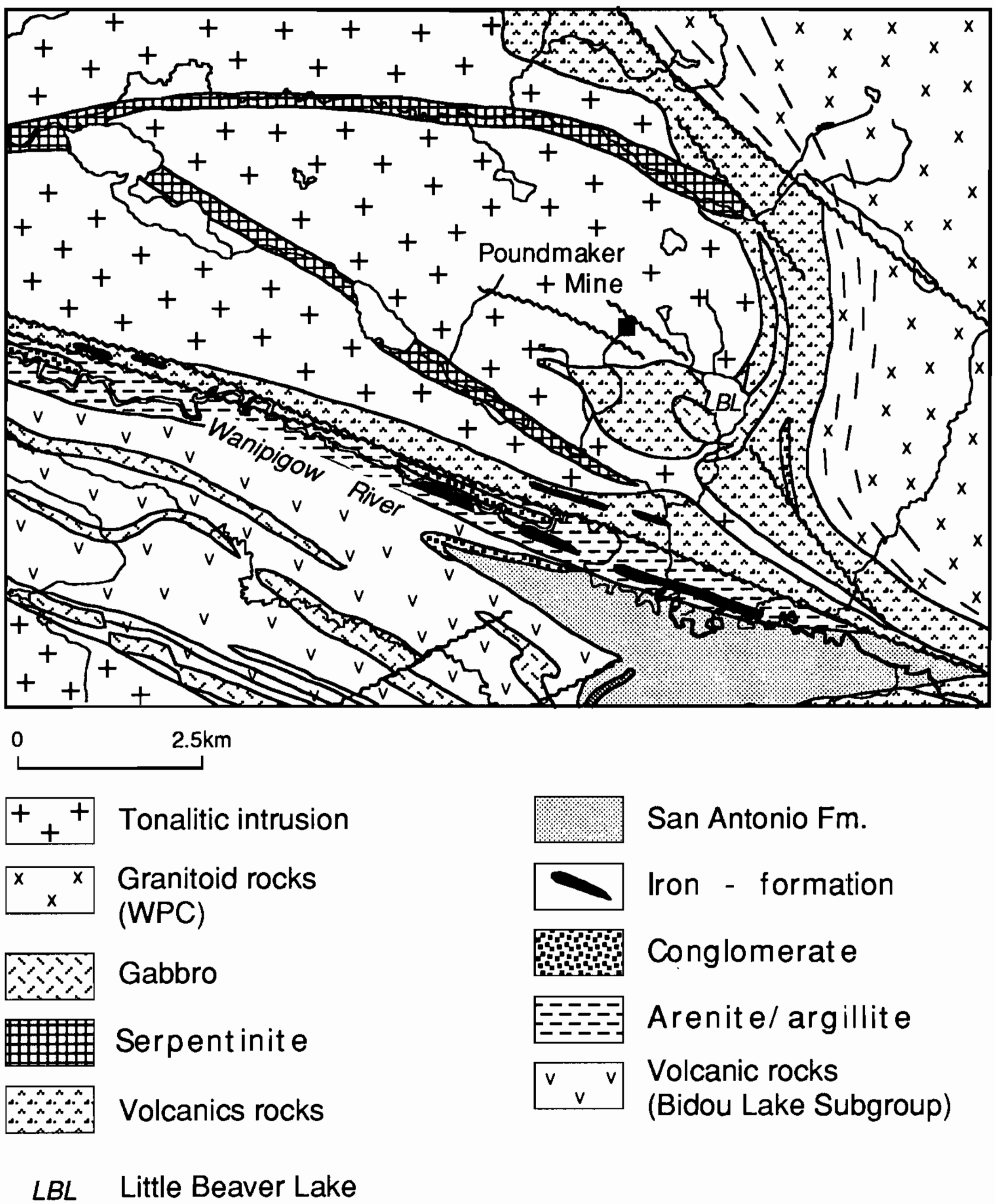



Figure 8: Geological sketch map of the Wanipigow River - Little Beaver Lake area.

All of the granitoid rocks observed to the west of the Little Beaver Belt are tonalitic. The Clinton-Poundmaker tonalite is massive and relatively undeformed whereas its equivalent to the south between the Hay Creek Serpentinite Belt and the Wanipigow Fault is foliated.

Iron-formation is indicated on several existing maps near the trace of the Wanipigow River Fault to the east of Wanipigow Lake (Fig. 8). These occurrences also coincide with positive airborne gradiometer anomalies (GSC, 1988). The iron formation appears to be discontinuously developed but appears to occupy two spatially and lithologically distinctive positions. The first is as narrow bands of lean iron formation that occur intercalated with strongly foliated pillowed basalt directly north of the Wanipigow Fault. The second, although not observed in outcrop has been drilled and is well-located by magnetic anomalies to occur within a poorly exposed band of sedimentary rocks that lies directly south of the Wanipigow Fault. These sedimentary rocks are exposed at Silver Falls on the Wanipigow River where a southward-fining clastic sequence includes coarse polymictic conglomerate, well bedded to massive quartz arenite, siltstone and argillite to which the magnetic iron formation appears to be associated. There are many uncertainties associated with correlating this sedimentary package on a regional scale. It may either be a facies-equivalent of the San Antonio Formation, which extends nearby from the Bissett area, or of the Edmunds Lake Formation which also includes sections of mixed conglomerate, sandstone, argillite and iron-formation.

## STRUCTURE

Large-scale folds and faults are evident on geological maps from various parts of Rice Lake belt. The structure of this region is the result of at least three phases of deformation but correlation of deformation events from area to area has not been firmly established.

Structural studies in the southeastern part of belt (McRitchie and Weber, 1971; Weber, 1971a; Zwanzig,1971; Brommecker et al., Brommecker, 1991) all indicate that the main generations of structures are as follows (Fig. 9):

D1: isoclinal folding with variable cleavage development

D2: tight folding with the development of the main penetrative foliation

D3: open folding and kink folding with development of a crenulation cleavage. The structural trends associated with each episode (Fig. 10) indicate the existence of early northerly structures overprinted by NW-SE folds and cleavage, all of which are overprinted by late ENE cleavage.

| Time | Oldest | | | Youngest |
| --- | --- | --- | --- | --- |
| Deformation event | D0 | D1 | D2 | D3 |
| Possible tectonic significance | Syn-volcanic and syn-sedimentary extension | Thrusting | Out of sequence thrusting | Dextral strike-slip |
| Cleavage type | None | S1-penetrative, flattening, spaced fracture | S2-penetrative, flattening, spaced fracture, crenulation | S3-crenulation, kink |
| Minor folds | Chaotic | Rare isoclines | Closed to tight, lobate-cuspate, chevron | Open, chevron, box, kink |
| Major folds | | Early fold responsible for synclinal facing across the Beresford Lake Main Shear | Beresford Anticlinorium<br>Beresford Anticline<br>Beresford Syncline | Major bend in the axial trace of the Beresford Anticlinorium |
| Minor faults and shear zones | Brittle structures, faults with felsic dykes emplaced along them | Layer parallel shear zones, and shear zones to accomodate the local extension and compression of layers | Limb thrusts on F2 folds, axial planar shear zones, flexural slip shear zones, shear zones to accomodate local extension and compression of layers | Dextral strike-slip faults and shear zones, conjugate sinistral strike-slip shear zones, Riedel pattern development |
| Major faults and shear zones | | Moore Lake Shear<br>North Carbonate Shear<br>Beresford Lake Main Shear | South Carbonate Shear | Main dextral D3 fault and shear zone south of the Gunnar Mine |
| Gold mineralization | | | | |
| Igneous history | Gabbroic intrusions<br>Pyroxenite intrusions<br>Felsic to intermediate porphyry intrusions | Hornblende-biotite diorite<br>Intermediate dyke with associated breccia | Dove Lake Dyke | |
| Metamorphism | | | | |

Figure 9: Summary of the structural history of the eastern part of the Rice Lake Greenstone Belt (after Brommecker, 1991).

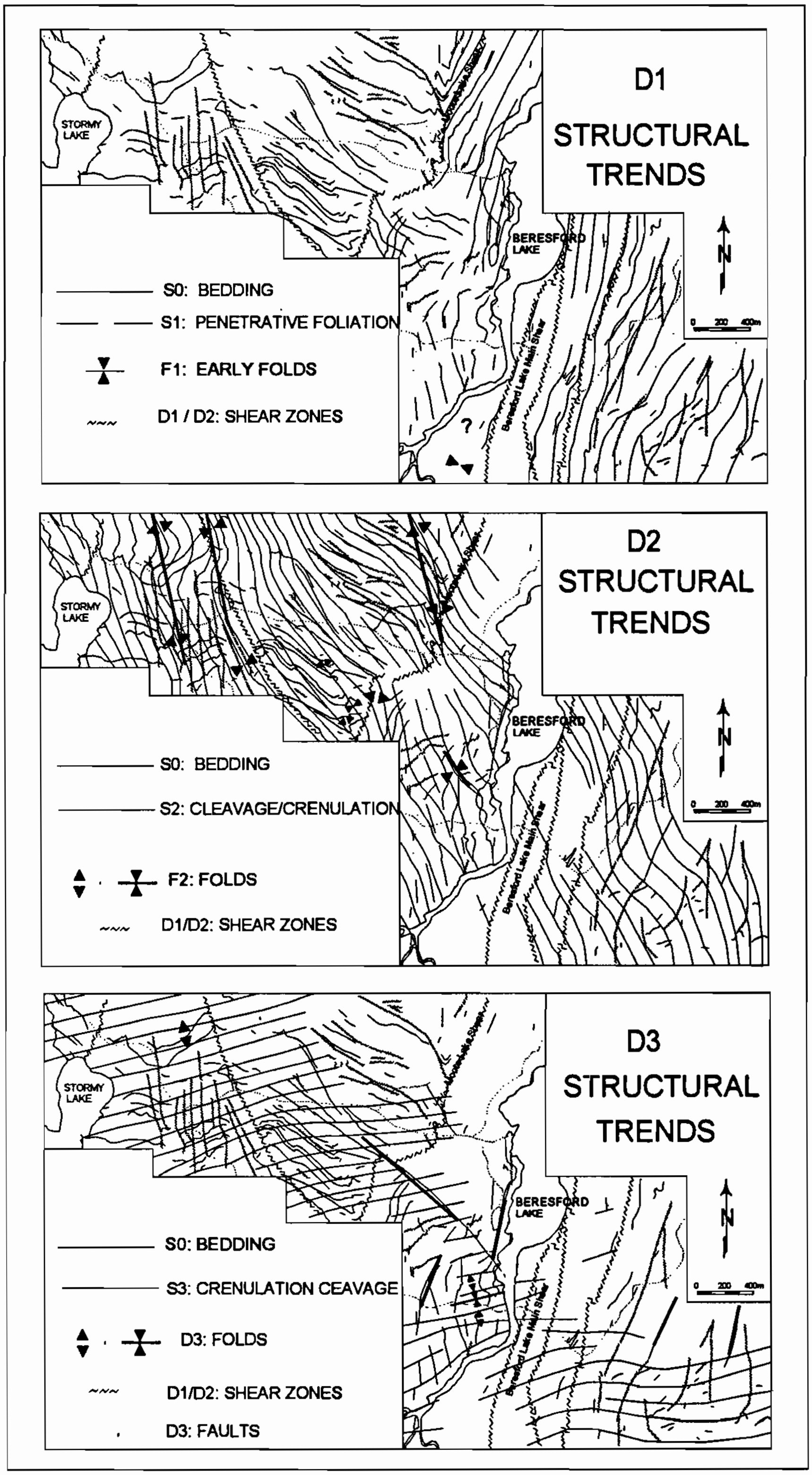



Figure 10: Structural trend maps of the three major deformation events in eastern Rice Lake Belt (after Brommecker, 1991).

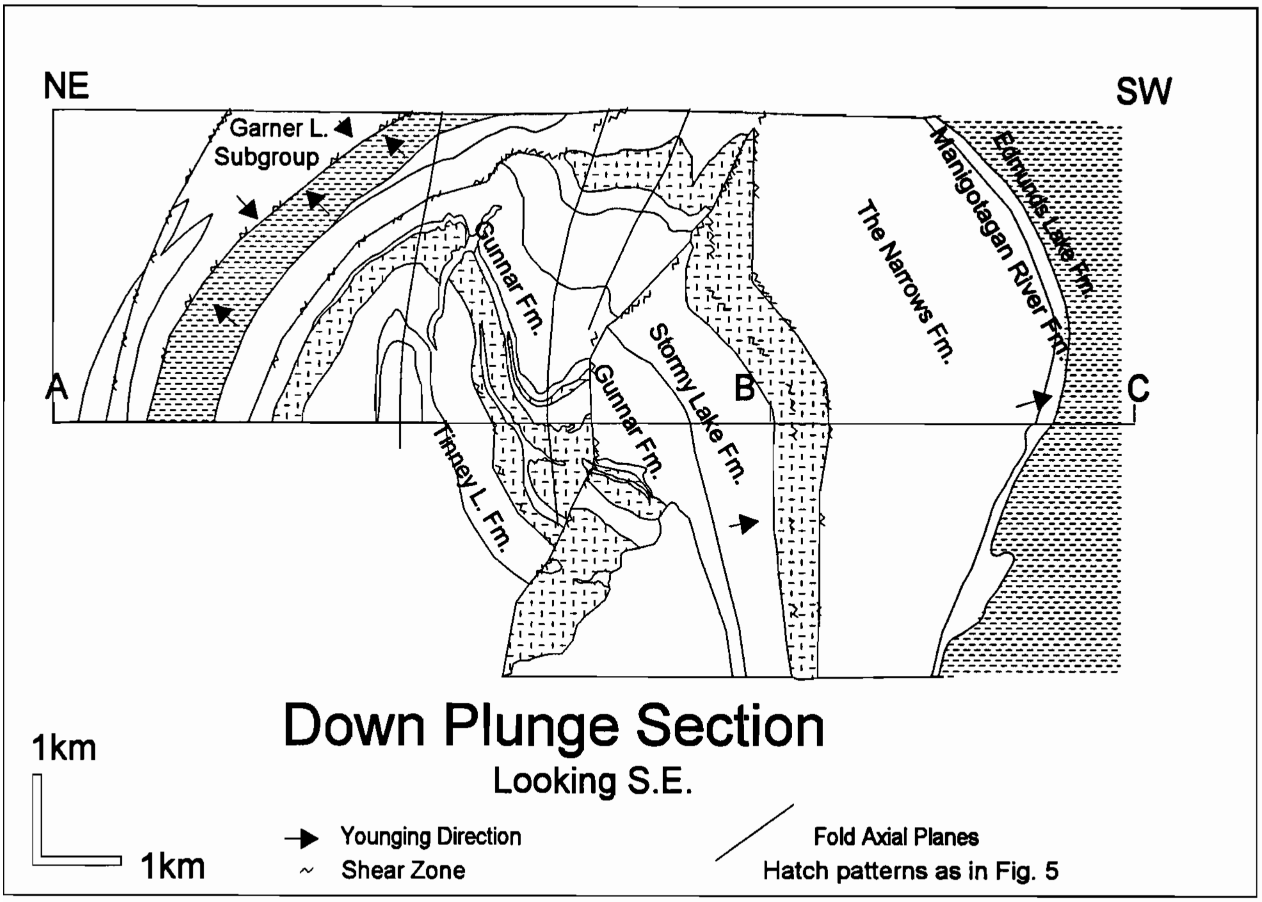



Figure 11: Down plunge section of the Beresford Anticlinorium

Deformation has also involved movement along major shear zones and faults (Fig. 9). Large layer-parallel shear zones with unknown magnitudes of displacement are common in the area. Examples are the North Carbonate Shear at the Central Manitoba Mine (Stockwell and Lord, 1939) and the Beresford Lake Main Shear east of the Gunnar Mine(Brommecker, 1991). Similar shear zones which cross-cut stratigraphy in some areas have large offsets, as is the case with the South Carbonate Shear at Central Manitoba (Stockwell and Lord, 1939). The Moore Lake Shear (Fig. 6; also known as the Beresford Lake Deformation Zone) truncates stratigraphy at a high angle on its west side near the Gunnar Mine and at a low angle on its east side. Some of these shear zones are of different generations (Fig. 9,10).

A down-plunge view of the structure in the Stormy Lake area shows that the southwest limb of the anticlinorium is overturned (Fig. 11). The Beresford anticline is shown to be tight to closed whereas the Beresford syncline is open. The mafic rocks of the Garner Lake Subgroup east of the Beresford Lake Main Shear face opposite to structurally underlying sediments of the Edmunds Lake Formation. Of particular significance are the extreme variations in the thickness of units across the anticlinorium. The dramatic thinning of all units on the north-eastern limb of the structure suggests that the limb may be tectonically thinned. The down-plunge projection also shows that the South Carbonate Shear is a reverse fault on a limb of the Beresford syncline. Other shear zones appear to be folded about the Beresford anticlinorium.

Rocks in the Bissett area also show evidence of three penetrative deformations. The most prominent evidence of ductile deformation is a penetrative schistosity that, on average, strikes west-northwest and dips steeply northward. This foliation (regionally S2 or S3) is axial planar to a large reclined syncline in San Antonio Formation and locally overprints an earlier foliation (S1?) that is sub-concordant with bedding in the Rice Lake Group volcanic and epiclastic rocks. A prominent mineral lineation is coincident with the intersection of the two foliations. This lineation trends northward at the south shore of Rice Lake but, north of Rice Lake, it deviates increasingly to the east (Fig.12), a condition that is thought to result from D3 deformation along the Wanipigow Fault (Poulsen et al., 1986).

The most intense effects of deformation are found in ductile shear zones that are common throughout the area. These zones are typically heavily carbonatized and include two types: those, such as the Normandy Creek and footwall shears (Fig. 12) that are concordant with lithological layering and those, such as the Rice Lake shear, that are discordant. Although definitive evidence is lacking, the presence of "down-dip" lineation and the fact that the Rice Lake shear places Rice Lake Group volcanic rocks over younger arenites, indicate that at least some of these structures are dominantly reverse faults (Fig. 12).

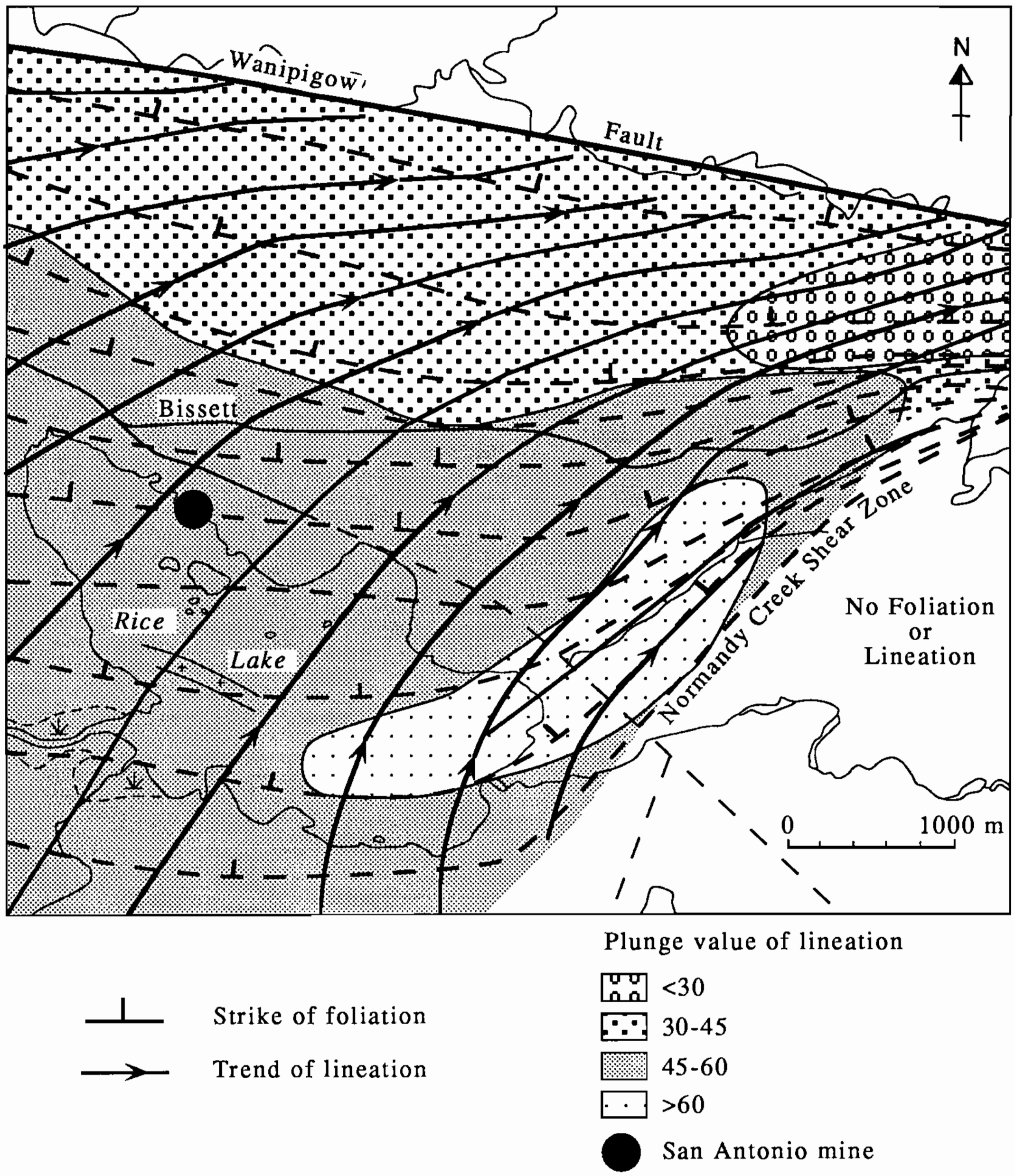
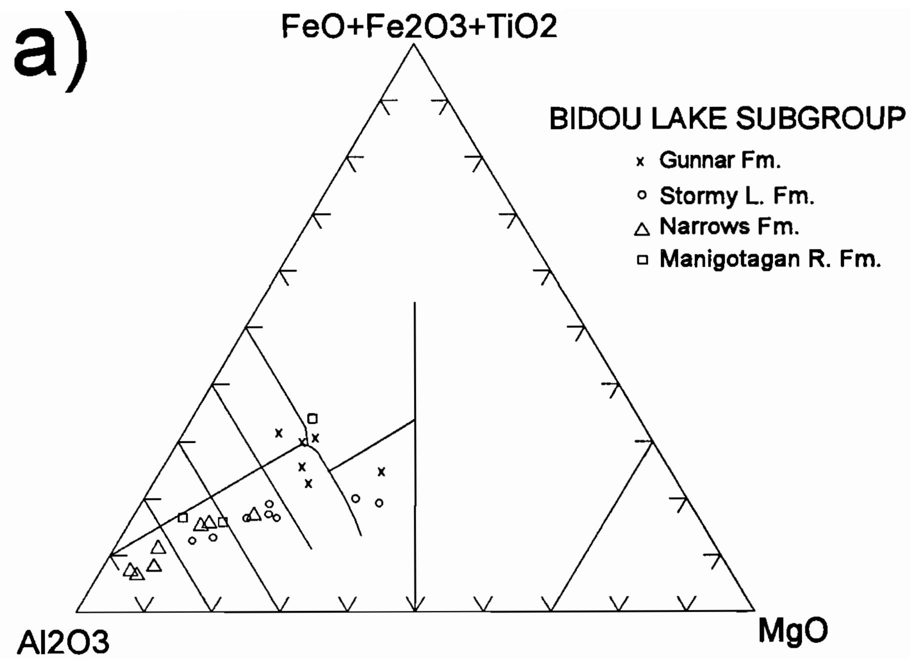



Figure 12: Structural trend map of foliation and lineation in the Bissett area (after Poulsen et al., 1986).



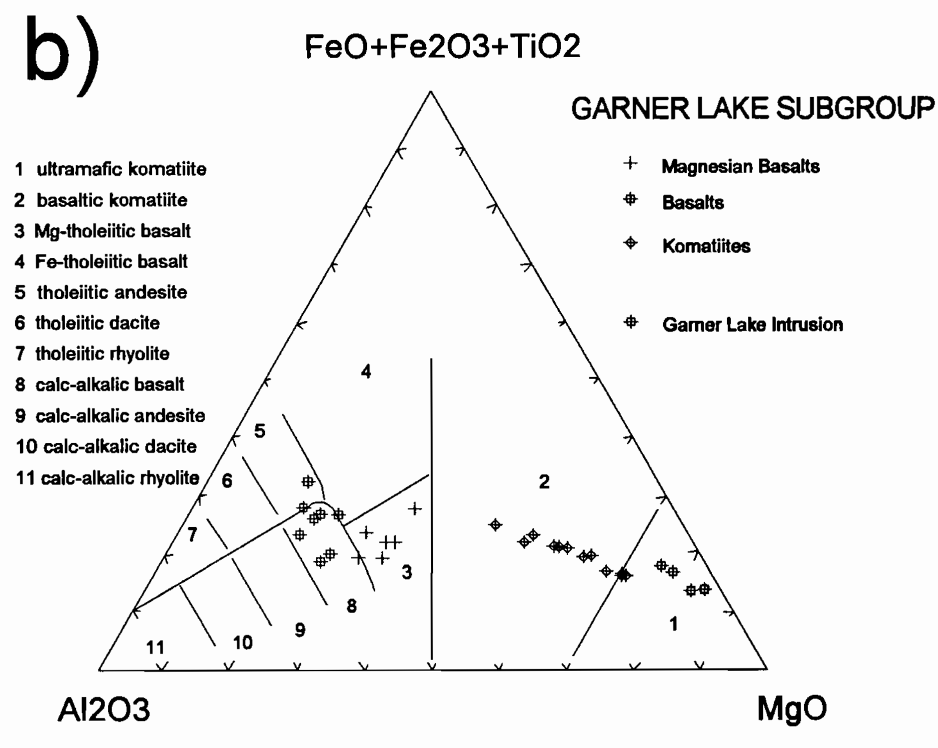




Figure 13: a) Jensen diagram showing the chemical compositions of volcanic and volcaniclastic rocks of the Bidou Lake Subgroup (after Brommecker, 1991).

b) Jensen diagram showing the chemical compositions of volcanic rocks of the Garner Lake Subgroup and of the cumulate rocks in the Garner Lake layered intrusion (after Brommecker et al., 1993).

## LITHOGEOCHEMISTRY

Church and Wilson (1971) made the first attempt to classify the volcanic rocks of the Rice Lake Belt according to their bulk chemical compositions and to make comparison with younger volcanic products. They noted that the volcanic sequences in the Rice Lake belt are essentially bimodal and consist of mafic (mainly basalt, basaltic andesite) and intermediate ( mainly dacite and dacitic andesite) rocks. They noted further that the abundance of dacite compared to rhyolite is unusual by comparison with other greenstone belts in Superior Province but could not decide if this bimodality was an artifact of two separate magmas or rather of incomplete sampling of a more continuous range of compositions. Recent additional analyses from the Bidou Lake Subgroup (Brommecker, 1991) suggest that the second is most plausible (Fig. 13a).

We also now recognize the extensive occurrence of komatiites in the eastern and northern parts of the Rice Lake belt, particularly in the Garner Lake area. Although these rocks are not voluminous and most were recognized to be ultramafic in the past, they were thought to be late-tectonic intrusions owing to their common preservation as slices within the many faults and shear zones in the belt. Definitive textures (spinifex, polysuturing) and distinctive chemical compositions (Fig. 13b) indicate, however, that both komatiitic flows and subvolcanic intrusions are present in addition to Mg-tholeiitic and calc-alkaline basalt.

## GEOCHRONOLOGY

The earliest geochronological information for the Rice Lake greenstone belt was provided by K-Ar determinations by the GSC and Rb-Sr studies by Turek (1971): both confirmed the Archean age (circa 2700 Ma) of the rocks in the area and also indicated younger metamorphic or alteration events at approximately 2500 Ma and 2300 Ma. The first zircon studies, by T. Krogh (Krogh et al., 1974) in the western part of the belt, indicated, however, that much older crust (circa 3000 Ma) exists in the region. This and several modern U-Pb zircon studies (Turek et al., 1989; Turek and Weber, 1991, 1994; Davis unpublished) have shown that the rocks of Rice Lake greenstone belt span the same wide range of ages as are found elsewhere in Uchi Subprovince. In particular, there is considerable overlap and correlation of ages (Table 2) with similar rocks in the Red Lake area (Corfu and Wallace, 1986; Corfu and Andrews, 1987; Corfu and Davis, 1992).

## Table 2 - Geochronology Data for Rice Lake and Red Lake

| location | rock type | age Ma | uncertainty | analyst | year |
|---|---|---|---|---|---|
| * Red Lake data | | | | | |
| Wallace Lake | tonalite boulder | 3010 | 13 | Turek | 1991 |
| English Brook | meta-tonalite | 3003 | 3 | Turek | 1994 |
| west Hole River | meta-tonalite | 2999 | 10 | Krogh | 1974 |
| Wallace Lake | quartz arenite | 2998.7 | 1.3 | Davis | 1994 |
| *Hoyles Bay | rhyolitic ash-flow bx. | 2992 | 20 9 | Corfu | 1986 |
| *Campbell Mine | rhyolite | 2989 | 3 | Corfu | 1986 |
| *Trout Bay | Rhyolitic lapilli tuff | 2940.1 | 2.4 1.7 | Corfu | 1986 |
| *Trout Bay | rhyolite | 2925.4 | 3.4 2.9 | Corfu | 1986 |
| Wallace Lake | qtz. porphyry dyke | 2920.6 | 3 | Davis | 1994 |
| Lake Wpg. | quartzofeldspathic. gneiss | 2900 | 10 | Krogh | 1974 |
| Rice River | quartzofeldspathic. gneiss | 2900 | 10 | Krogh | 1974 |
| *Balmer east | tuff | 2894 | 2 | Corfu | 1987 |
| *Cochenour | rhyolite tuff | 2893.5 | 1.4 1.2 | Corfu | 1986 |
| Jeep Mine | foliated granodiorite | 2880 | 9 | Turek | 1989 |
| Garner Lake | peg. gabbro | 2871 | 1 | Davis | 1994 |
| Garner Lake | tonalite | 2871 | 1.5 | Davis | 1994 |
| *Dickenson | qtz. gabbro | 2870 | 15 | Corfu | 1987 |
| *Trout Lake | foliated tonalite | 2838 | 4 3 | Noble | 1989 |
| *Trout Lake | foliated tonalite | 2806 | 12 2 | Noble | 1989 |
| *Rahill Zone | felsic dyke | 2757 | 9 4 | Corfu | 1986 |
| *Madsen | spherulitic flow | 2746 | 36 17 | Corfu | 1987 |
| *Austin/ Madsen | Tuff | 2744 | 1 | Corfu | 1987 |
| *Balmer Lake | qtz-fsp porphyry | 2742 | 3 2 | Corfu | 1987 |
| *Heyson | rhyolite crystal tuff | 2739 | 3 | Corfu | 1986 |
| Obukowin L. (n. of Wallace) | tonalite | 2737 | 10 | Krogh | 1974 |
| Beresford Lake | qtz-fsp porphyry dyke | 2732.8 | 6.2 | Turek | 1991 |
| *Graves | rhyodacite | 2732.8 | 1.4 1.2 | Corfu | 1986 |
| Black Island | rhyodacite | 2732 | 10 | Wanless | 1983 |
| Wallace Lake | tonalite | 2731 | 10 | Turek | 1989 |
| Manigotagan R. | Narrows dacite | 2731 | 3.2 | Turek | 1989 |
| *Little Vermilion L. | granodiorite | 2731 | 3 | Corfu | 1987 |
| Beresford L. | Gunnar Porphyry | 2730.7 | 12.6 | Turek | 1989 |
| Hare's I. Rice L. | rhyolite | 2729 | 3.2 | Turek | 1989 |
| *Redcrest | quartz diorite | 2729 | 1.5 | Corfu | 1987 |
| Ross River | quartz diorite | 2727.6 | 8.4 | Turek | 1989 |
| Gem Lake | rhyolite | 2721.7 | 2 | Davis | 1994 |
| *McKenzie Is. | granodiorite | 2720 | 2 | Corfu | 1987 |
| *Abino Mine | granodiorite dyke | 2720 | 7 5 | Corfu | 1987 |
| *Dome | granodiorite | 2718.2 | 1.1 | Corfu | 1986 |
| *Hammell L. | granodiorite | 2717 | 2 | McMaster | |
| Deer Island East | granodiorite gneiss | 2715 | 10 | Krogh | 1974 |
| 3km E. Black Isl. | granodiorite | 2715 | 10 | Krogh | 1974 |
| *Dickenson | qtz-fsp porphyry | 2714 | 4 | Corfu | 1987 |
| *Killala-Baird | granodiorite | 2704 | 1.5 | Corfu | 1987 |
| *Wilmar Mine | granodiorite | 2701 | 1.5 | Corfu | 1987 |
| *Walsh Lake | granodiorite | 2699 | 1 | Noble | 1989 |
| s. Manigotagan | paragneiss & orthogneiss | 2690 | 10 | Krogh | 1974 |
| Black Lake | post-tect. granite | 2663 | 7.3 | Turek | 1989 |

## TECTONIC INTERPRETATION

Several attempts have been made to come up with a coherent tectonic interpretation of the Rice Lake belt, in most cases supported by the results of extensive geological mapping. For example, Stockwell (1940) was of the opinion that the overall structure of the belt was anticlinorial so the oldest rocks occur in the centre (Fig. 14, a modification of his Figure 2) and that rock units at the edges, for example the sedimentary sequence at Wallace Lake and the volcanic rocks at Garner Lake, are the youngest. Although advancing many local improvements, the regional stratigraphic scheme of McRitchie (1971a,b) and Weber (1971a,b) led to similar conclusions concerning the relative ages of major units. Recent structural mapping and geochronological results (Table 2) contradict some aspects of this interpretation, however, and support an interpretation that is more in accord that of the geology of the adjacent Red Lake district in Ontario. Volcanic rocks at Red Lake that formed at approximately 2730 Ma are similar to those in the centre of the Rice Lake belt and are subordinate to, and in sharp contact with, a pre-2800 Ma sequence composed mainly of basalts and komatiites, as well as both clastic and chemical sedimentary rocks and minor felsic volcanics. The latest stratigraphic, structural, and geochronological evidence suggests that the Rice Lake belt also is composed of two or more fundamentally dissimilar volcanic sequences. In particular, komatiites occur with magnesian and tholeiitic basalts, oxide facies iron formation, quartzites and carbonates (Wallace Lake) and felsic pyroclastic rocks (Garner Lake): this association of rock types is identical in most respects to that in the pre-2800 Ma Balmer, Ball and Bruce Channel assemblages at Red Lake. These units are distintive from, but in uncertain contact with, the more voluminous circa 2730 Ma volcanics of the Bidou Lake and Gem Lake Subgroups.

Given the inferred similarity with Red Lake geology and considerable new data, it is possible to view the supracrustal rocks of the Rice Lake also to be composed of several distinctive "tectonic assemblages" in the same way that Stott and Corfu (1991) have divided the Uchi Subprovince in Ontario. This is done, not so much as an endorsement of the assemblage concept, but rather as an effective means of making geological comparisons across the Ontario-Manitoba border. Using such an approach we are able to identify several tectonic assemblages, using nomenclature that is as consistent as possible with past lithostratigraphic nomenclature. The main characteristics of the assemblages, their age constraints and their mutual contact relationships are outlined in Table 3 and their distribution is shown in their present configuration (Fig. 15).

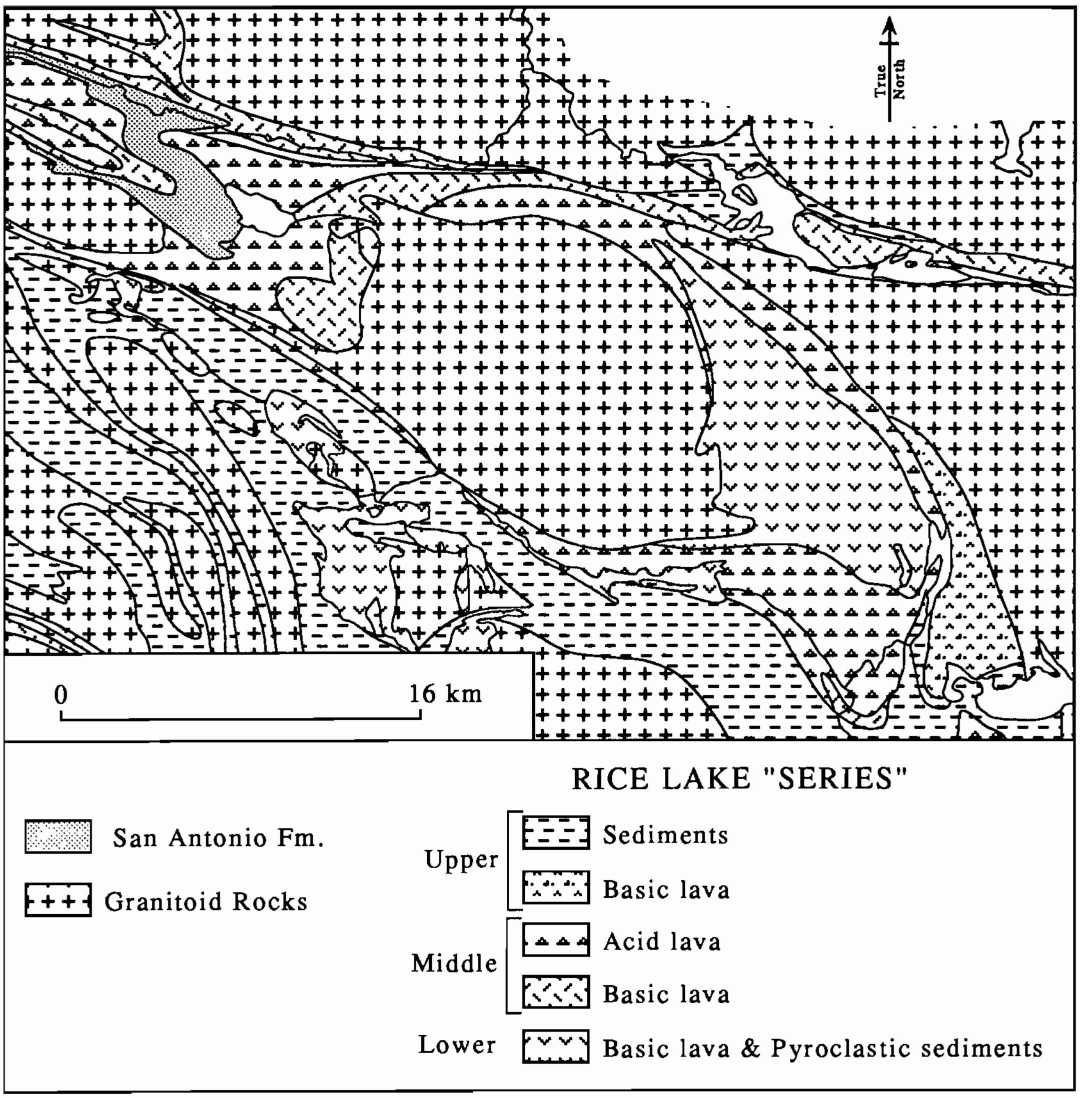



Figure 14: An early example of regional stratigraphic interpretation of the Rice Lake Belt by C. H. Stockwell (after his figure 2, 1941).

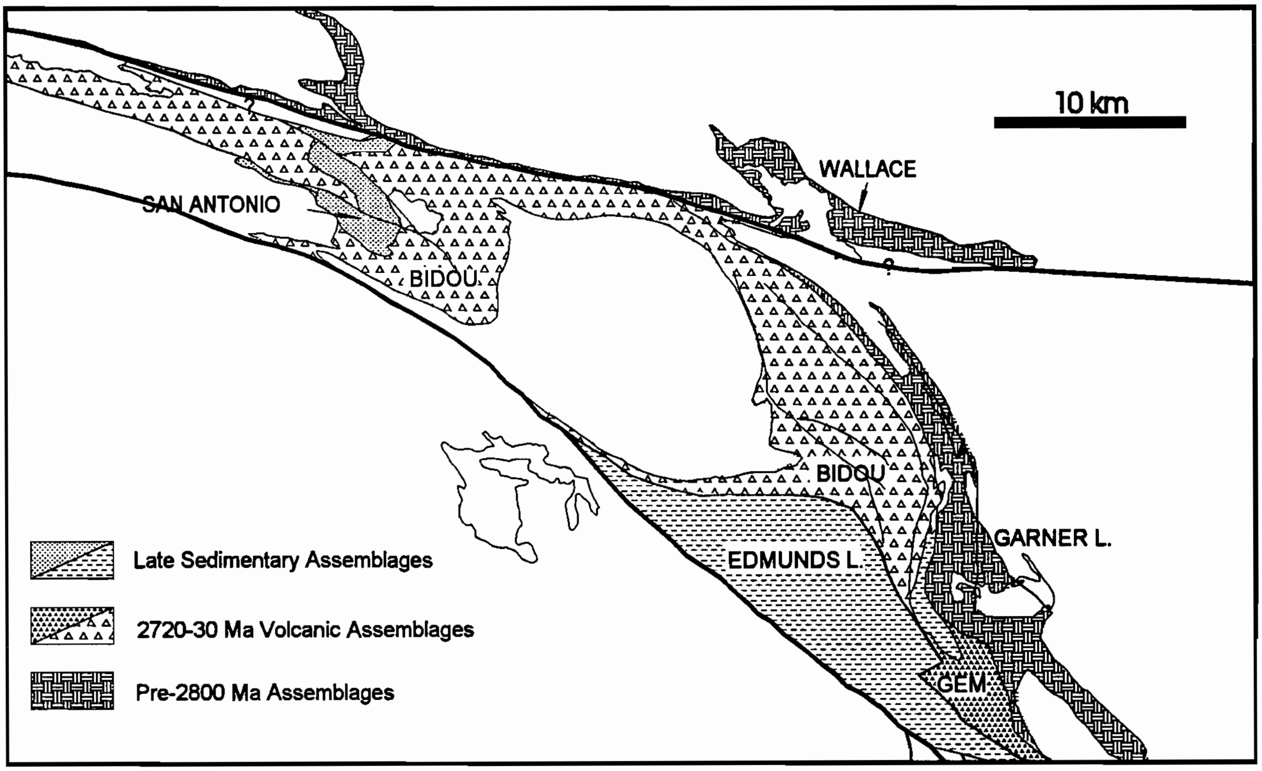



Figure 15: A re-interpretation of the regional geology of the Rice Lake Greenstone Belt as being composed of distinctive assemblages (subgroups) of different age and of uncertain relationships to one another.

Table 3: Main Supracrustal Elements of Rice Lake Belt

| Assemblage Name | Age Constraints | Lithological Characteristics | Structural Characteristics | Uchi Equivalents* | Tectonic Interpretation* |
|---|---|---|---|---|---|
| Wallace Lake | <3000 Ma >2920 Ma | quartzite, iron-formation, komatiites (?); | inferred to overlie equigranular 3000 Ga granitoid basement; overlain by basalts of unknown age | Ball Assemblage | shallow submarine to subaerial sedimentation and volcanism |
| Garner Lake | >2870 Ma | komatiites, mg- and Fe-basalt, iron-formation | basement unknown but possibly metasedimentary; mainly fault- bounded | Balmer Assemblage | oceanic mafic plain |
| Bidou Lake | >2729 Ma | basalt-andesite-dacite; minor ss and congl. | basement unknown | Confederation Assemblage | arc volcanism |
| Gem Lake | 2720 - 2730 Ma | basalt-rhyolite- ignimbrite | conformably overlies Bidou Lake? - in fault contact with Garner Lake? | St. Joseph Assemblage | arc volcanism - proximal and vent facies |
| Edmunds Lake | <2720 Ma >2650 Ma | graded metagreywacke; argillite; minor congl., Fe fm | possible conformable contact (faulted?) with underlying Gem Lake | Billett Assemblage; English River Assemblage | late-orogenic turbidite basin; fore-arc wedge |
| San Antonio | < 2730 Ma | trough cross-bedded quartz- and lithic-arenite; minor congl. | intact unconformable contact with underlying Bidou Lake | none | alluvial-fluvial molasse basin |

* after Stott and Corfu, 1991

Although there is still much to be learned about the origin of these assemblages and their interrelationships, there are some clear alternatives of interpretation. The distribution of the assemblages suggests an original age and lithological progression from northeast to southwest: older Mesoarchean quartz arenite- bearing Conley Formation (Wallace Lake) and komatiite-bearing successions (Garner Lake) are both cut by ultramafic intrusions and give way southward to Neoarchean tholeiitic and calc-alkaline volcanic rocks and subvolcanic intrusions formed mainly between 2730 and 2720 Ma in a submarine to locally subaerial arc (Bidou Lake, Gem Lake). Flyschoid rocks (Edmunds Lake) were deposited southward of this arc, possibly in a forearc accretionary wedge and molassic rocks (San Antonio) were deposited in more restricted basins, presumably in response to rapid uplift of the arc volcanics during faulting under transpressional conditions.

Although the above interpretation is feasible in light of available data, there are uncertainties and unresolved issues surrounding it. First, it is not clear whether the inferred Neoarchean volcanic arc was formed directly on Mesoarchean sialic basement or whether it was essentially ensimatic and subsequently placed there along (thrust?) faults. This uncertainty stems from the difficulty of accurately identifying and interpreting the nature of the contacts between older and younger volcanic rocks which all display similar field characteristics. A possible clue, which suggests the direct deposition of the Bidou and Gem Lake volcanic rocks on the older basement, is the fact that the Wanipigow Plutonic Complex contains large volumes of equigranular and locally porphyritic tonalite that is identical in composition and, in one case,in age to the subvolcanic Ross River intrusion (Turek et al., 1989), in the greenstone belt. This might be interpreted to indicate that the volcanic rocks of the Rice Lake belt are but one higher level manifestation of a much wider circa 2730 Ma magmatic arc that extended well into the Wanipigow Complex where subsequent uplift has resulted in the preservation of only the deeper roots of the arc. A second point of uncertainty involves the relationship of the Edmunds Lake Formation to the other supracrustal assemblages of the region. Local field relationships suggest a near conformable transition from arc volcanic rocks of the Bidou Lake Subgroup into volcanic-derived turbidites (see below). On the other hand, similar relationships are observable where the turbidites are in contact with the Garner Lake and Gem Lake Subgroups. Furthermore, D. W. Davis (pers. comm., 1994) has identified zircons in the turbidites that suggest a circa 3000 Ma provenance for some of the detritus in these sediments and therefore not an entirely local derivation. These inconsistencies either indicate that the Edmunds Lake turbidites are, in most places, in fault contact (unexposed) with adjacent volcanic rocks or that, despite local appearances of conformity, they were deposited above a profound unconformity at a regional scale.

## ECONOMIC GEOLOGY

There are more than 200 gold occurrence in the Rice Lake Greenstone belt (Fig. 16). They occur mainly in the circa 2730 Ma volcanic rocks and associated synvolcanic intrusions. With the exception of the Ogama-Rockland deposit which is hosted by tonalite of the Ross River pluton and the Jeep Mine which occurs in older gabbro of the Wanipigow Plutonic Complex, most of the significant gold deposits in Rice Lake belt are hosted by rocks of a restricted stratigraphic interval that is dominated by epiclastic volcanic rocks, basalt flows and layered gabbroic sills of the Bidou Lake Subgroup (Fig. 17). Judging by the detailed mapping of layers and bulk chemical trends, the sequence of layering in gabbros is similar across the belt, from a melagabbroic base to a commonly quartz-bearing, leucogabbroic top. Quartz veins at the Central Manitoba, Mirage, and Oro Grande deposits are hosted directly by leucogabbro but the epiclastic and basaltic rocks in the Beresford Lake area also host significant veins.

Although there are a multitude of gold occurrences in Rice Lake District, each with its unique attributes of structure, host rocks and alteration, there are several first order generalizations which pertain to the most significant deposits (Fig. 17). Points of consideration as the basis of an exploration model in this district include:

i) At a regional scale, most significant deposits occur in a restricted stratigraphic interval that marks the transition from volcanic units that are predominantly composed of basalt to those composed of porphyritic dacite. The interval of transition is marked by the presence of epiclastic rocks, extensive gabbroic sills and locally, banded iron formation. Although the full significance of this lithological association is not obvious,

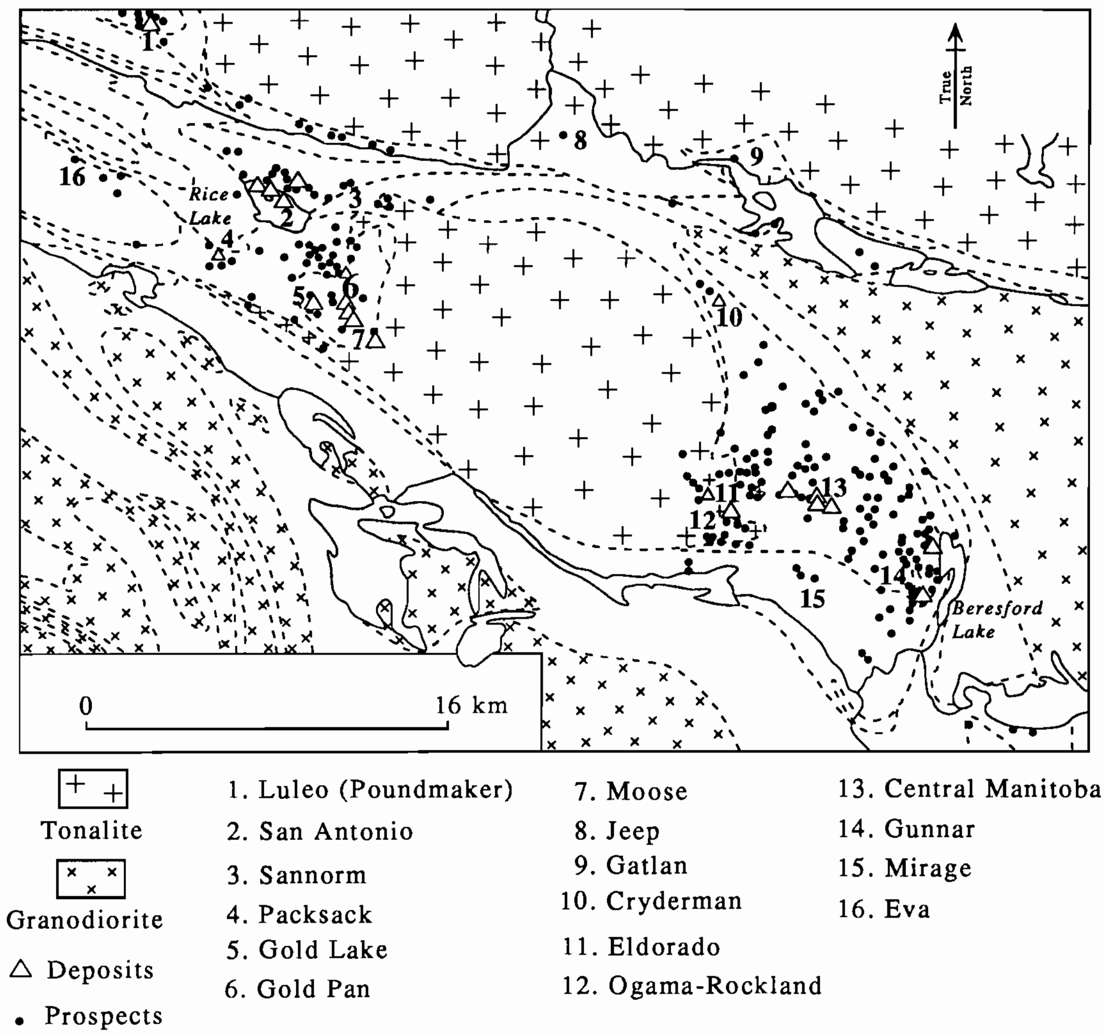
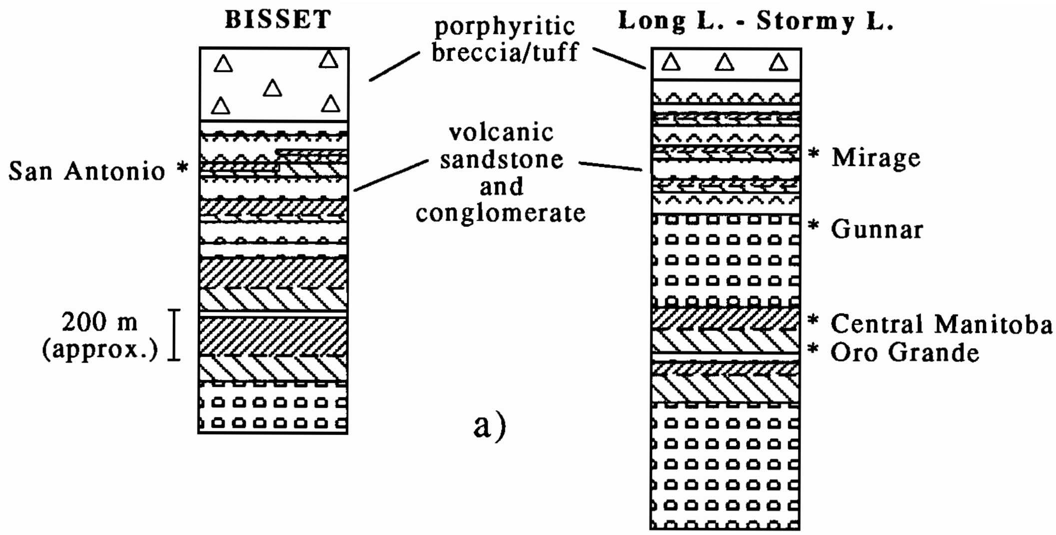
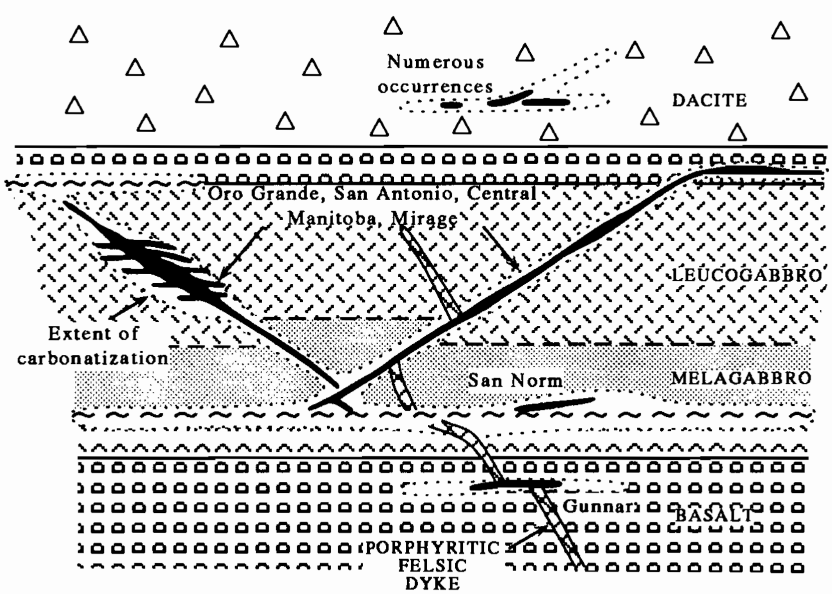



Figure 16: Distribution of known gold deposits and occurrences in Rice Lake Belt (adapted from Stockwell, 1941).




a)




b)

Figure 17: a) Stratigraphic setting of some of the major gold deposits in the Rice Lake Belt.

b) Schematic diagram illustrating the interrelationships of stratigraphic position, structure and distribution of alteration for some of the major gold deposits in the Rice Lake Belt (after Poulsen, 1989).

the structural anisotropy afforded by the intercalation of these rock types is one factor that locally controls the location of veins.

ii) Two dominant types of structures host productive veins: veins that are longitudinal with respect to lithological contacts are a product of layer-parallel shear whereas those that are transverse are likely the result of local layer-parallel elongation and shortening of the stiffest members of the stratigraphic sequence. Not all such structures formed simultaneously, nor are they all prospective hosts for auriferous veins. Early formed reverse faults are most favourable, but these are not easily distinguishable from younger structures on the basis of orientation alone because successive generations of structures resulted in probable reorientation, overprinting and reactivation of the earliest structures. The interpretation consistent with deposit-scale observations is that most formed during or prior to D2 deformation and are overprinted by at least D3 structures (Lau, 1988; Brommecker, 1991).

iii) CO2-bearing fluids of similar composition were present during the development of virtually all veins and shear zones (Diamond, 1989; Diamond et al., 1989), regardless of their relative age and gold content. The intensity of carbonatization adjacent to structures is not directly related to gold deposition nor to progressive changes in fluid composition. However there is a direct relationship between carbonatization and fracturing and, in that sense, the recognition of such alteration is a useful guide to potential auriferous structures, if not to gold itself.

## FIELD TRIP STOPS

The field trip is organized into a series of stops that are to be made over a period of three days (Fig. 18). Some of the stops are optional owing to more difficult logistics but their descriptions are included for completeness.

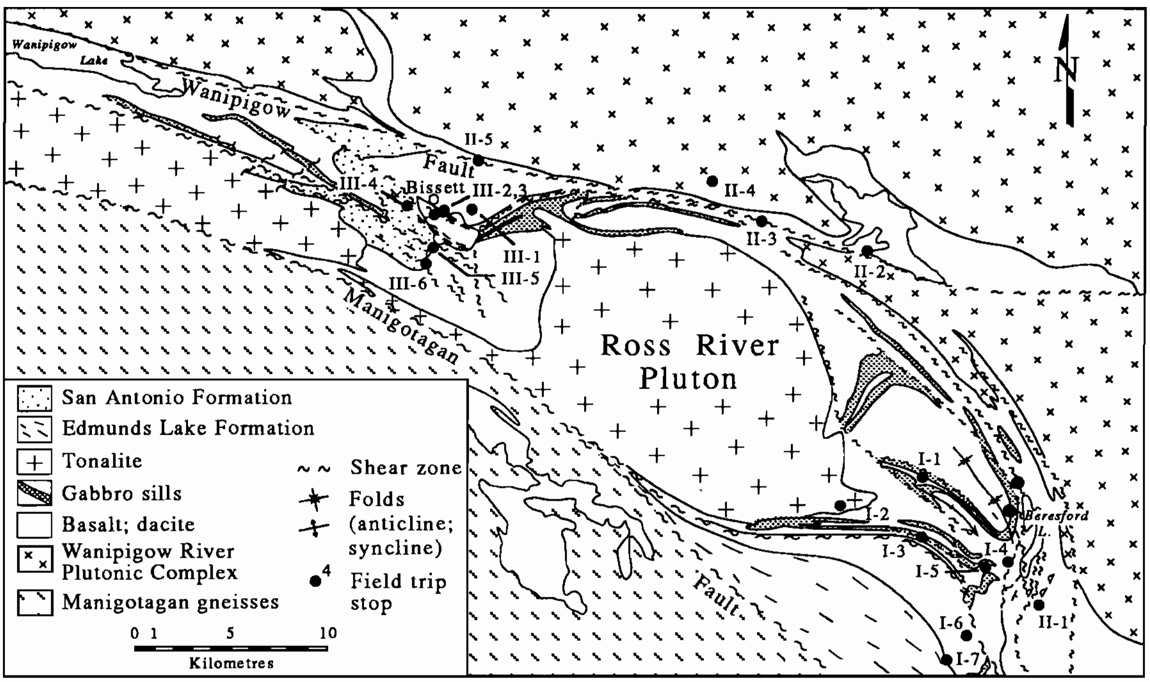



Figure 18: Simplified geological map to the Rice Lake Belt showing the locations of Field Trip Stops.

## Day 1: The Long Lake - Stormy Lake - Manigotagan River Area

This part of the field-trip will mainly examine the characteristic lithologies that constitute the Bidou Lake Assemblage which is part of the 2730-2720 Ma arc-like assemblage and, volumetrically, the most abundant supracrustal package in the belt. Typical examples of gold mineralization as well as structural features will also be examined.

Drive east from the town of Bissett on Highway 304 for 34.2 km until you pass a large area of rusty tailings on both sides of the road. Continue past the tailings for 200 m and turn right on to a side road leading to the abandoned waste dump of the Central Manitoba Mine.

### Stop I-1: The Central Manitoba Mine

The Central Manitoba Mine milled approximately 395,000 Tonnes of ore grading 12.6g/t gold between 1927 and 1937. The mine produced gold from a series of veins in shear zones located within or along the margin of a differentiated, east-southeast striking, south dipping, gabbro sill (Fig. 19). The shear zones also strike east-southeast as well and dip steeply to shallowly to the south. The northward dipping South Carbonate Shear and southward dipping North Carbonate Shear form a wedge-shaped domain that bounds the zone of mineralization (Fig. 19). An excellent description of the underground development and the geology of the deposit as a whole can be found in Stockwell and Lord (1939).

***Stop Descriptions:***

Locality a: The Kitchener Vein and Central Manitoba Gabbro

From the parking area walk approximately 300 m west across the remains of the mine waste pile and through the bush to a series of low outcrops near the abandoned Growler shaft.

Here, the Kitchener Vein, which produced over 90% of the gold from the Central Manitoba Mine and the differentiated gabbro sill, which hosts mineralization elsewhere, will be examined (Fig. 20). The vein is located in a shear zone at the contact between the gabbro sill and a thin band of tuffaceous, cherty sedimentary rocks. Ore shoots in the vein plunge shallowly to the east and are localized in s-shaped folds in the shear zone (Stockwell and Lord, 1939). A stereographic projection (Fig. 19) summarizes the structural features associated with the Kitchener Vein. The quartz vein is enveloped in a narrow zone of quartz-carbonate-chlorite-pyrite alteration. Ore mineralogy consists of pyrite, chalcopyrite, minor pyrrhotite and gold.

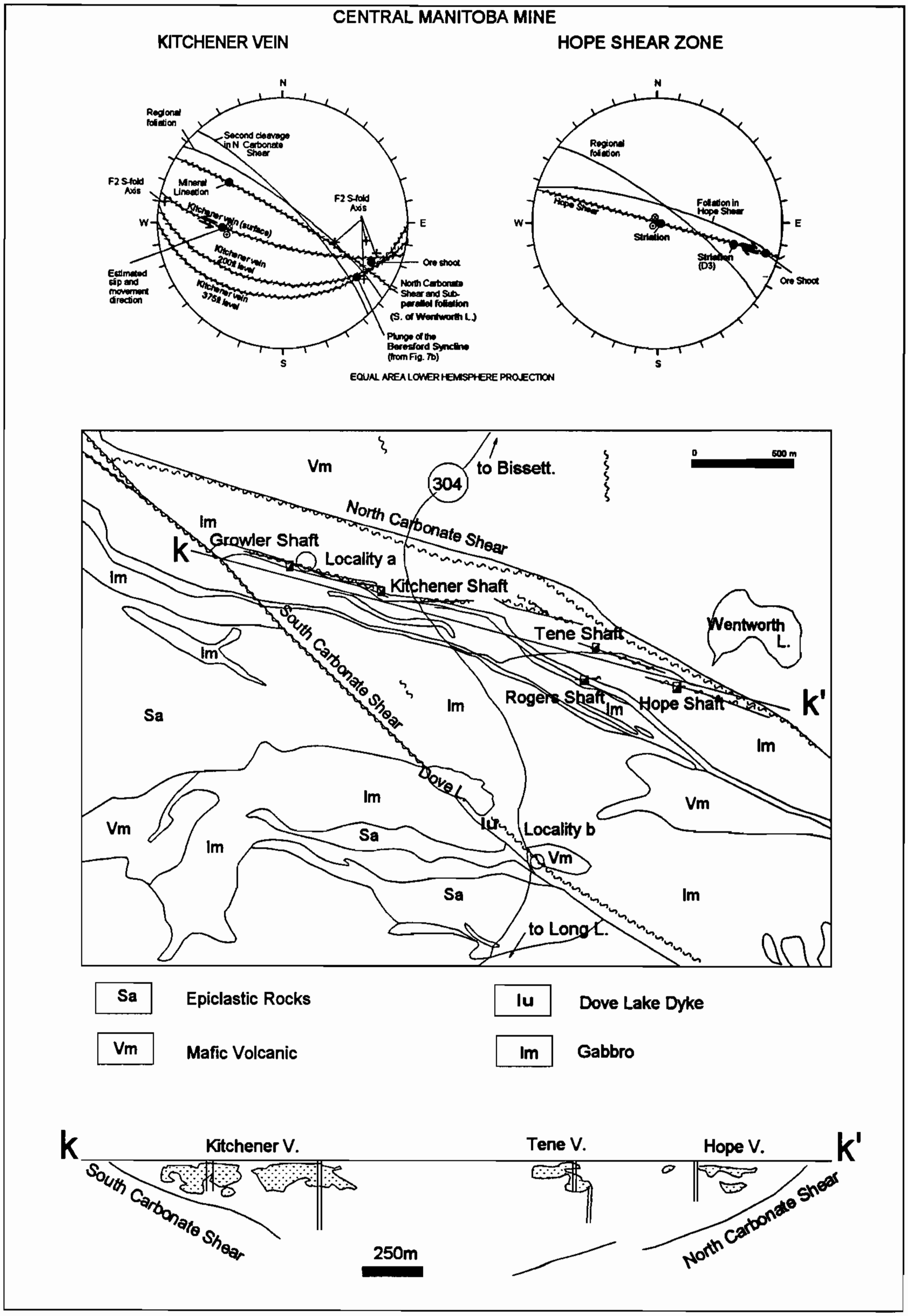



Figure 19: Geological sketch map of the area around the Central Manitoba Mine (after Stockwell and Lord, 1939; Brommecker, 1991)

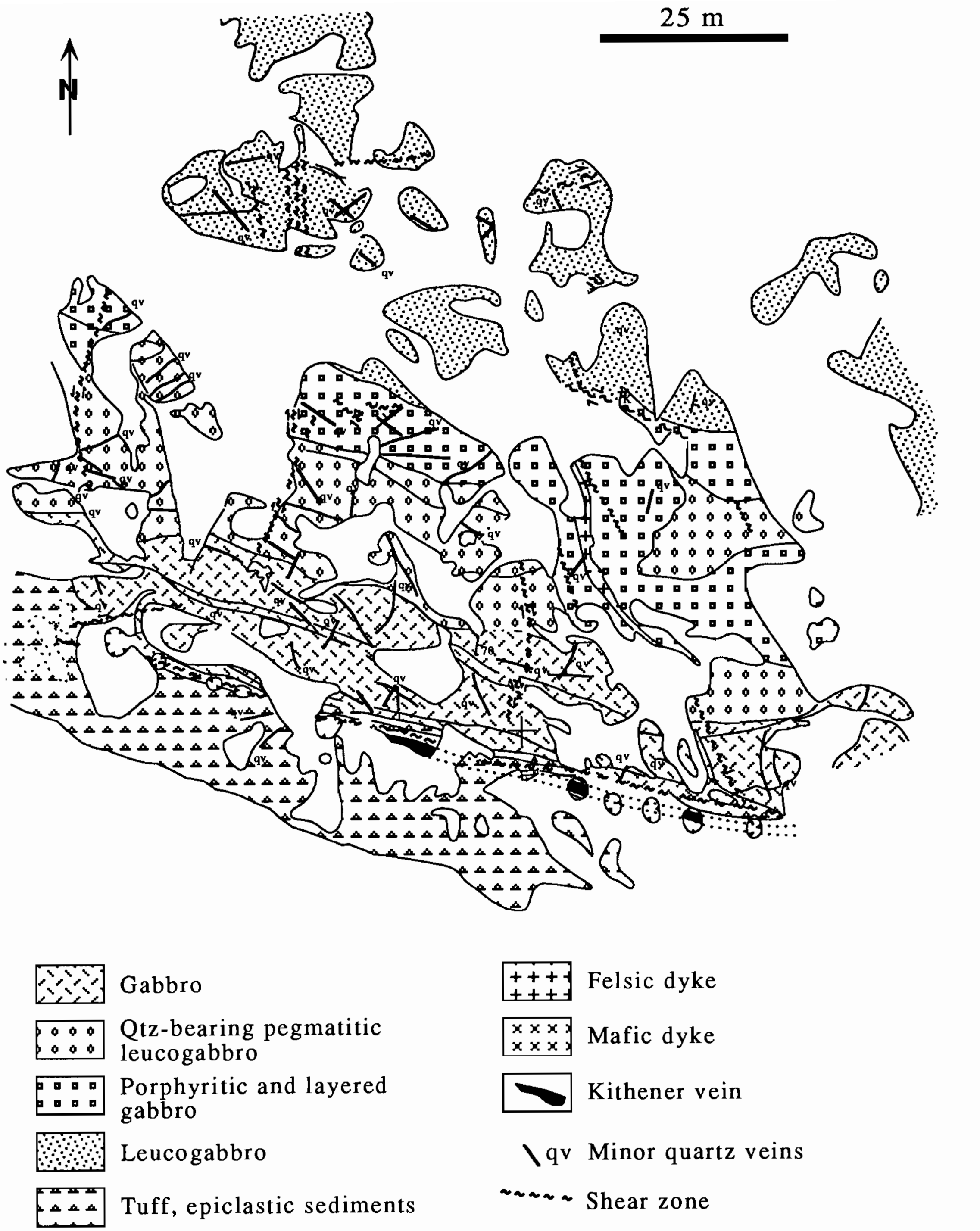



Figure 20: Geological sketch of the outcrops in the vicinity of the Kitchener Vein, Central Manitoba Mine (mapping by R. Brommecker, S. B. Green, K.A. Baker, Lin Baoqin, Shang Ling, Shen Ershu, and Zhang Lidong).

The southern, uppermost third of the gabbro sill at this locality is distinctly more leucocratic and texturally varied than the lower, northern two thirds of the sill. The top third is also characterized by zones with pegmatoid patches and visible quartz whereas the lower part is more equigranular and has no quartz visible to the naked eye. Most sills in the Rice Lake belt display this differentiation and the more fractionated portions can be important hosts to gold minralization. In fact, the eastern end of the Kitchener Vein extends into this part of the Central Manitoba Sill and the Tene Vein is entirely hosted by it (Fig. 19).

Return to the highway and drive south 1.6 km and park at the side of the road. Outcrop is on left side of road.

Locality b: The South Carbonate Shear and Dove Lake Dyke

The regionally important South Carbonate Shear (Fig. 19) is intruded by the Dove Lake Dyke in this location. The Dove Lake Dyke is compositionally zoned, from cortlandite at its northwest end to quartz diorite at its southeast end. At this stop the dyke is a "cortlandite" (Scoates, 1971) which is an ultramafic intrusion with many relict strongly pleochroic (red-brown to greenish-brown) igneous hornblende crystals poikilitically enclosing polygonal pseudomorphs of olivine and/or pyroxene.

Continue south on Highway 304 for 1.4 km and turn right toward Long Lake at the T-intersection with Provincial Road 314. From this T-intersection drive 5.2 km until you reach a park plaque indicating you have arrived at the Ogama-Rockland Mine.

**Stop I-2: The Ogama-Rockland Mine**

The Ogama-Rockland Mine produced approximately 134,000 Tonnes of ore at a grade of 12.3 g/t during sporadic operation from 1942 to 1951. Production was from narrow veins within the tonalitic rocks of the Ross River Pluton. The shear zones hosting the gold-bearing veins dip steeply to the northeast (Fig. 21). The largest ore shoot plunges steeply in the Ogama Shear and, according to Troop (1949), the "major ore shoots appear to be connected with warpings in the shear plane". The ore shoot is broadly coincident with a right step (a bend to the right viewed along the strike of the shear zone) and a slight change in the attitude of the shear zone to a more northernly orientation to the south of the ore shoot.

Striations and mineral lineations plunge shallowly to the northwest in the Ogama Shear where it outcrops just northwest of the shaft (Fig. 21). Foliation in the shear zone is oblique to its boundaries in such a way as to indicate dextral movement. Furthermore, a steeply dipping quartz-feldspar porphyry dyke displays dextral offset by the Ogama Shear (Fig. 21). The Ogama Shear is therefore a dominantly dextral strike-slip structure. This interpretation is consistent with Troop's (1949) statement that "the relative movement of the hanging wall was to the SE". The ore shoot in the Ogama Shear is therefore in the dilational zone of a fault jog.

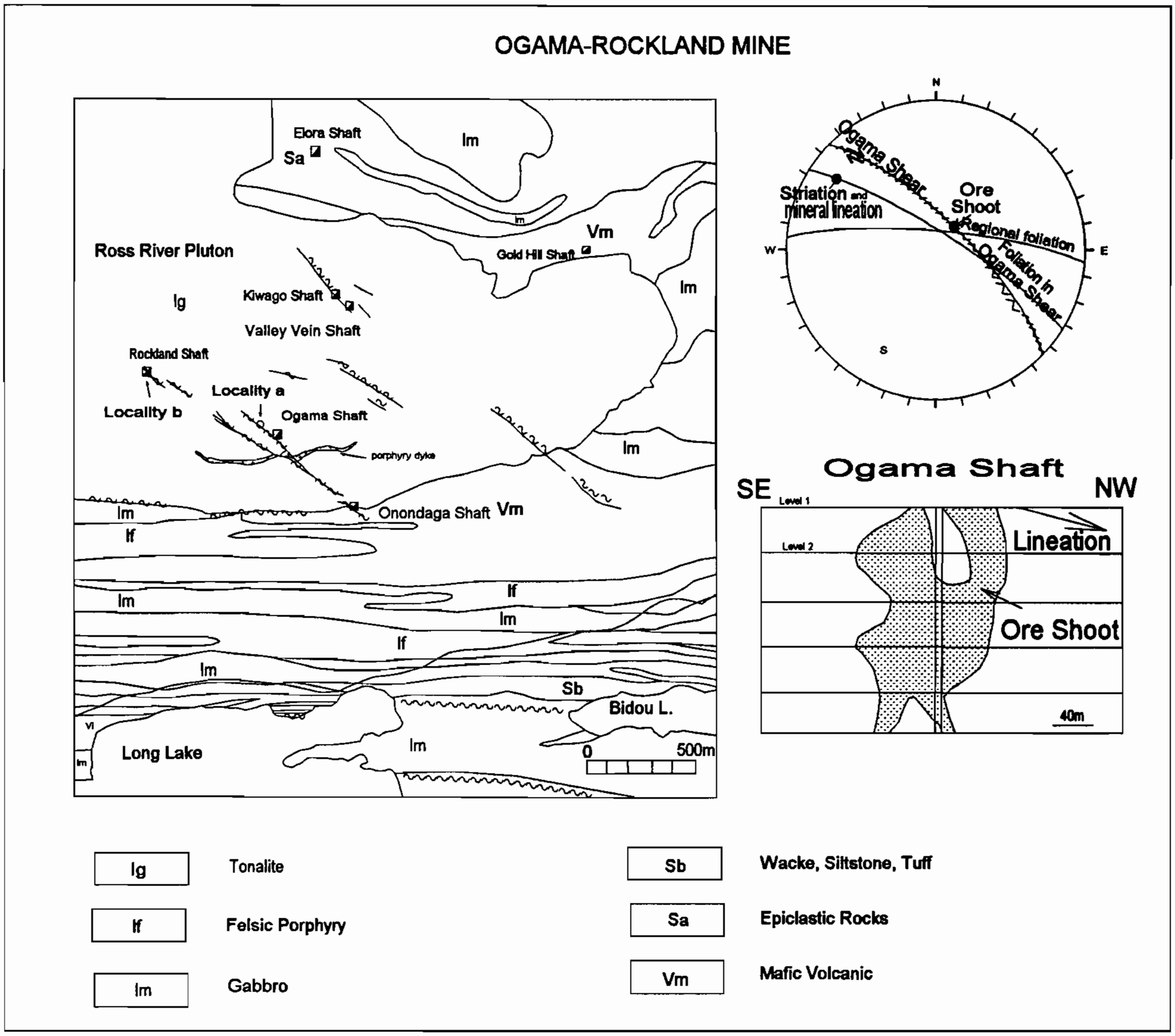



Figure 21: Geological sketch of the geology in the vicinity of the Rockland, Ogama and Onondaga veins, Long Lake area.

***Stop Description:***

At this stop we will examine the Ogama Shear zone at locality 1 (Fig. 21) and the Rockland Shear at locality 2 (Fig. 21).

Locality a: The Ogama shear

The shear is exposed about 100m NW of the Ogama Shaft and contains little significant veining. Dextral shear sense indicators can be seen along with shallow lineations. The tonalite to quartz-diorite host rock is strongly foliated and altered to assemblages containing abundant sericite, carbonate, and pyrite.

Locality b: the Rockland vein

The vein is exposed here and typical ore material can be found on the waste pile. Again alteration of wall rocks is narrow and consists of sericite-carbonate-pyrite with ore-veins consisting mainly of quartz-carbonate-pyrite-chalcopyrite and traces of galena, sphalerite, and arsenopyrite.

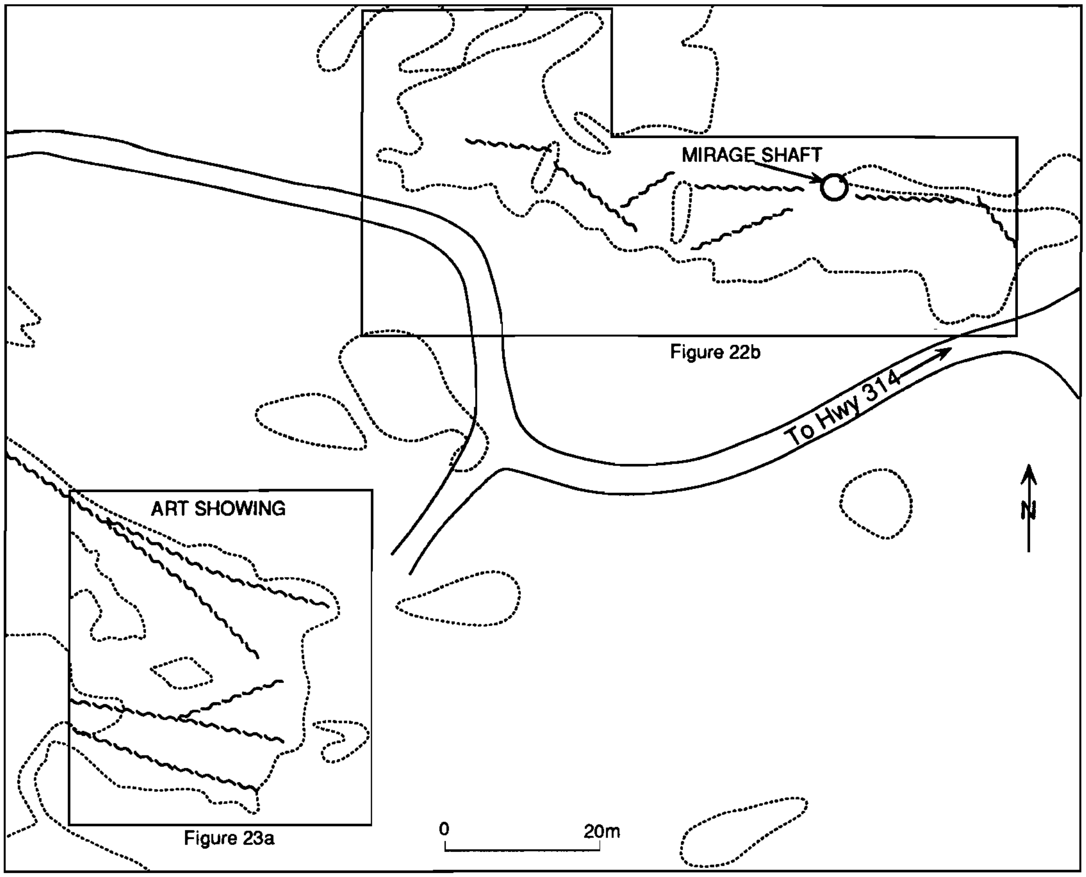
Return to Long Lake and continue east to the T-intersection with Provincial Road 314. From the intersection continue straight (southeastward) along Road 314 for 1.0 km. Park near a bush trail on the right. Walk south and west along the bush trail 1.5 km.

**Stop I-3: The Mirage Mine**

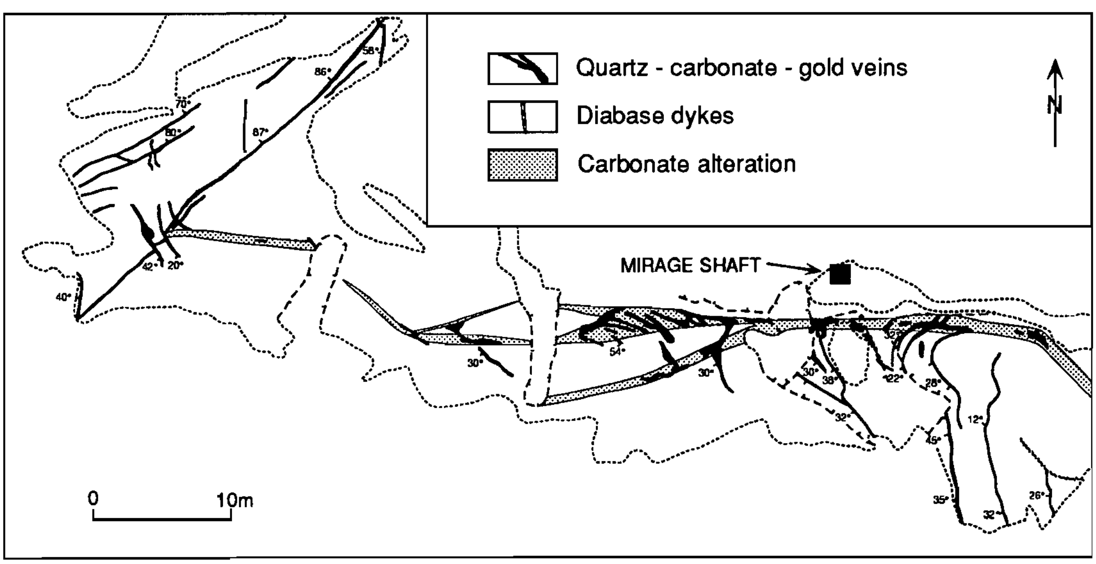
The Mirage mine has no significant recorded gold production. It was, however, the object of extensive exploration by Esso Minerals in the 1980's and is an excellent example of the type of metagabbro-hosted mineralization that is so common in the Rice Lake belt. Coarse gold occurs in quartz-ankerite veins in and around, a complex network of shear zones (Fig. 22). Iron- carbonate, sericite, and chlorite are the main alteration minerals. Sulfides, mainly pyrite, are minor. Mineralization is within a very thick layered gabbro sill and is generally confined to an anorthositic-gabbro unit of the sill. The geology of the occurrence has been described in detail by Keith (1988).

***Stop Description:***

Here we examine exposures in the Mirage Shaft Area (locality a, Fig. 22) and at the Art Showing (locality b, Fig. 22) which typify the complex vein and shear zone networks that can occur in the competent gabbro host rocks.




a




b

Figure 22: a) Geological sketch of the Mirage deposit (from Brommecker, 1991).
b) Sketch of veins and alteration near the Mirage Shaft.

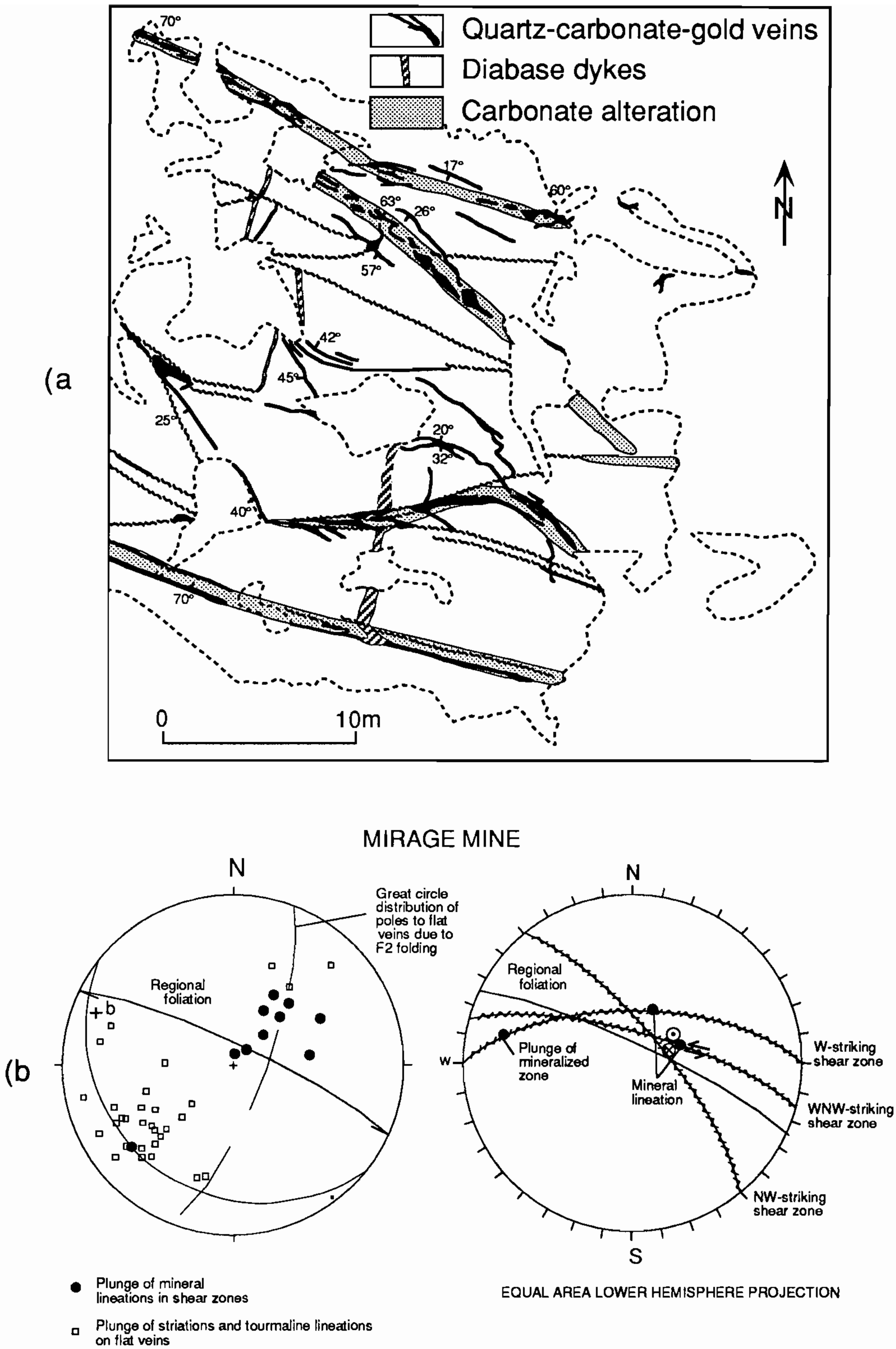



Figure 23: a) Sketch of veins and alteration at the Art Showing (after Brommecker, 1991)

b) Stereographic projections illustrating the orientations of structures at the Mirage deposit.

Two types of gold-bearing veins are present at both localities: 1) steeply dipping veins in shear zones and 2) shallowly dipping "flat" veins. The steeply dipping veins occur as lenses, pods, and short tabular bodies along linear zones of highly strained and altered rocks. The flat veins are 1-5cm wide continuous veins that occur near, and often extend away from, the zones of high strain (Fig. 22). The flat veins commonly display the morphology of an extensional vein. However, they also commonly contain what appear to be slickensided planes parallel to their walls that contain a pronounced down-dip lineation formed by the alignment of tourmaline crystals. The tourmaline crystals are parallel to striations observed on some vein surfaces. Both the flat veins and shear zone-hosted veins contain visible gold, but according to Keith (1988) and Grant (1987) gold is most abundant in the flat veins. Preliminary drilling by Esso Minerals in 1987 indicated that the zone of mineralized flat veins near the Mirage shaft (Fig. 22) plunges shallowly to the west (Grant, 1987). Fig. 23 summarizes the orientations of the structures that can be observed in this area.

Return to Provincial Road 314 and continue eastward for 4.0 km until you reach the intersection with the road to Beresford Lake Campground. Turn left and continue along this road for 1.5 km. Turn left onto a dirt road into the abandoned Gunnar Mine site.

**Stop I-4: The Gunnar Mine and Gunnar Formation of the Bidou Assemblage**

The Gunnar Mine produced 259,681 tonnes of ore at a grade of 11.9 g/t from 1936 to 1942. Most of the ore came from narrow quartz veins and lenses in the No. 1 Shear where it intersects a quartz-feldspar porphyry dyke. Sulfides associated with the mineralization within the quartz vein consist mainly of pyrite and minor sphalerite, pyrrhotite, and galena. Narrow (1-30cm) zones of alteration around the veins include ankerite, sericite, chlorite and pyrite.

The Gunnar Mine is located near the axis of the Beresford anticline (Fig. 24). The deposit is within the pillowed and massive mafic volcanic flows of the Gunnar Formation. The Gunnar Formation in the area is intruded by a number of felsic to intermediate porphyry dykes which are parallel and strike north-northwest and dip east-northeast. Thin beds of interflow sediment or pillow breccia mark the boundaries of flows. The flows in the mine area generally strike southeast and dip steeply to the southwest (Fig. 24). Some sedimentary beds were loci of strain and are highly sheared. The shear zones hosting gold-bearing veins strike and dip parallel to flow contacts (i.e. strike southeast to east-southeast and dip steeply southwest).

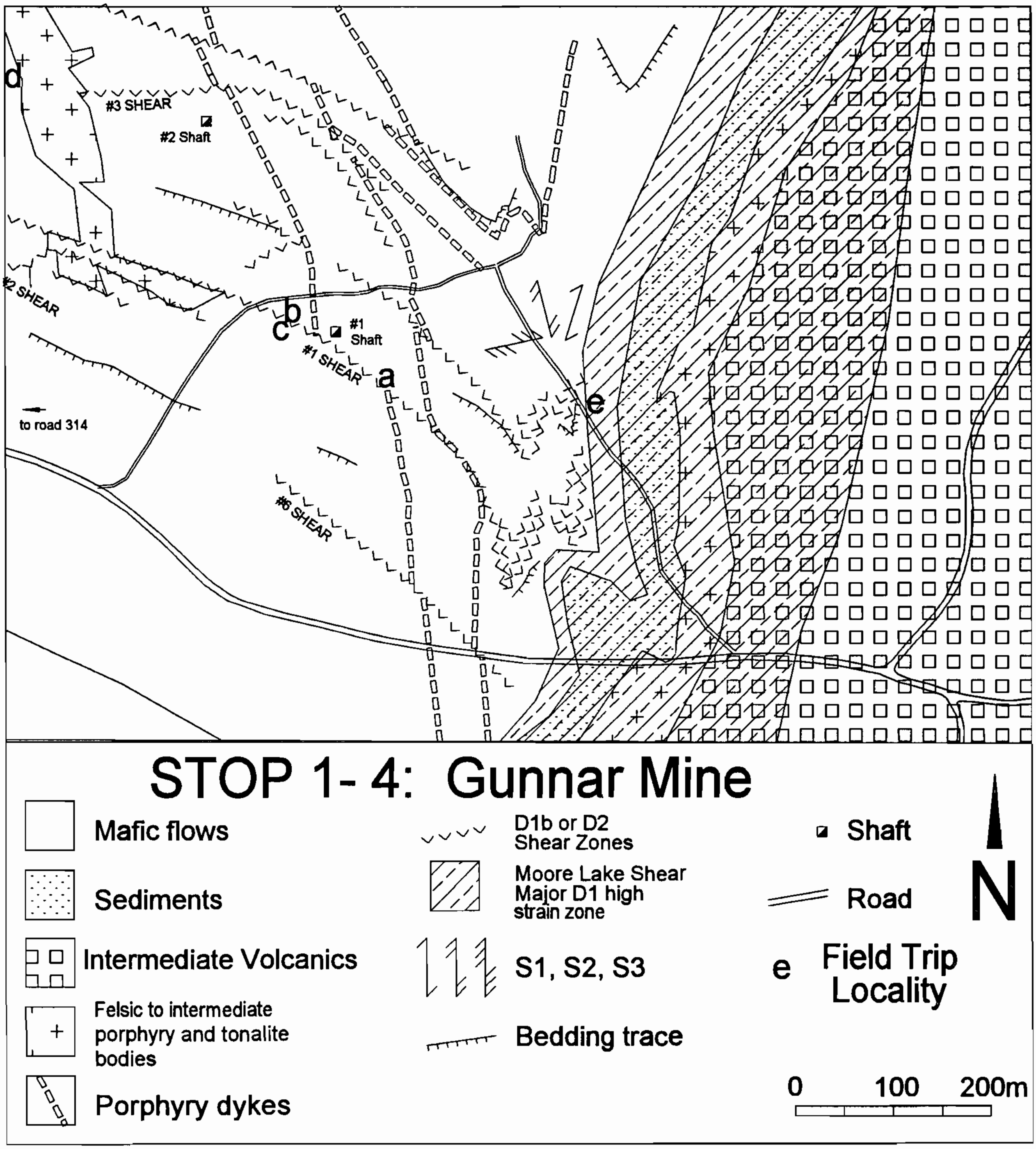



Figure 24: Geological sketch of the Gunnar Mine area (after Stockwell and Lord, 1939; Brommecker, 1991).

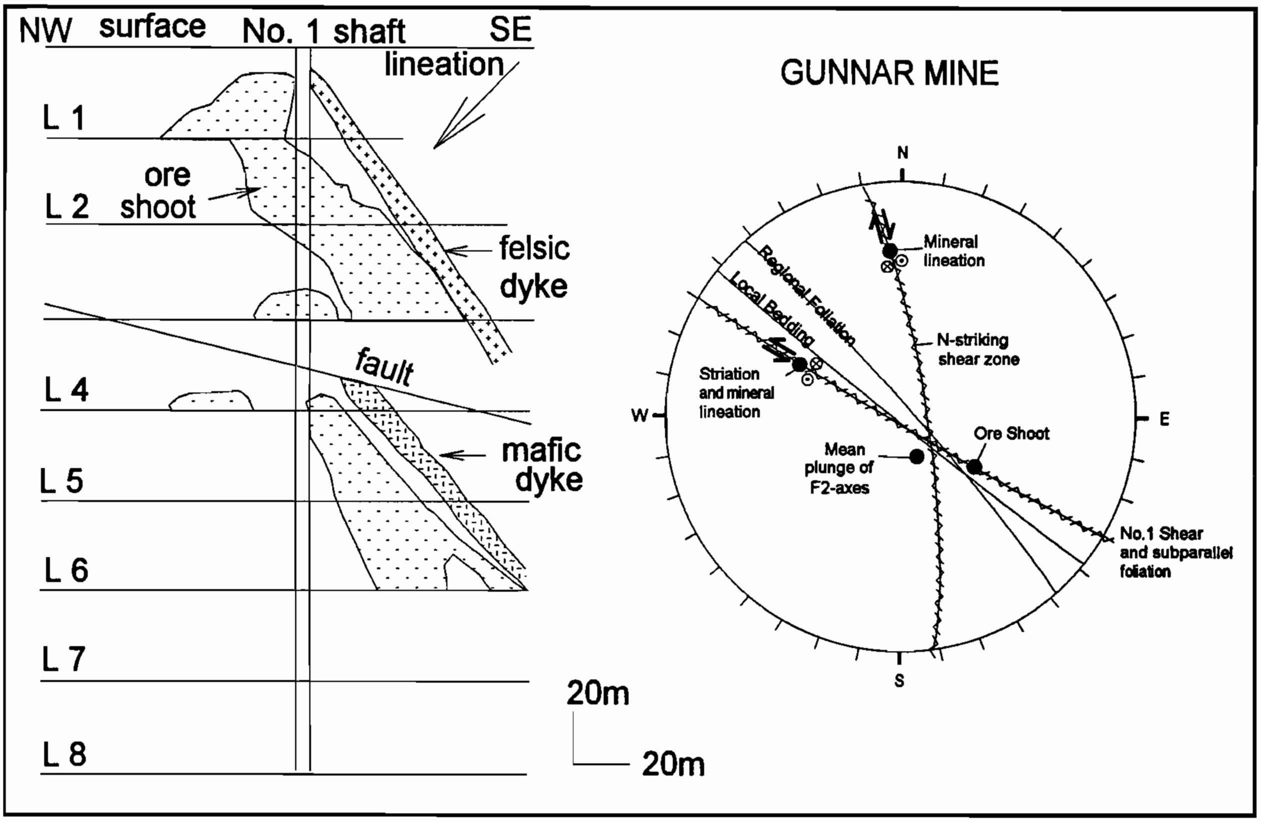



Figure 25: Structure of the Gunnar Mine. a) Longitudinal section, b) stereographic projection.

The geology and development of the Gunnar Mine has been described in detail by Stockwell and Lord (1939), Shepherd (1939), and Lord (1942). Important aspects of the underground development as described by the above authors is summarized below. There were two main ore shoots in the mine, both within the Gunnar No.1 Shear (Fig. 25) and separated by a gently dipping fault. The upper ore shoot coincided with the intersection of the shear and a quartz-feldspar porphyry dyke and the lower ore shoot coincided with the intersection of the shear and a biotite lamprophyre (probably the hornblende-biotite diorite mapped in this study and shown as "mafic dyke" on Fig. 25). The lamprophyre is mostly undeformed, although locally it is cut by stringers of auriferous quartz. Lord (1942) concludes that the lamprophyre dyke was intruded near the end of the shearing and that the vein quartz was introduced shortly after intrusion of the dyke.

Figure 25 summarizes the main structures that are observations in the Gunnar Mine area. The interpreted movement direction on the No.1 Shear is perpendicular to the plunge of the ore shoots in it. The geometric relationship of the lineations, ore shoots and attitude of the shear zone indicate that the ore shoots are located on a compressional fault bend.

***Stop Description:***

Numerous features will be examined at various localities in the Gunnar Mine area (Fig. 24):

Locality a: East end of the Gunnar No.1 Shear Zone

The shear zone has no significant veining or mineralization at this location but early fractures can be observed to bend into it in a sinistral sense. The quartz-feldspar porphyry dyke that marks the eastern extent of the mineralization can also be examined here.

Locality b: Mineralized section of Gunnar No.1 Shear Zone

A massive to brecciated quartz vein containing pyrite and minor pyrrhotite, galena, and sphalerite is central to the shear zone. A thin alteration zone composed of ankerite, sericite, chlorite and pyrite envelopes the vein. Directly south of the vein, a set of porphyritic mafic dykes both cut and are cut by minor subsidiary shear zones. Good examples of pillowed basalt typical of the Gunnar Formation are also present in the adjacent outcrops.

Locality c: Gunnar No.3 Shear Zone cutting a body of tonalite

Porphyritic mafic (lamprophyre) dykes cut the tonalite and both are cut by the shear zone. The tonalite has been dated by Turek et al. (1989) at 2731+/-13 Ma and provides a minimum age for the Gunnar Formation and a maximum age for the shearing.

Locality d: Breccia dykes

Intrusion breccias near the edge of the tonalite body cut mafic volcanics of the Gunnar Formation at this locality.

Locality e: Moore Lake Shear Zone

The amount of deformation increases markedly and abruptly directly east of the Gunnar Mine. At this location, intense foliation and extreme transposition of layering defines the Moore Lake Shear zone which is one of the features which marks the attenuated eastern limb of the Beresford Anticline. Multiple foliations, minor folds and imbricated rock units are common in this outcrop.

Return to Provincial Road 314 and park at the Beresford Lake turn-off.

**Stop I-5: The Stormy Lake Formation of the Bidou Lake Subgroup**

At this stop we will make a short traverse across a typical section of the Stormy Lake Formation of the Bidou Lake Subgroup. A weakly differentiated sill will be examined where it intrudes iron formation and volcanic wackes and volcanic breccias which are part of a southward-facing sequence.

***Stop Description***

Sites to be examined (Fig. 26) include:

Locality a: N-S trending shear zone in gabbro with D3-kinks

Locality b: Coarse grained gabbro which is locally glomeroporphyritic

Locality c: Quartz-bearing leucogabbro.

Locality d: Medium grained gabbro showing intrusive contact with iron formation

Note typical F2-folds with axial-planar S2 cleavage at this location.

Locality e: Volcanic wackes, breccias, and tuffs of the Stormy Lake Formation

Note that the younging direction is to the south.

Continue south along Provincial Road 314 for approximately 5.2 km to a point 0.5 km north of the bridge across the Manigotagan River.

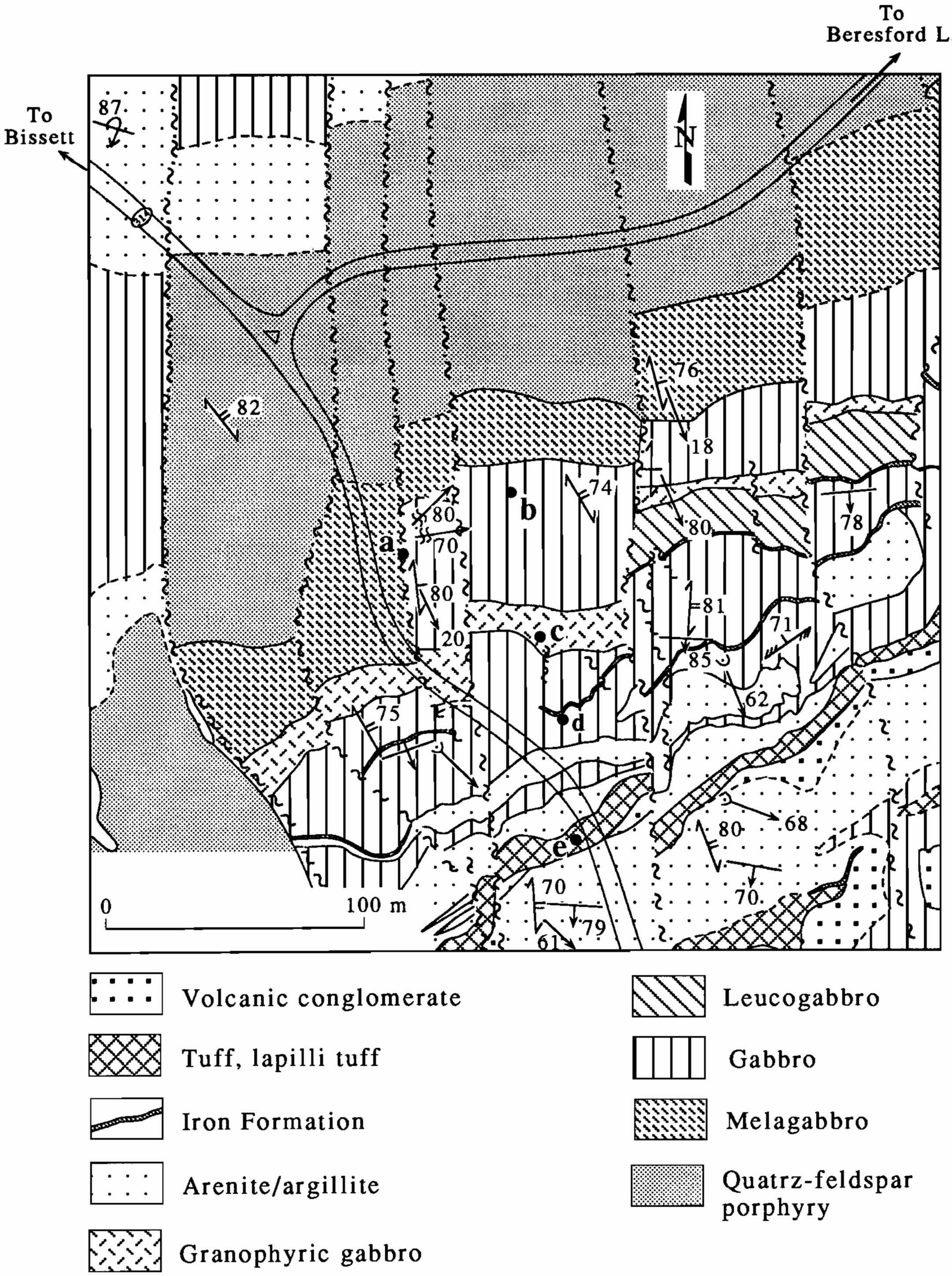



Figure 26: Sketch map of the geology of the Stormy Lake Formation as exposed in outcrops along Provincial Road 314 near the turnoff to Beresford Lake. (mapping by R. Brommecker)

**Stop I-6: The Narrows Formation Dacite and Glomeroporphyritic Gabbro**

The Narrows Formation, defined after bedrock exposures at The Narrows on Long Lake (Campbell, 1971), comprises mainly intermediate to felsic volcanic rocks which were deposited near or at the stratigraphic top of the Bidou Lake subgroup (Weber, 1971). The Narrows Formation overlies the Stormy Lake Formation of mixed intermediate and mafic volcanics and sediments and several older mainly mafic volcanic and sedimentary formations (Gunnar, Dove Lake, Tinney Lake, Stovel Lake and Unnamed basalt formations; Campbell, 1971; cf. Table 1). Seneshen and Owens (1985), who conducted the most detailed work in the Stormy Lake area, described three main lithologic units: (a) Lapilli tuff and crystal tuff; (b) heterolithic tuff breccia and (c) generally monolithic breccia. Both fragments and matrix are intermediate to felsic in composition. The formation has been interpreted as a succession of largely subaqueous origin, in part pyroclastic and in part laharic flows (Weber, 1971b).

A U-Pb zircon age of 2731±3 Ma (Turek et al., 1989) was obtained from the rhyodacite of The Narrows Formation to be examined at this stop (Fig 27). All the intermediate to felsic extrusive and intrusive rocks dated in the Rice Lake belt have given the same age of ca. 2730 Ma, with the exception of the Gem Lake Subgroup rhyolite dome, which is slightly younger (2722±2 Ma; Table 2). This includes the Hare's Island Formation intermediate to felsic volcanics (2731±3 Ma), rhyodacite breccia of the Black Island succession at the western end of the Rice lake greenstone belt (2732±10 Ma), dykes in the Beresford Lake area (2731±13 Ma), the Ross River quartz diorite, the largest intrusion in the belt, and tonalite in the Wanipigow plutonic complex (2731±13, 2731±10 Ma; Turek et al., 1989, Turek and Weber, 1991; Ermanovics and Wanless, 1983; cf. Table 2), suggesting that 2730 Ma intermediate to felsic magmatism in the Rice Lake greenstone belt is widespread and probably the most voluminous in the belt. In contrast to the Bidou Lake subgroup which ranges from basalts to rhyodacites (46-65% SiO2), the Gem Lake subgroup ranges from basalts to rhyolites (up to 70-75% SiO2). Although interpreted to being younger than the Bidou Lake subgroup (Weber, 1971b), and Gem Lake felsic volcanics indeed yield a slightly younger age than the Bidou Lake intermediate to felsic volcanic rocks, the two subgroups may be more spatially than temporally separated and are essentially co-magmatic.

The Bidou Lake Subgroup contains 10-30% gabbroic sills. Some of the largest ones are differentiated into gabbro and anorthositic phases, such as the Stormy Lake gabbro, others are spectacularly glomeroporphyritic, with up to football size plagioclase aggregates, particularly along contacts of the gabbro with the host rocks. Phinney et al. (1988) have done extensive petrogenetic studies on these megacrystic mafic rocks in Manitoba and elsewhere. They found that the megacrysts have higher anorthite contents (An 80-85) than the matrix plagioclase laths (An 60-70) suggesting that the megacrysts were not in equilibrium with their host melts at the time of dyke emplacement. Based on experimental and geochemical data they conclude that high pressure fractionation from a primitive mafic melt led to ascension of a fractionated less dense melt to a low pressure magma chamber (at 1-2 kb) where plagioclase

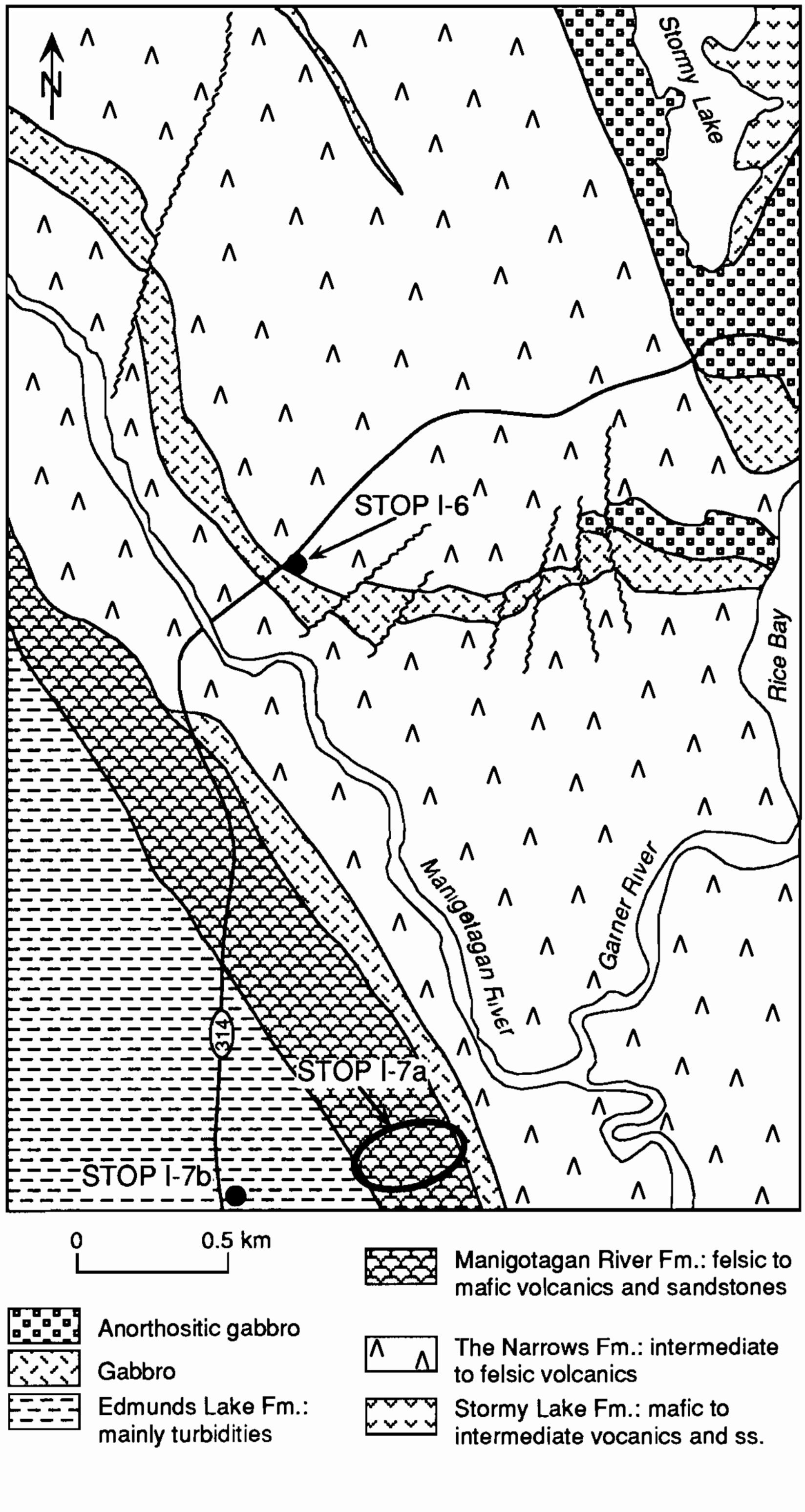



Figure 27: Sketch map of the geology of the Narrows and Manigotagan River Formations near Provincial Road 314 south of Stormy Lake.

megacrysts crystallized in anorthosite complexes and portions of these were flushed to the subsurface along with new melts flowing into the chamber.

***Stop description***

The outcrop to be examined is situated on the east side of Provincial Road 314, ca. 0.5 km north of the bridge over the Manigotagan River. The bedrock consists of massive dacite (to rhyodacite) with a joint-like fracture pattern along which greenish alteration is visible. If this fracture pattern is indeed a joint pattern it would imply a subaerial flow, although such flows have not been identified elsewhere in the Narrows Formation.

Walk farther east and examine the football gabbro with glomeroporphyritic phases, which are particularly well developed along the footwall (northern) contact of the gabbro with the volcanic rocks.

Continue along Provincial Road 314 to a point approximately 2.3 km south of the bridge across the Manigotagan River.

**Stop I-7: Manigotagan River and Edmunds Lake Formations**

The southwest facing Manigotagan River Formation represents the uppermost part of the Bidou Lake subgroup and marks a transition between the volcanic rocks of the Narrows Formation and the overlying sedimentary rocks of the Edmunds Lake Formation (Fig. 27). It consists of seven lithologically distinct members (Table 4) which include primary and reworked felsic to mafic volcanic rocks and minor mafic lava flows. The members range from 5 to 103m thick and, although somewhat variable in thickness, all members are continuous across the map area for 1.2 km. Two chronologically and compositionally different mafic sills occur in the sequence, one at the base of the formation, and the other separating members 3 and 4; discontinuous gabbro intrusions also occur in members 2 and 3.

There is an upward transition within the Manigotagan River Formation from felsic and mafic pyroclastic rocks in the lower part, through felsic, reworked pyroclastic rocks and mafic lava flows in the central part, to mafic lava flows and felsic pyroclastic rocks in the upper part (Fig. 28, Table 4). Felsic pyroclastic flow deposits at the base and top of the Formation (Members 1 and 7) were deposited subaqueously but were probably derived from subaerial eruptions. The subaqueous tephra-fall deposits (member 2) were probably derived from flank fissure-type phreatomagmatic eruptions. Member 3 represents a marked change in conditions; it is an upward coarsening, progradational, subaqueous fan succession. The lower thin-bedded turbidites (Fig. 28) represent an outer fan to basin plain environment. These grade upward to interchannel sandstones and siltstones and upward fining channel-fill conglomerate and sandstone sequences diagnostic of a mid-fan environment. The provenance was probably a subaerial, felsic to intermediate volcano; this is indicated by the compositions of clasts in the

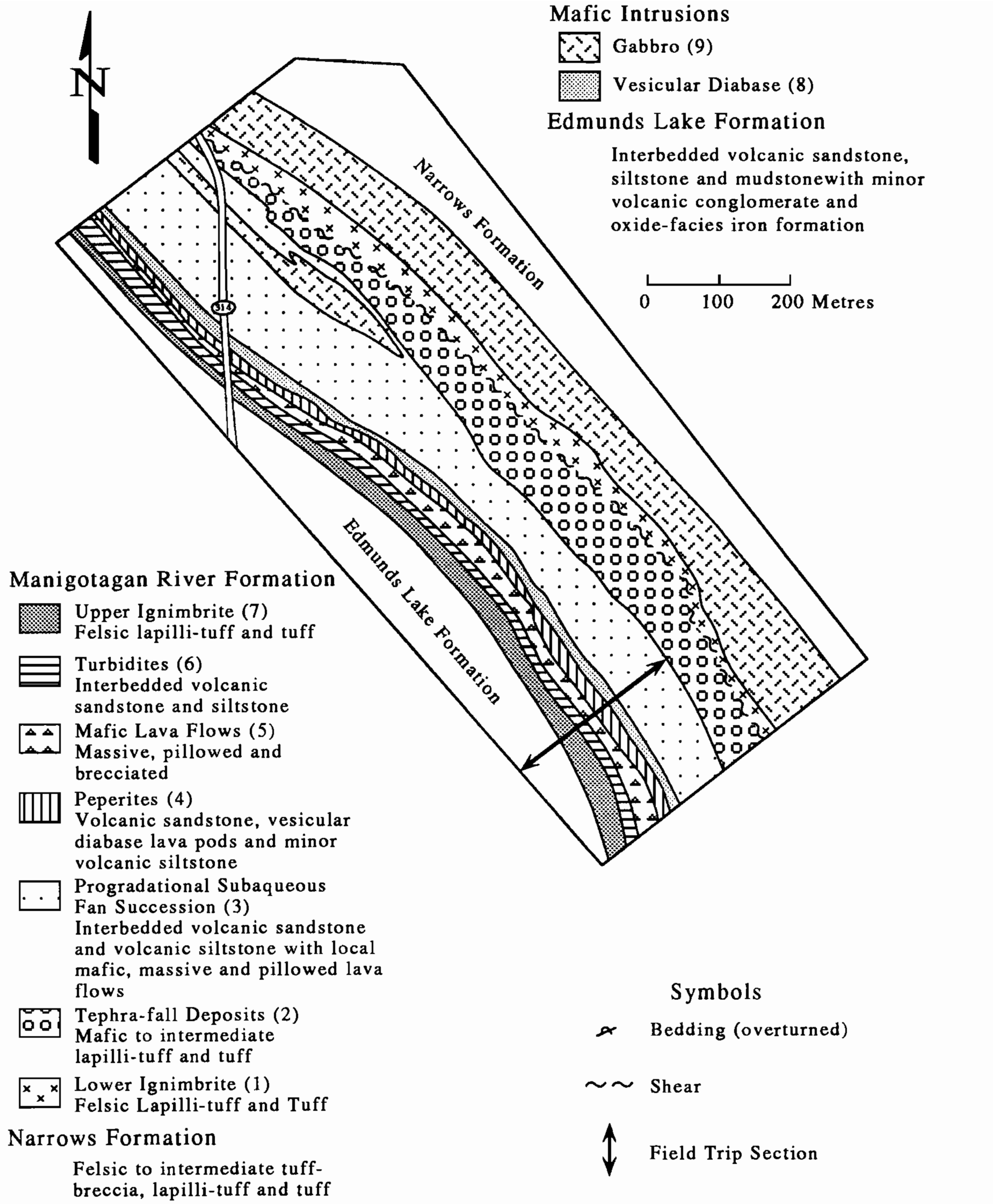



Figure 28: Sketch map of the stratigraphy of the Manigotagan River Formation at Stop 1-7a (mapping by D. Seneshen).

## Table 4: Summary of Members in the Manigotagan River Formation

| Member | Thickness (m) | Composition | Components | Structural Features | Genesis |
|---|---|---|---|---|---|
| Ignimbrite (7) | 15-50 | felsic | lapilli-tuff and tuff consist of vitric ash, vitric felsic fragments, pumice, dacite fragments; plagioclase, quartz and microcline crystals | thin to very thick bedded; normal or, less commonly, doubly graded | subaerial eruptions generated pyroclastic flows which entered water |
| Turbidite (6) | 11-24 | felsic | sandstone consists of vesicular to non-vesicular mafic volcanic clasts; plagioclase and quartz crystal grains and a siltstone matrix | thin to very thick bedded; normally graded Bouma divisions; possible ripples and load structures | local slumps from the higher parts of a subaqueous fan generated by turbidity flows |
| Lava Flows (5) | 6-29 | mafic | amygdaloidal and plagioclase-phyric; recrystallized to locally felty groundmass | massive lava flows have brecciated upper and lower zones; lateral transition from massive to pillowed flows; concentric zoning of vesicles in some pillows; vesicularity increases upward in the sequence | subaqueous flank fissure eruption fed by underlying diabase sill (unit 8) |
| Peperite (4) | 5-22 | intermediate | sandstone consists of felsic volcanic clasts, plagioclase and quartz crystal grains, mudstone matrix; lava pods are amygdaloidal and plagioclase-phyric with a recrystallized groundmass | thin to very thick bedded; normal graded; local low-angle cross laminations | upper part of subaqueous fan succession was intruded by a shallow diabase sill causing mixing of magma and wet sediment |
| Mass Flows; minor Lava Flows (3) | 32-103 | felsic to intermediate | conglomerate consists of felsic, intermediate and mafic volcanic clasts, volcanic sandstone clasts, plagioclase and quartz crystal grains and siltstone matrix; sandstone consists of felsic volcanic lithic grains, plagioclase and quartz crystal grains and a siltstone matrix | thin to very thick bedded; normal graded; scours and load structures common; local trough and festoon cross bedded interpillow sandstone; some pillows show concentric zoning of vesicles; vesicularity increases upward in lava flows | renewed explosive volcanic activity provided felsic to intermediate debris for progradation of a subaqueous fan; mafic lava flows erupted by central or flank fissure eruptions concomitant with fan progradation |
| Tephra-fall Deposits; minor Volcanic Conglomerate and Sandstone (2) | 17-91 | mafic to intermediate | lapilli-tuff and tuff consist of felsic to mafic, vesicular to non-vesicular volcanic clasts, plagioclase and quartz crystal grains, actinolite porphyroblasts after clinopyroxene crystals and a mafic ash matrix; volcanic conglomerate and sandstone consist of felsic to mafic, vesicular to non-vesicular volcanic clasts, plagioclase and quartz crystal grains in a siltstone matrix | thin to very thick bedded; lapilli-tuff and tuff beds non-graded and have abrupt contacts; minor volcanic conglomerate and sandstone beds are normal graded; volcanic conglomerate beds have erosive basal contacts | tephra-fall from shallow water or subaerial, flank fissure phreatomagmatic eruption(s); volcanic conglomerate and sandstone sequences are either channel-fill deposits within tephra-fall deposits or erosional remnants |
| Ignimbrite (1) | 6-39 | felsic | lapilli-tuff and tuff consist of vitric ash, dacite fragments, vitric felsic fragments, pumice and plagioclase and quartz crystals | medium to thick bedded; normal to less common doubly graded | same as upper ignimbrite but fewer pyroclastic flows in the examined section |

conglomerate, most of which are volcanic, and by the euhedral to subhedral shapes of plagioclase and embayed quartz grains which resemble pyrogenic crystals in underlying members. Mafic flows intercalated with the lower part of the fan succession attest to contemporaneous volcanism and sedimentation. Peperite that comprises Member 4 formed by the mixing of magma and wet sediment. Mixing occurred where a shallow diabase sill (unit 8, Fig. 28) intruded volcanic sandstone and siltstone of the upper part of the fan succession; irregular lava pods and dykes extended several metres into the sediment and locally broke through the seafloor to feed massive, pillowed, and brecciated lava flows of Member 5. Volcanic sandstone and siltstone (Member 6) that overly the lava flows were probably deposited by turbidity flows generated by local slumps from the higher parts of the subaqueous fan (Members 3 and 4).

The Manigotagan River Formation records multiple variations in magma compositions, and in volcanic and sedimentary processes over time. The lower felsic ignimbrite (member 1) and the mafic to intermediate tephra-fall deposits (member 2) were apparently erupted in succession and represent the later eruptive phases of the stratovolcano from which dacitic tephra of the underlying Narrows Formation was erupted. The progradational fan succession, which largely consists of resedimented, felsic to mafic pyroclastic debris, probably reflects a renewed, explosive eruptive event. Mafic lava flows in the lower (member 3) and upper (member 5) parts of the fan succession were probably erupted through fissures and were fed from the same magma chamber. Following the eruption of the upper mafic lava flows, there was a hiatus in volcanism, and the turbidites of member 6 were deposited. Subsequently, another explosive eruption occurred and the felsic ignimbrites of member 7 were deposited. After this final eruptive event, the stratovolcano apparently underwent erosional destruction, subsidence and burial by the flysch sequence of the Edmunds Lake Formation. Although the contact between the Edmunds Lake Formation and the Manigotagan River Formation is not exposed, erosional destruction of the stratovolcano is suggested by the petrographic similarity between sedimentary units in the former and underlying felsic pyroclastic units in the latter (Seneshen and Owens, 1985).

On a regional scale, the Edmunds Lake Formation overlies both the Bidou Lake and Gem Lake Subgroups of volcanic rocks without recognizable unconformity. The formation is characterized by greywacke/mudstone turbidity current deposits . With the exception of local gabbroic sills there are no volcanogenic magmatic rocks within the formation. The formation grades towards the south into paragneisses and migmatites of the Manigotagan gneiss belt of the English River Subprovince. Due to this transition the thickness of the formation is unknown, but could be considerable. A granitoid intrusion from Black Lake dated 2663±7 Ga (Turek et al., 1989) is a minimum age for the formation and dates the peak of the (Kenoran) metamorphism in the gneiss belt and structural data suggests that the formation is older than the San Antonio Formation. The latter has not been affected by the D1 deformation (Weber 1971b).

Campbell (1971) summarized the characteristics of the Edmunds Lake Formation as:

- thin-bedded units
- well-sorted sediments, markedly different in lithology from the underlying sediments
- uniform grain size
- laterally continuous beds
- absence of cross-lamination
- abundant graded bedding
- conglomerate with increase in abundance and thickness upward in the formation

( The latter only applies to the low grade metamorphic portion; in the higher grade belts conglomerates are absent)

The lower stratigraphic portion is typified by cherty units locally with magnetite, quartzose greywacke, and arkosic sandstone with pebble conglomerate. Stratigraphically upwards the detritus influx increases and chemical sediments disappear. Weber (1971b) compared the upper conglomeratic facies with a flyschoid facies, with granitoid boulders in the conglomerates being derived from an older basement to the north and northeast. U-Pb data from detrital zircons also indicate 3.0 and 3.1 Ga sources in the greywacke (D.W.Davis, pers. comm., 1994).

***Stop Descriptions:***

At this stop we examine outcrops representative of the Manigotagan River Formation (locality a, Fig. 27, 28) and of the Edmunds Lake Formation (locality b, Fig. 27)

Locality a: Manigotagan River Formation

At this locality (Fig. 28), the upper part of the Formation (members 3-7) is exposed. Vesicular diabase and layered gabbro with irregular distributed plagioclase-rich patches which are locally quartz-bearing is also present.

The upper ignimbrite consists of up to twelve flow units, 0.7 to 17 m thick containing variable proportions of dacite fragments, vitric felsic fragments, pumice, rare mafic scoria and microcline-phyric felsic fragments. Plagioclase and lesser quartz crystals enclosed in a granoblastic quartzo-feldspathic matrix interpreted to be recrystallized vitric ash. The ignimbrite consists of composite sheets of multiple flow units most of which consist of a lower lapilli tuff and an upper non-bedded or planar bedded tuff division. Individual flow units (lapilli tuff or tuff divisions) show reverse grading of pumice, normal grading of vitric and/or dacitic fragments and pumice-rich and pumice-poor sequences indicate subaqueous pyroclastic flow deposits. Dark felsic clasts, generally rounded with recrystallized (devitrified) ("lisgang") rims are common.

The lower pillow basalt (member 5) shows an eroded top filled in with cross-bedded sand. The flow is vesicular at base.

Sediments beneath the basalt consist of thin-bedded siliceous siltstones/argillite and thicker beds of higher energy mass flows with scattered clasts of underlying sediments. Slab stacking indicates slope or flow to the east.

return to the parking area on Provincial Road 314.

locality b: Edmunds Lake Formation

The field trip stop is at the parking area for departure to stop I-8-A. At the bottom of outcrop are exposures of mainly thin-bedded chert, mudstone argillite, and fine grained sandstone (10-20 cm thick). There is some evidence of density currents here in the form of unsorted conglomerate.

A pair of flags mark a location where climbing ripples in finely laminated argillite indicate decreasing flow above density flow with graded beds. Nearby and further up section, decreasing numbers of ripples may indicate increasing flow. This probably indicates shallow water environments with periodic influx of density currents.

- END OF DAY 1 -

## Day 2 - The Garner Lake-Wallace Lake-Wanipigow River Area

Drive east from Bissett on Highway 304 for approximately 37.5 km to the T-intersection near Long Lake. Turn left (east) on Provincial Road 314 and continue driving southward, passing the turnoff to Beresford Lake campground at a point approximately 5 km from the T-intersection. Stay on Provincial Road 314 and travel an addtional 1.4km south of the turnoff to a poorly maintained turnoff to the left (This road is occasionally gated). Turn left onto the road and drive (or walk) approximately 1.7 km east to the bridge across the Beresford River. The rocks to the west of the bridge belong to the Manigotagan River and Edmunds Lake Formations and are on-strike equivalents of those at Stop 1-8, locality b. Note that, here, graded bedding indicates that the metasedimentary rocks face eastward. Walk across the bridge to examine a series of outcrops to the east and south of this point.

### Stop II-1: Supracrustal rocks of the Garner Lake Subgroup

The rocks south and east of Beresford Lake contrast strongly with those of the Bidou Lake and Gem Lake Subgroups in that the sequence contains much more basalt and recently recognized komatiite. Some of the rocks in this area had previously correlated with the mafic Banksian Lake Formation of the Gem Lake Subgroup but, as described above, are better viewed as part of a newly defined and distinctive Garner Lake Subgroup. Note that, although supracrustal rocks in this area occupy a relatively narrow north-south strip, the strata within the strip actually tend to strike east-west, only bending into north-south strikes near the Beresford Lake Shear Zone (Fig. 29). The series of localities visited at this stop therefore progress down the stratigraphic section toward Garner Lake where even lower stratigraphic units can be examined in less accessible exposures.

### *Stop Descriptions*

Proceed eastward from the bridge (Fig. 29) for approximately 500 m to a series of low outcrops on both sides of the fire road.

Locality a: Iron-formation and basalt

At this location folded banded iron-formation is interlayered with pale grey-green Mg-basalt. The iron-formation is mainly magnetite facies although there are local sulphide pods which may have resulted from epigenetic sulphidation. The basaltic rocks are locally carbonatized to chlorite-ankerite schists.

Continue another 100 m eastward on the fire road to a small clearing on the right hand side (there is a small outcrop of folded iron-formation at roadside). This marks the beginning of a (generally very wet) trail that leads southward toward Garner Lake. Follow the trail southward approximately 1 km to a point where the trail rises to a

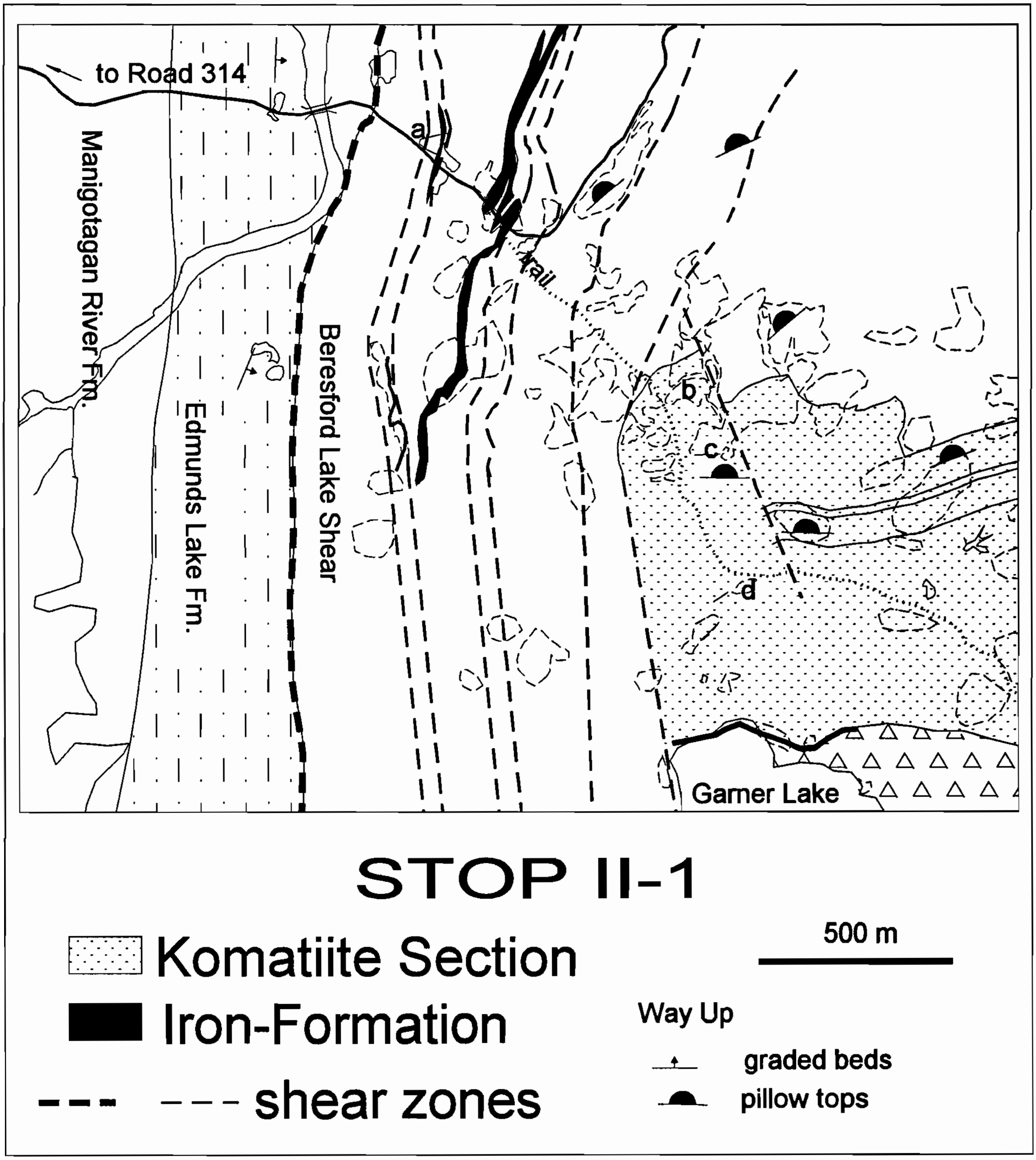



Figure 29: Sketch map of the geology of the Garner Lake Subgroup between Beresford and Garner Lakes (Stop 2-1).

relatively narrow passage between large outcrops on either side. Climb eastward along the outcrop ridge to the left.

Locality b: Basaltic komatiite

At this location the rocks consist of interlayered northward-facing pillowed basaltic komatiite flows and narrow buff-weathering massive komatiite units. Although the massive units here are not convincingly flows they are basaltic komatiites in composition (approximately 16% MgO anhydrous, Fig. 13b) and locally possess excellent polysuture structure that is typical of ultramafic flows elsewhere in Superior Province.

Continue southward for approximately 200 m along the ridge to a cluster of low outcrops at its southern end.

Locality c: Komatiite and basaltic komatiite

The rocks here are similar to those at locality b but with greater evidence for the origin of the buff-weathering komatiites. A 10-cm thick unit of spinifex texture and a well-exposed rubbly flow-top both support an extrusive origin. Samples of this flow and a spinifex-textured clast in the breccia contain 20 to 22% MgO (anhydrous). Note also that some of the pillowed flows here are composed of basaltic komatiite (13 to 16% MgO) containing common drainage cavities.

Return to the trail via locality c and continue southward approximately 600 m to a large outcrop on the right side.

locality d: Spinifex-textured basaltic komatiite.

The spinifex in this large outcrop is mainly of the coarse "stringbeef " variety and its morphology and arrangement within the outcrop further supports the observation that this is a northward-facing sequence of flows.

Return along the trail to the fire road and return westward to Provincial Road 314. Head north to Highway 304 and continue northward to the turnoff to the Wallace Lake Campground. Turn right (north) and proceed approximately 1 km to and turn left into the garbage pit clearing (this turn is before the cottages appear). Follow the dirt road on the west of the garbage pits to the shore of Wallace Lake. Park by the large garage and follow the shoreline eastward for approximately 400 m to a series of exposures overlooking Wallace Lake (Fig. 30).

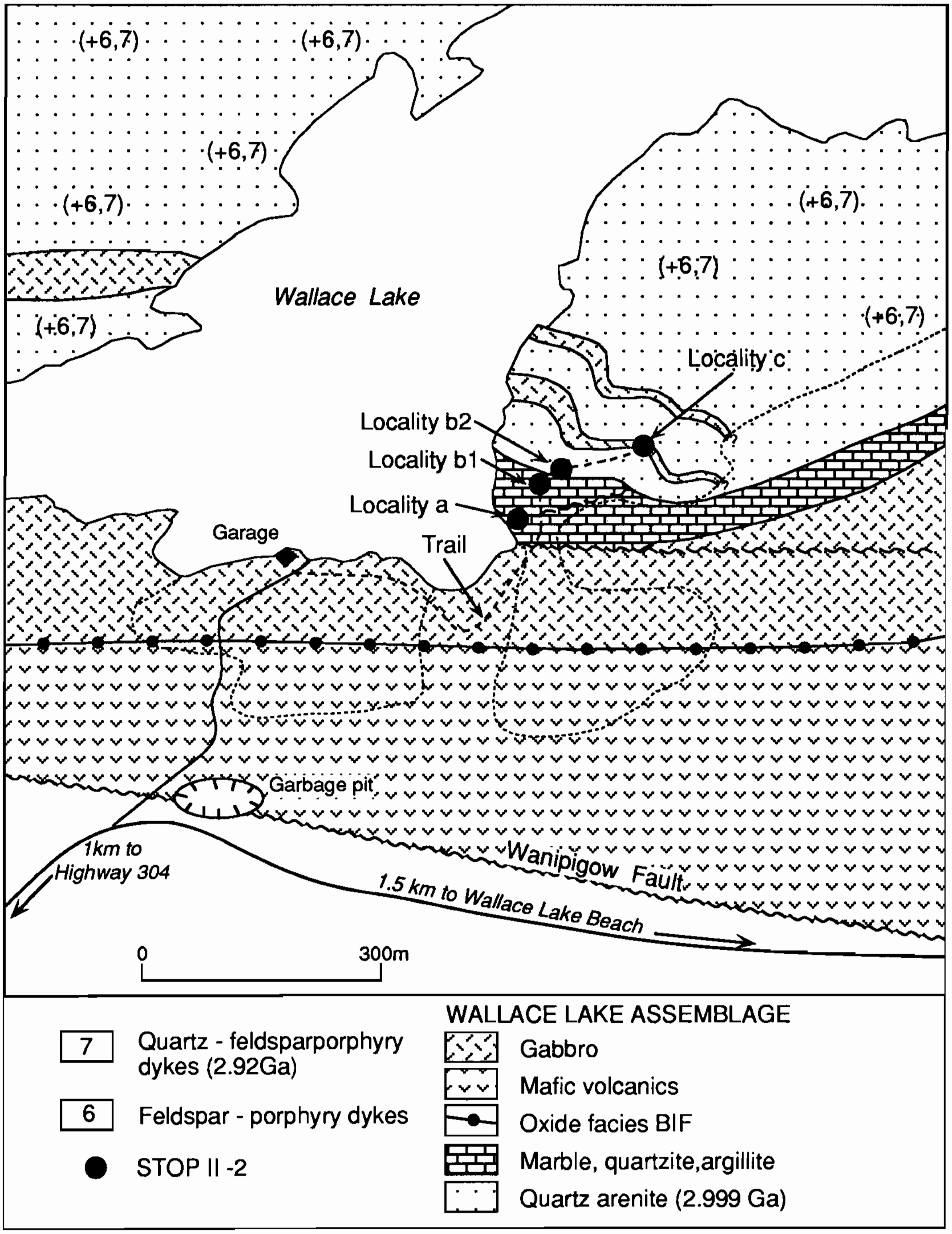



Figure 30: Sketch map of the geology on the south shore of Wallace Lake (Stop 2-2).

**Stop II-2: The Conley Formation of the Wallace Assemblage**

The Wallace Lake assemblage (WLA) is largely equivalent to the Conley Formation (McRitchie, 1971a) although additional work is required to establish its full extent. Weber (1988), mainly on lithological grounds, postulated that these rocks are part of the 2.8-3.4 Ga Mesoarchean continental platform assemblage as mapped and defined in Northwestern Ontario (Thurston et al., 1987; Williams et al., 1992). Subsequent U-Pb zircon data from the Wallace Lake area have confirmed this interpretation (Turek et al., 1989; Turek and Weber, 1991, 1994).

The WLA is exposed in a segment of the Rice greenstone belt that is separated from the main Rice Lake greenstone belt by the Wanipigow Fault (Fig. 30). An apparent dextral displacement of ca. 20 km is indicated along the Wanipigow fault, based on the relative displacements of the contact between greenstones and granitoid rocks of the Wanipigow Plutonic Complex. However, lithologies can not be correlated across the fault. Gravity data collected and interpreted by Brisbin (1971) indicate a relatively thick section of rocks (5.5 km) at Wallace Lake north of the Wanipigow Fault compared to Rice Lake (3.3 km) and Beresford Lake (5.2 km) suggesting that different crustal levels or possibly even different stratigraphic packages could be juxtaposed at the fault.

The WLA comprises the lithologies listed in stratigraphic order in Table 1, **Table** 5. The lower half of the section will be encountered during the field trip (Fig. 30). This stratigraphic succession is a preliminary interpretation. A modern stratigraphic/structural study of the Wallace Lake area is still outstanding and desperately required, particularly because it probably has one of the best developed and exposed sections of the Mesoarchean platform assemblage in the Superior Province.

Table 5: Units Comprising the Wallace Lake Assemblage

| Lithological Units |
|---|
| Intermediate to felsic volcanic rocks of uncertain age relationship and possibly representing more than one age. |
| ultramafic rocks (serpentinite), in part komatiitic flows(?) |
| gabbroic dykes2 |
| mafic volcanic flows |
| oxide facies banded iron formation |
| greywacke/argillite |
| argillite |
| marble |
| interlayered marble and quartzite |
| quartzite |
| quartz arenite with conglomerate beds1 |

[1]Conglomerate clasts include 3.0 Ga tonalite clasts and intermediate-felsic volcanic/subvolcanic rocks of unknown age.
[2]Gabbroic dykes have been intruded by feldspar porphyry dykes and subsequently by 2.92 Ga quartz feldspar porphyry dykes.

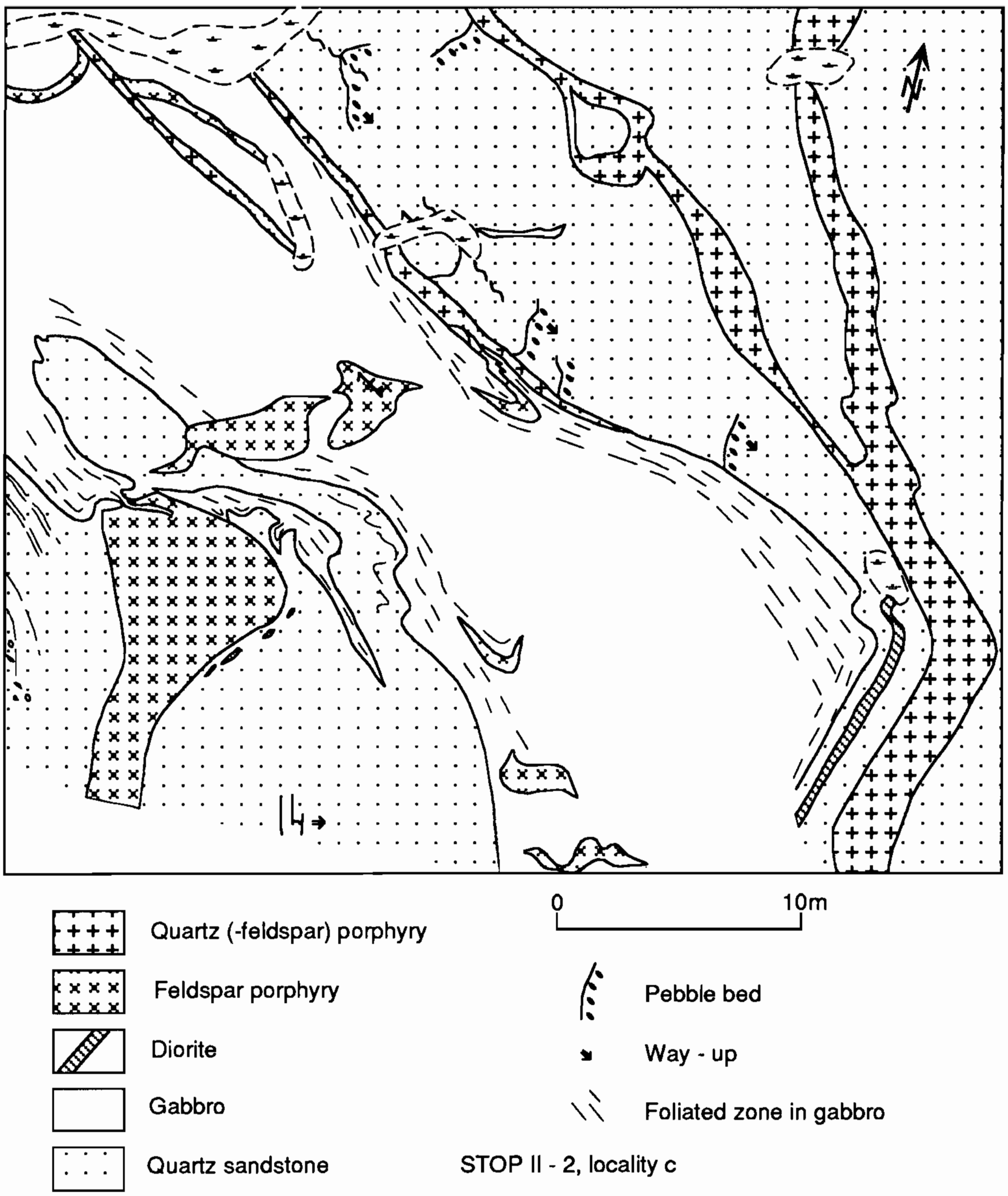



Figure 31: Geology of the quartzite section of the Conley Formation at Wallace Lake (mapping by W. Weber and P. Adamo, 1994).

Quartz arenite with conglomerate beds forms a succession with an apparent thickness of 1000 m in the Wallace Lake area. This formation is composed of immature detritus shed from a largely granitoid hinterland and deposited in subaerial fluvial environment. U-Pb data indicate that the formation was deposited, intruded by mafic and felsic dykes, and deformed prior to 2.92 Ga (the U-Pb age of a 2.92 Ga quartz-feldspar porphyry dyke). Tonalite clasts from conglomerate at the north shore of Wallace lake have yielded a U-Pb zircon age of 3010±13 Ma (Turek and Weber, 1991) and detrital zircons have yielded similar ages (Poulsen et al., 1994). This hinterland is likely the Wanipigow Plutonic Complex (WPC). Although field relationships indicate intrusive relationships between the quartz arenites and WPC in the Wallace Lake area (McRitchie, 1971a), U-Pb zircon geochronology confirms the existence (or preservation) of ~3 Ga crust along the northern margin of the Rice Lake greenstone belt between Lake Winnipeg and Wanipigow Lake (Ermanovics and Wanless, 1983; Turek and Weber, 1994). At the western end of the Rice Lake greenstone belt near Seymourville (Hole River settlement) a potentially very significant erosional unconformity has been described (Ermanovics, 1981) where quartz arenite overlies 3.0 Ga tonalite. Ermanovics equated these quartz arenites with the San Antonio Formation, but it is equally possible that these arenites are part of the Mesoarchean platform assemblage.

The quartz arenite is commonly well bedded (Fig. 31). The grain size is highly variable; conglomeratic beds with pebble sized clasts are commonly interlayered with coarse grained quartz rich arenites. The clasts are: quartz, rounded and angular (broken up quartz vein), light green mudstone rip ups, feldspar porphyry, quartz feldspar porphyry, light green rhyolite. Coarser conglomerates with boulder sized tonalite clasts occur locally. Green and dark grey thin, laminated siltstone interbeds are scattered throughout the section.

The quartz arenite grades stratigraphically upward into protoquartzite and then into fine grained quartzite (< 1m). Further up in the section these quartzites become laminated (metachert?) and are interlayered with brown weathered carbonate (~ 10m thick sequence). These carbonates show in places a distinct layering, possibly representing stromatolite structures. The carbonates higher up lack the quartzite beds and become more massive (~40 m). At Limestone Hill, west of the field trip section, the carbonates contain oxide facies banded iron-formation.

Farther up in the section the carbonates are overlain by euxinic pyrite bearing slate and argillite, followed by interlayered argillite and greywacke. Throughout the Wallace Lake area, this section commonly contains oxide facies banded iron-formation up to 10 m thick. This is the cause for the string of strongly positive magnetic anomalies in the region. This iron formation, the quartz arenites and the carbonates are the most distinctive stratigraphic units of the Wallace Lake assemblage. The iron formation appears again in the Moore Lake area, 10 km southeast of Wallace Lake, and continues into the Garner Lake area. This and the presence of ultramafic flows in both areas suggest that the platform assemblage extends into the Garner Lake region, an interpretation confirmed by U-Pb geochronology. However, this geochronology also indicates that at least some of the rocks in the Garner Lake region are younger, i.e. 2.8 Ga.

Mafic volcanic rocks are locally associated with quartz arenites (Gaba and Theyer, 1984) . However, the major basalts units shown on the maps (cf. McRitchie, 1971b) may be part of the Rice Lake Group in a strict sense and are in tectonic contact with the Wallace Lake assemblage. Gabbroic dykes intrude the quartz arenites in many places. Some of them contain zones of distinctly layered more leucocratic quartz-magnetite layers.

Quartz-feldspar phyric intermediate to felsic tuffs and intrusions occur at the north shore of Wallace Lake (Gaba and Theyer, 1984) and elsewhere. These rocks are difficult to distinguish from the quartz arenites in poorly exposed outcrops, but as the outcrop on the field trip demonstrate, intrusive phases are locally abundant(Fig. 31). There are two areas of outcrops of ultramafic rocks in the Wallace Lake. One is a serpentinite (antigorite with minor clinochlore, carbonate and magnetite; Scoates, 1971) in contact with 2730 Ma younger (?) tonalite, and is similar to the strings of serpentinites along the Wanipigow fault between Lake Winnipeg and Saxton Lake. The second occurrence has been described as a spinifex-textured ultramafic unit (Theyer, 1983), possibly a flow.

***Stop Descriptions***

Walk from garage over gabbro (part of Wallace Lake assemblage?). At pair of flags, note local interlayers of quartz-magnetite bearing, slightly more leucocratic gabbro. These phases are also typical of the Jeep gabbro which may be part of the same gabbro intrusion. Walk along cleared trail through low bush and then onto slightly higher area.

Locality a: At first pair of flags turn left towards shore;

a1) North of gabbro are brown relatively featureless carbonate ca. 40 m; towards north: ca 10 m of interlayered carbonate and chert, with fuchsite schist at bottom of one outcrop. Walk inland to the next pair of flags: laminated chert interlayered with carbonate which is in part also thinly layered (stromatolite structures?).

a2) Conley shaft; sulphide mineralization (malachite staining) in 3m of black euxinic slate interlayered with "silicified limestone". Stephenson (1971) identified chalcopyrite, sphalerite and galena, besides pyrite. Recently analyzed grab samples yielded µ0.02% Cu or Pb.
Geochemical data published in Theyer (1991) from a property appraisal report, dated 1936 (Conley Jr., pers. comm.1990) list: "erratic, in cases very high gold and silver

concentrations in grab and drill core samples that range from nil to 2440 g/t Au and 22g/t Ag to a spectacular 20,228 kg/t Ag. Recent analyses from Assessment Files diamond drill core yielded 33 ppm Au over 0.5 m in hole No. 1, 21 ppm over 0.5 m in hole No. 3 and 19 ppm Au over 0.3 m in hole No.7 out of 7 holes drilled to a maximum depth of 21m on the Conley property.

Between location a2 and b1 there is approximately 50 m of dolomitic carbonate, locally with slate.

Locality b:

b1: At the bottom of the large outcrop (Fig. 30), fine grained quartzite, then coarse grained quartz-rich sandstone (protoquartzite) with granule and pebble sized clasts and local matrix supported pebble conglomerate beds. Green colour is the result of altered plagioclase.
Clasts are:, quartz, rounded and angular (broken up quartz vein), light green mudstone rip ups, feldspar porphyry, quartz feldspar porphyry (subvolcanic or volcanic), light green rhyolite

b2: At first pair of flags: good layering, graded bedding tops to east-southeast. Fine grained sediments (mudstone and layered argillite) probably represent the main period of deposition with little sediment influx. Earthquake induced and/or rising hinterland produce flash floods of detritus of weathered granitoid and felsic to intermediate volcanics source.
Up the hill (down section) more rip-ups, less fine grained sediments, no layered argillite and thicker sandstone layers indicates higher energy sedimentation.

locality c: Gabbro intruding east facing quartz arenites.
Gabbro is intruded by felsite dyke (feldspar porphyry) which is folded and boudinaged and then in turn intruded by northwesterly trending quartz feldspar porphyry (Fig. 31). This latter has been dated at 2920.6±3 3a Ma (U/Pb zircon)(D.W.Davis, unpubl. report, 1994). Quartz arenites have yielded detrital zircons of 2999 Ma. which is in agreement with a 3.01 Ga age for tonalite boulder in conglomerate from the north shore of Wallace Lake (Turek and Weber, 1991), supporting the evidence that these rocks are Mesoarchean.
Stop 3b. Just below 3a: Contact between quartz arenite and carbonate exposes 2-3m fine grained orthoquartzite, a relationship similar to Stop b2.

Return to Highway 304 and turn right (west) continuing for approximately 1.9 km to the Bissett airstrip located in the sand-covered area north of the highway. Turn right on a dirt road which loops around the east end of the airstrip and proceed to a quarry on its northeast side (Fig.32). Park here and walk to the quarry.

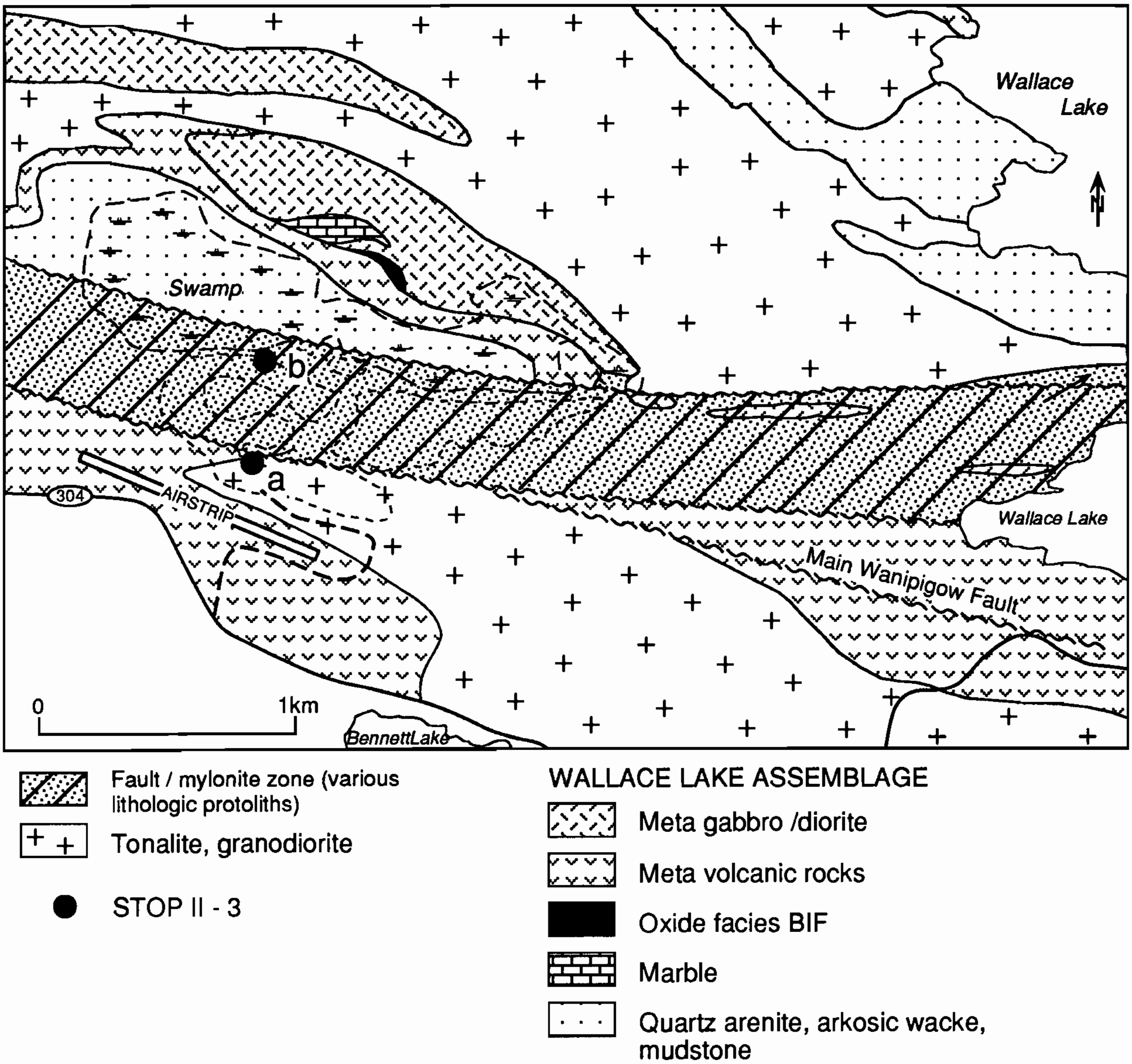



Figure 32: Geology of the Wanipigow Fault in the vicinity of the Bissett airstrip near Wallace Lake (after Gaboury and Weber, 1984).

## Stop II-3: The Wanipigow Fault Zone

The sigmoidal shape of the Rice Lake greenstone belt is the result of a transpressional regime during which shortening took place in an approximate north-south direction. Major movements occurred along a dextral strike slip and high angle reverse fault, the Wanipigow fault (WF) at the belts northern margin and a dextral slip fault, the Manigotagan fault (MF) at its southern margin.

The WF is the more prominent and significant of the two. It coincides in most places with a sharp boundary between supracrustal rocks of the greenstone belt and granitoid rocks of the Wanipigow Plutonic Complex whereas the MF is a series of faults developed along the transition zone between low metamorphic grade metasediments of the Uchi Subprovince and high metamorphic grade gneisses of the English River Subprovince. Offset of geological contacts suggests a dextral displacement of ca. 20 km in the Wallace Lake area along the WF and a similar displacement along the MF. However, the fact that units can not be traced across the WF and retrogressed granulites of the English Lake complex juxtapose greenschist facies rocks of the Rice Lake belt west of Bissett (Weber, 1991) suggest also significant vertical displacements along the WF, an interpretation confirmed by detailed structural data in the Bissett area (Poulsen et al., 1988).

The WF is less pronounced between the Ontario border and Red Lake and has not been documented farther west than the east shore of lake Winnipeg. A distinct feature of the WF is the string of associated irregularly spaced serpentinite lenses, e.g. between Lake Winnipeg and Bissett. These serpentinites have been interpreted (Scoates, 1971) to be related to ultramafic rocks, sills and flows occurring farther east along the northern and eastern contact between the greenstone belt and the WPC, but probably tectonically re-emplaced along the WF. This interpretation implies that Mesoarchean platform assemblages initially were spread along the entire southern margin of the WPC.

The fact that the Wallace Lake Mesoarchean platform assemblage is restricted to the north of the WF and the Garner Lake platform assemblage is separated from the Rice Lake Group by the Beresford Lake deformation zone (in the absence of WF in the southeastern part of the belt) suggests that the WF was possibly superimposed onto an earlier high angle reverse fault. Refraction seismic data (Haijnal, 1971) has indicated a discontinuity at ca 20 km depth located ca.15 km north of the WF and the termination of 5 km deep "greenstone" related refractions 5 km north of the WF, suggesting that the WF is possibly the surface expression of a shallow northerly dipping major crustal reverse fault.

In the field the WF is defined by straight mylonites forming cliffs where granitoid rocks juxtapose less resistant supracrustal or ultramafic rocks, such as along the south shores of Wallace and Siderock lakes and in the Wanipigow Lake and English Brook areas. Elsewhere the fault forms topographically low gullies without distinct cliffs, such as between Bissett and Wallace Lake. South of the Jeep mine, granitoid rocks of the WPC have been deformed to highly fissile in part porphyroclastic mylonite, resembling laminated or thin-bedded arenite.

***Stop Description:***

Mylonite derived from granitoid rocks is exposed in the quarry (Fig. 32, locality a). The protoliths are tonalite and granodiorite thought to be part of the Wanipigow Plutonic Complex. Five hundred metres north of the quarry is a ridge of mylonite (locality b) probably derived from epiclastic and fragmental volcanic rocks.

Return to Highway 304, turn right and continue 6 km west to a poorly marked sideroad ( note that beaver dams across a stream commonly result in the first 100 metres of this road to be water covered. Walk northwards towards the abandoned Jeep Mine. A low outcrop 200 m from highway 304 exposes strongly deformed schist (volcanic rocks) within the Wanipigow Fault Zone displaying at least three generations of minor structures (cleavage and asymmetric folds). Continue approximately 500 metres farther along the road to a series of high ridges which expose granodiorite and gabbro-diorite of the Wanipigow Plutonic Complex.

**Stop II-4: The Wanipigow Plutonic Complex near the Jeep Mine**

The Wanipigow Plutonic Complex (WPC) is defined as the approximately 10 km wide "belt" of granitoid rocks along the northern margin of the Rice Lake greenstone belt, generally north of the Wanipigow fault. The granitoid complex between Wallace Lake and Garner Lake along the northeastern margin of the greenstone belt is also considered part of the WPC. Minor supracrustal rocks, mafic and ultramafic rocks occur at several locations within this granitoid terrain, such as northwest of Bissett. As well as forming the northern margin of the Rice Lake greenstone belt the WPC also forms the southern margin of the Berens Subprovince.

The term "Wanipigow Plutonic Complex" replaces the term " Wanipigow River suite" introduced by Marr (1971) for the granitoid rocks north of the greenstone belt between Bissett and the Ontario border, because more recent geochronology has demonstrated that this granitic suite is a complex of intrusions of various ages, rather than a differentiated synkinematic comagmatic suite as interpreted earlier by Marr (1971).

Marr (1971) identified a range in composition from hornblende diorite to quartz diorite and quartz monzonite (= granodiorite) based on a number of traverses through the complex. Recent observations by the authors through access along new logging roads appear to indicate that most rocks are of quartz diorite or tonalite composition and are in fact very similar to the Ross River pluton. An exception is the presence of

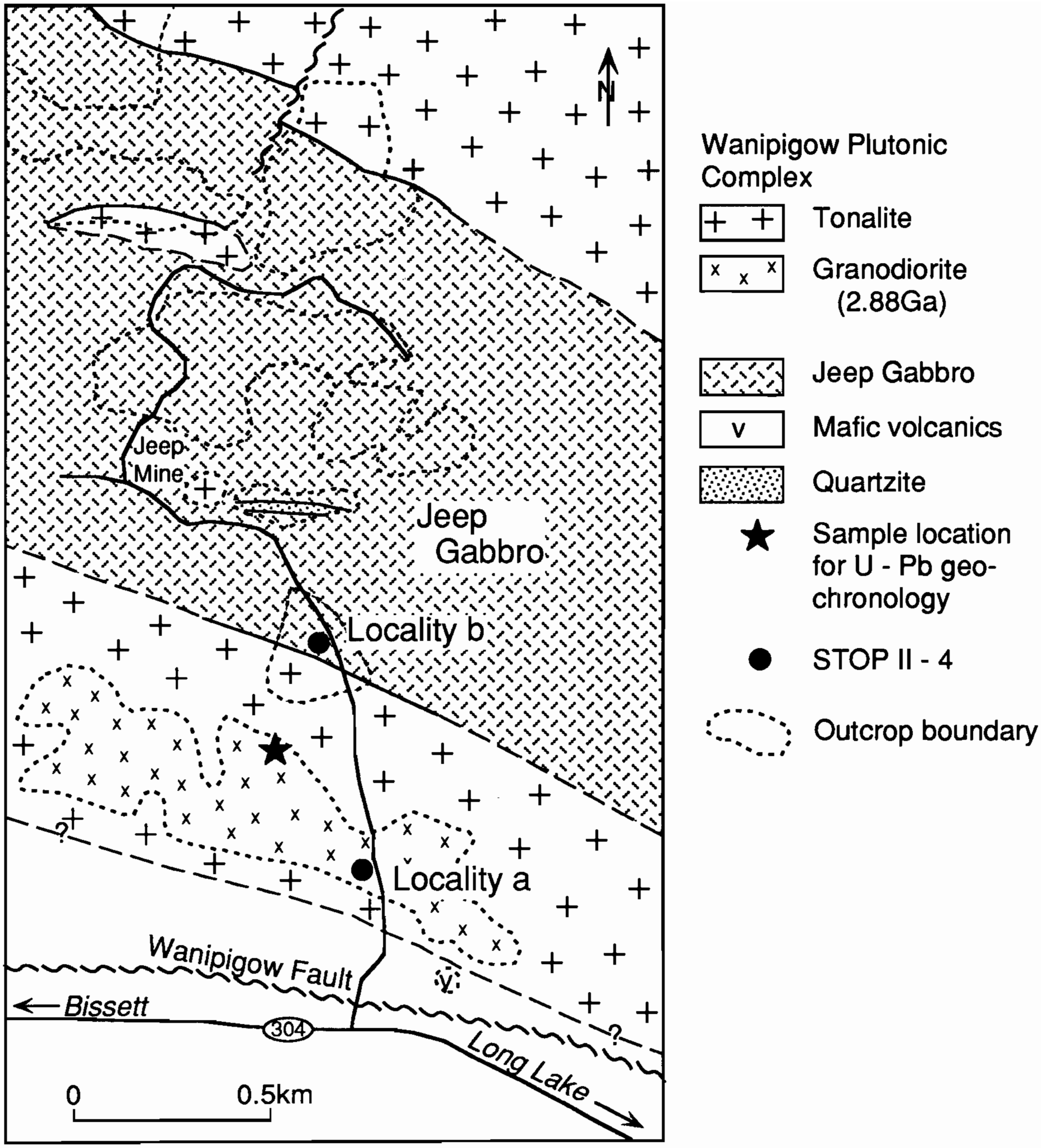



Figure 33: Geology of the Jeep Mine area (after Gaboury and Weber, 1984)

more abundant pegmatitic phases in the WPC. Granodioritic compositions have been observed near the Jeep Mine along the southern contact with the greenstone belt. . U-Pb zircon geochronology indicates that rocks of the WPC range in age from 3.0 Ga to 2.73 Ga. In two locations between Seymourville (Hole River settlement) and Wanipigow Lake, in the western part of the WPC, tonalites have yielded approximately 3 Ga ages (3003±3 Ma, Turek and Weber, 1994; 2999±10 Ma, Ermanovics and Wanless, 1983). In two locations in the western part of the WPC, quartzo-feldspathic gneisses have yielded 2900±10 Ma (Ermanovics and Wanless, 1983) and further east near the Jeep mine a granodiorite has given an age of 2880±9 Ma (Turek et al., 1989). "Synvolcanic" ages of 2737±10 Ma (Ermanovics and Wanless, 1983) and 2731±9 Ma (Turek et al., 1989) have been obtained from tonalites north of Wallace Lake and two granodiorite from the WPC at the east shore of Lake Winnipeg have yielded even younger U-Pb zircon ages of 2715±10 Ma (Ermanovics and Wanless, 1983). There appears to be no distinct petrographic difference between the 3 Ga and 2.73 Ga tonalites and the proportions of these rock units within the WPC could only be determined by detailed mapping and geochronology.

***Stop Description:***

The ridges traversed by the Jeep Mine road (Fig. 33) contain outcrops of mainly plutonic rocks.

locality a: Stop at a point along the road 600 m north of Highway 304. Here several large outcrops expose 2.88 Ga granodiorite of the Wanipigow Plutonic Complex (Turek et al., 1989). This is consistent with the fact that the granodiorite elsewhere contains inclusions of rocks belonging to the circa 2.93 Ga Wallace Lake Assemblage. The single strong steep foliation in these rocks is relatively late (regional S2 or S3?). Continue northward for an additional 250 m.

locality b: Outcrops in this area expose the southern part of the Jeep gabbro. At this locality, the body is mainly dioritic and locally contains zones of intrusion breccia. Xenolith types include tonalite, metapyroxenite and lamprophyre.

Return to Highway 304 and continue west to Bissett.

Return to Highway 304 and continue west to Bissett. Proceed west through the centre of Bissett for approximately 1.5 km passing the Vanson Road (old road leading to Vanson Mine) on your right. Continue west past this sideroad for .25 km and turn right on the newer Abitibi bush road continuing for approximately 3.5 km ENE to a bridge across the Wanipigow River. Cross the bridge and park opposite a trail leading into the bush on the west side of the road. Follow the trail to abandoned Vanson Mine site (Fig. 34).

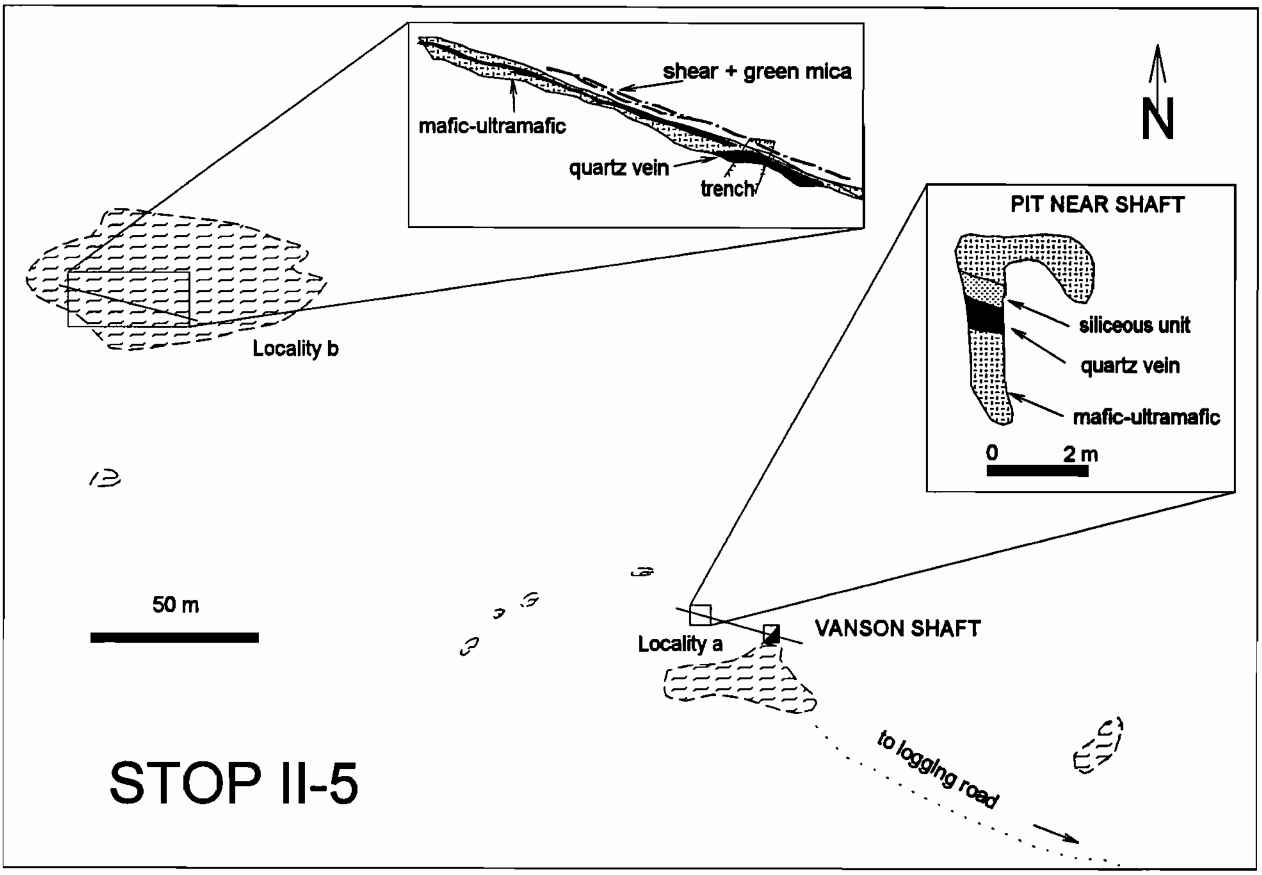



Figure 34: Geology of the Vanson Mine area (based on mapping by R. Brommecker and I. Derome, 1987).

**Stop II-5: The Vanson Mine**

The development here took place mainly in the early 1930's but ultimately proved unsuccessful (see below). The shaft was sunk on a wide quartz vein which is still exposed at surface. The deposit is hosted felsic / mafic rocks (Fig 34) that are strongly transposed in the vicinity of the Wanipigow Fault Zone in a part of the belt that is characterized by high strain. The vein is also transposed and deformed, locally forming a quartz mylonite, and demonstrates that considerable ductile deformation (D2, D3?) took place after the vein formed. This is a general problem associated with deducing the timing of gold-quartz veins with respect to regional deformation: whether one interprets veins to be "early" or "late" can depend as much on where one observes them rather than when they formed. The strong deformation at this deposit also makes it unclear as to which subgroup the rocks belong: intermediate to felsic lithologies are reminiscent of Bidou Lake Subgroup whereas local lenses of ultramafic rocks of komatiitic composition suggest affinities to the Garner Lake Subgroup. Given the high strain, the tectonic intercalation of the two is possible.

***Stop Description:***

The rocks at the Vanson Mine can be examined at two localities , at the shaft (a, Fig. 34) and at a point 200 m to the west (b, Fig. 34).

Locality a: Vanson vein

The main rock types in the area of the shaft are foliated, locally porphyritic, dacite and rhyolitic sericite schist. Foliation strikes west-northwest and dips steeply north. Minor folds are common and plunge steeply eastward. The local setting of the quartz vein is best examined in a trench 15m northwest of the shaft. The main host rock to the mylonitized 60 cm-wide quartz vein is massive to weakly foliated mafic rock that may represent a dyke or sill. A silicified, "cherty" band along the northern contact may represent a relict felsic volcanic rock.

Locality b: Transposed host rocks

This outcrop the shows the strongly banded nature of the rocks in this area. Metre-wide intercalations ( in part tectonic?) of felsic, locally pyritic, sericite schist, intermediate schistose feldspar porphyry and mafic dykes (?) are common throughout. Note again the association of the quartz vein at the south end of the outcrop with a narrow mafic body ( 21%MgO anhydrous) and the local development of a green mica as an alteration product.

-END OF DAY 2 -

## Day 3 - The Bissett Area

The Town of Bissett owes its existence to the San Antonio Gold Mine which is the site of an initial gold discovery in 1911. The field trip will examine exposures near the mine to illustrate the setting of gold in this area: an equivalent section of hangingwall rocks is exposed east of the mine and representative examples of the footwall rocks are well exposed on Hare's Island. Depending on availability, exposures of the host "San Antonio Mine (SAM) Unit" (Theyer, 1983) as well as representative mineralization and alteration may be examined underground or in scattered surface outcrops. The unconformably overlying sandstone and conglomerate of the San Antonio Formation is well exposed west of Bissett and its relationship to underlying Rice Lake Group volcanic and plutonic rocks can be illustrated southwest of Rice Lake near Red Rice Lake.

Proceed eastward along highway 304 from Bissett (Hotel San Antonio) for approximately 1.3 km to a large open area created as a fire break in the late 1980's (Fig. 35). Proceed southward along a bush road (drivable in dry weather) for approximately one kilometre to a large outcrop overlooking Rice Lake (the headframe of the San Antonio Mine should be visible to the west).

### Stop III-1: Hangingwall Stratigraphy, San Antonio Mine area

Here rocks of the Rice Lake Group (Stockwell, 1938), were included into the Bidou Lake subgroup by Weber (1971a) and this correlation with the eastern part of the belt was subsequently confirmed by geochronology (Turek et al., 1989). Detailed mapping by Stockwell (1938), Davies (1963), Poulsen et al. (1986), Tirschmann (1986) and Ames (1988) in this 7.6 km thick section indicates that supracrustal rocks form a north-dipping, north-facing homoclinal panel (Fig. 35). The stratigraphic section, which is punctuated by two mafic sills, Unit A and the "SAM" Unit (Fig. 36) has been studied in detail by Tirschmann (1986) and informal names have been attached to key units for easy reference. The one km thick section that contains the SAM Unit and Unit A consists of volcanic conglomerates and sandstones and is informally termed the Hare's Island formation. Below the Sam Unit this formation consists mainly of volcanic conglomerate and minor volcanic sandstone whereas volcanic sandstone is dominant above the Sam Unit. Clasts in these mixed rocks range from dacite to rhyodacite (Ames, 1988) and are dominantly feldspar-phyric and contain only rare millimetric quartz eyes. Rocks of this formation have been interpreted to represent deposits of a braided river proximal to an active volcanic source, perhaps on the slopes of a stratovolcano (Tirschmann, 1986).

A unit of mafic volcanic rocks, informally termed the Shoreline volcanics, extends along the north shore of Rice Lake and overlies the Hare's Island formation. This is approximately 100 m thick and is composed mainly of basaltic andesite which

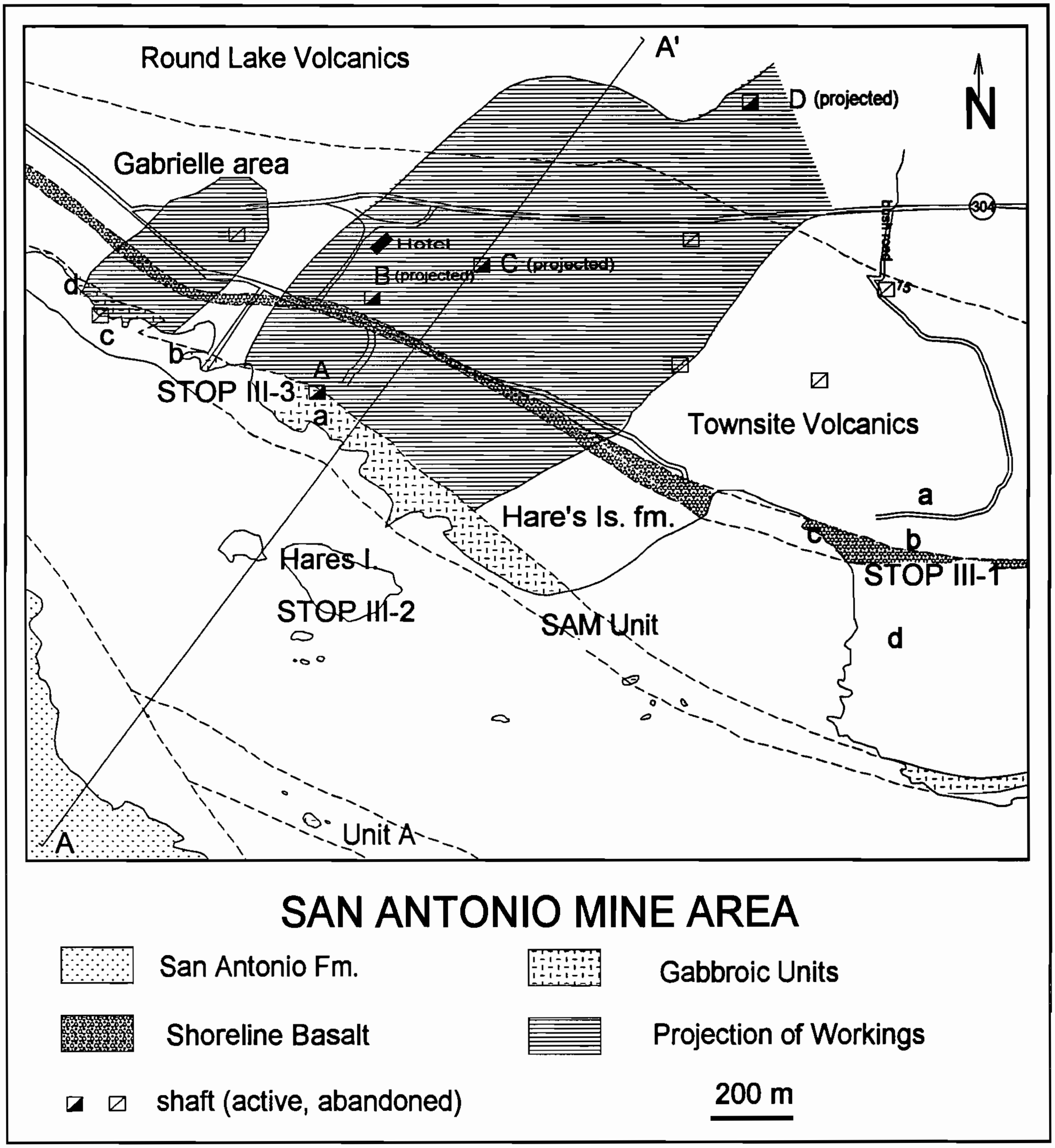



Figure 35: Geology of the San Antonio Mine area.

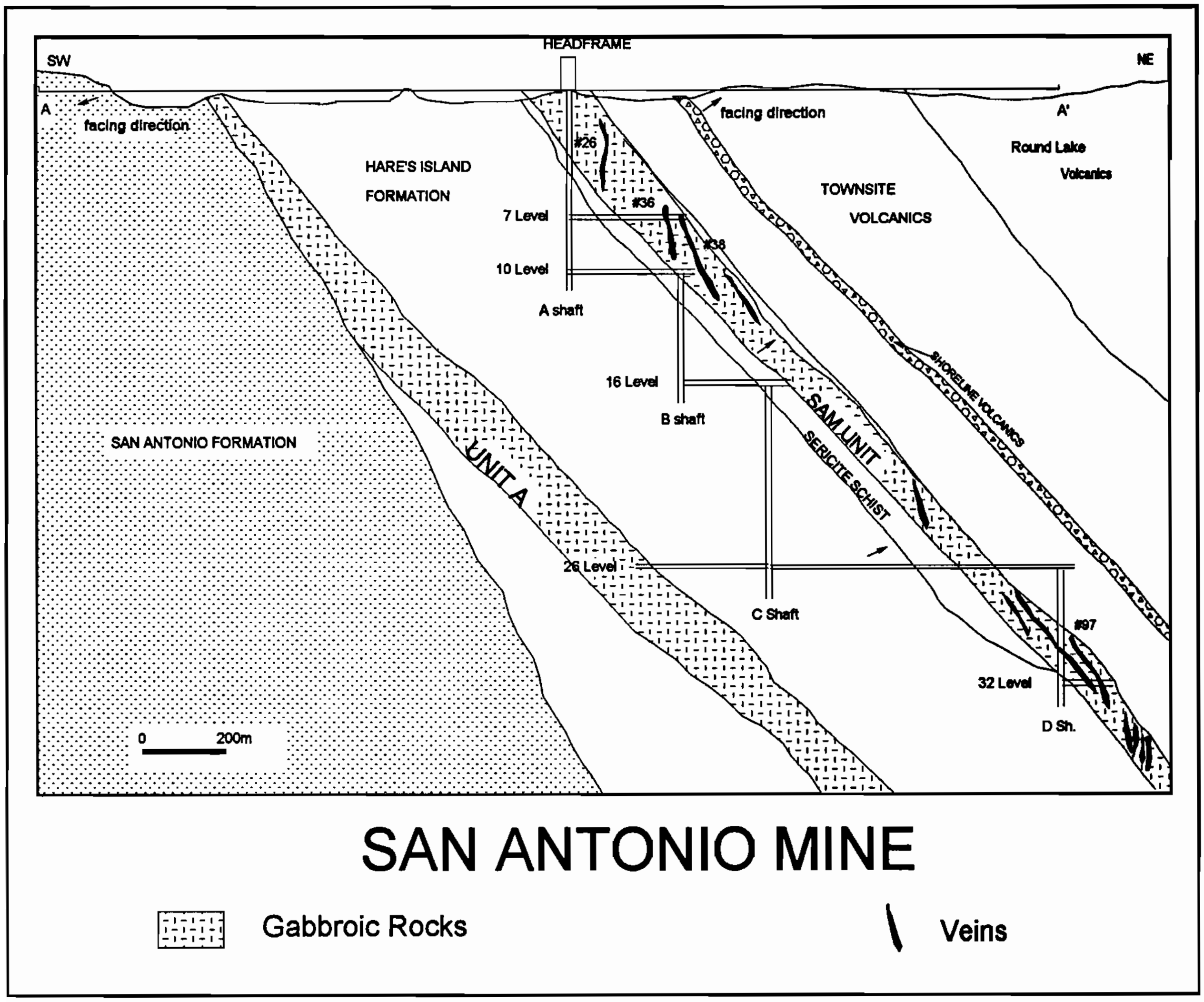



Figure 36: Geological cross-section through the San Antonio Mine.

demonstrates good pillow and breccia structures that are diagnostic of an extrusive origin. The composition of the Shoreline basalt is similar to that of the leucogabbro of the SAM Unit suggesting an extrusive / subvolcanic intrusive relationship between them.

The Shoreline volcanics are overlain by massive to brecciated porphyritic dacite of the Townsite volcanics. This unit is commonly uniform in composition except at its base which is composed of heterolithic breccia. The main mass of the porphyritic dacite contains distinctive 5-10 mm phenocrysts, local zones of breccia and metre-thick intervals of thin bedded tuff. Although these rocks have been variously interpreted as an intrusion, lava flow or crystal tuff, the weight of evidence favours a subaqueous pyroclastic origin (Tirschmann, 1986).

The uppermost stratigraphic unit in the Bissett area is termed the Round Lake volcanics. These rocks are more felsic than the Townsite volcanics and are composed mainly of coarse, heterolithic volcanic breccias, some of which are feldspar-phyric.

Although the evidence is not abundant, the stratigraphic facing is thought to be consistent with the structural order of the units because:

i) Scour channels in the Hare's Island formation were observed underground and convincingly show northward facing;

ii) Moderately convincing northward facing pillow tops have been observed in the Shoreline volcanics;

iii) The SAM unit is compositionally layered with a melagabbro base on the south side and a more leucocratic gabbroic top on the north side;

iv) The SAM unit is cut by feldspar porphyry dykes which are identical in composition to the overlying Townsite volcanics for which the dykes are likely feeders.

***Stop Descriptions:***

Outcrops representative of the rocks above the SAM Unit can be examined at this stop (Fig. 35).

Locality a: Townsite volcanics

The large outcrop north of the bush road exposes a good example of porphyritic dacite of the Townsite volcanics. Look for subtle signs of breccia development and local moderate NE plunge of deformed feldspar phenocrysts.

Locality b: Base of Townsite volcanics

The low outcrops south of the bush road reveal much more heterolithic breccia containing clasts of porphyritic dacite. This is the basal part of the Townsite volcanics.

Locality c: Shoreline volcanics

The low outcrops along the shore of Rice Lake expose the Shoreline volcanics. Look for repeating sequences of massive, pillowed and brecciated mafic flows. These tend to support a northward facing direction for this unit.

Locality d: Hare's Island formation

These large outcrops of Hare's Island formation on the east side of a bay in Rice Lake can be reached by a short traverse south from the bush road (locality b). The outcrops illustrate the finer grained volcanic sandstone facies that is typical of the upper part of the formation.

**Stop III-2: The lower part of Hare's Island Formation on Hare's Island (optional Stop)**

Hare's Island is accessible by boat from the Bissett town beach at Stop III-3, locality b.

The section on Hare's Island (Fig. 35) comprises volcanic conglomerate and minor interbedded lithic arenites in the stratigraphically lower part of the formation. The exposed 40m section beginning on the southeastern shore of the island entirely underlies the SAM unit.

Conglomerate is clast supported (65-85% clasts, 15-35% matrix), crudely bedded, nongraded to normally graded and poorly sorted. About 75% of the clasts are felsic to mafic volcanic rocks. Clasts range in diameter from .4 to 10 cm. The crude bedding is indicated by variations in the proportions of clasts to matrix , as well as by the localized presence of distinctive wispy orange fragments, particularly in the lower part of the Hare's Island section. Individual beds range from 3.5-10.0 m in thickness.

Clasts in the conglomerate include (1) subrounded feldspar-quartz-phyric felsic volcanics, (2) subangular to subround intermediate volcanic clasts ±feldspar phenocrysts (3) flattened to deformed mafic clasts with plagioclase phenocrysts, (4) subangular to subrounded aphyric felsic clasts and (5) angular to rounded milky quartz clasts. In addition wispy, elongate orange fragments (.5-10 cm), somewhat vesicular, occur locally and are concentrated in a few zones where they comprise 5-20% of the conglomerate. They have been interpreted as pumice.

A type 1 clast yielded a U-Pb zircon age of 2729±3.2 Ma (Turek et al., 1989). This age is identical to the age of the Narrows Formation in the Beresford Lake area.

**Stop III-3: San Antonio Mine**

A tholeiitic mafic body, less than 100m thick, within epiclastic rocks of the Hare's Island Formation of the Bidou Lake Subgroup hosts the San Antonio gold deposit (Fig. 35, 36). This body, locally known as the San Antonio Mine or SAM unit has been variously interpreted as a sill (Stockwell, 1935; Poulsen et al., 1986) or as a mafic flow (Theyer, 1983). The SAM Unit has a melanocratic base and a leucrocratic upper part which hosts most of the ore in the mine (Ames, 1988; Ames et al., 1991). The gold orebodies are quartz veins and stockworks oblique to the plane of the Sam Unit (Fig. 37). (Lau, 1988) analyzed the relationship between these veins in a competent gabbroic host and the fabric of adjacent, relatively less competent, volcanic rocks of the Rice Lake Group. Five different fracture sets of successively decreasing relative age were identified within the northeasterly dipping gabbroic sill that hosts the deposit:

i) The oldest set is transverse to the sill and is filled by dykes of mafic and intermediate bulk composition (Fig. 37). They are interpreted to be brittle extensional fractures of synvolcanic origin that have been subsequently rotated into their present position.

ii) Complex, elongate lens shaped zones of intensely fractured and mineralized host rock, termed "stockworks" are confined to the sill in *en echelon* fashion. Thirty steeply dipping stockworks have been identified to date and several of these attain thicknesses of ten metres: important examples include the No. 26, 36, 38 and 97 Veins (Fig. 36, 37). The stockworks typically comprise three structural elements: an inner central quartz vein; a central breccia zone composed of angular, altered wall rock fragments cemented by vein quartz; and a peripheral zone containing arrays of extensional, sigmoidally shaped "ladder veins" that are oriented at a mean angle of 45° to the stockwork zones. The stockworks, a major source of ore in the mine, are interpreted to be brittle shear zones that have formed in two stages, an initial sinistral reverse movement to account for the orientation and sigmoidal shape of the ladder veins, followed by a dextral reverse movement to account for the observed dextral displacement of dykes cut by the central quartz veins.

iii) Arrays of northeasterly striking and northwesterly dipping quartz veins are also important sources of ore in the mine: the most significant of these is the No. 16 vein (Fig. 37). These veins occupy central fractures in sinistral reverse ductile shear zones that comprise intensely foliated and lineated schists derived from the host rock. The shear veins, although of similar composition and gold grade as those of the stockworks, rarely exceed a width of one metre and tend to pinch and swell along strike and down dip.

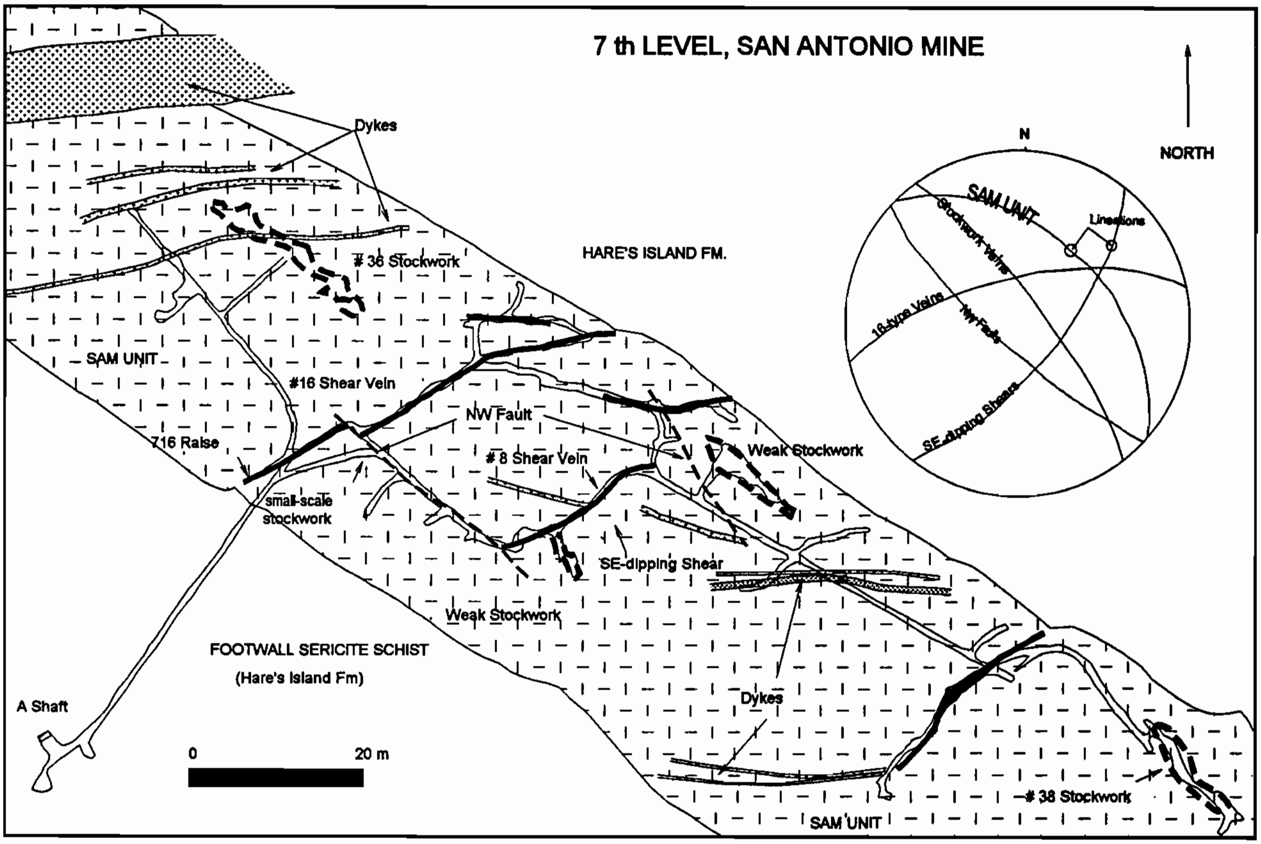



Figure 37: Geological plan of the 7th Level, San Antonio Mine (adapted from Lau, 1988).

iv) The most prominent fracture set that post-dates ore-bearing veins consists of northeasterly striking and southeasterly dipping quartz carbonate veins, less than 50 centimetres wide, that occupy narrow ductile shear zones of dextral reverse sense (Fig. 37). These structures offset dykes, stockworks and mineralized shear veins thereby having a disruptive effect on the continuity of ore.

v) The youngest set comprises northeasterly striking and southerly dipping post-ore brittle faults (Fig. 37). They have a dextral reverse sense of offset and contain vein breccias, typically 10 centimetres wide, that are composed of quartz, calcite and chlorite.

The five fracture sets interact to produce a complex three-dimensional network (Lau,1988) with a pronounced northeast plunge for the deposit as a whole (Fig. 35). This axial direction corresponds to a mineral elongation that is observed in adjacent volcanic rocks of the Rice Lake Group.

Several different types of wallrock alteration were recognized by mine staff at San Antonio in the 1940's and were mapped routinely as a guide to locating ore. D.E. Ames (Ames,1988; Ames et al.,1989) conducted an in depth study of the origin of this alteration and investigated its zonation with respect to ore-bearing veins. Carbonatization produced alteration mineral assemblages which pseudomorphically replace metamorphic minerals and which define alteration isograds that record changes in mineral assemblages. In the leucogabbro, these isograds correspond to the following changes (Ames et al., 1989):

i) actinolite + epidote + $CO_2$ = chlorite + calcite + quartz
ii) titanite + $CO_2$ = rutile + calcite + quartz
iii) chlorite + calcite + albite + $CO_2$ = paragonite + quartz + ankerite + $H_2O$
iv) quartz + paragonite + $K^+$ = albite + muscovite + $H^+$

These isograds are distributed in zones about the gold-bearing structures such that isograd (iv) is innermost and isograd (i) is outermost. The alteration assemblages and their zonation are similar in the vicinity of stockworks, shear veins and veins in southeast dipping fractures, indicating that the composition of the hydrothermal fluids remained relatively constant over the time span during which these different vein generations were formed. The alteration zonation about veins hosted by melagabbro is only recorded by isograds (i) and (ii) and, with increasing alteration, ankerite was formed from tremolite and calcite, a reflection of the more mafic bulk composition of this host rock.

Mass balance calculations (Ames,1988) show that $CO_2$, S and K were added to the gabbroic rocks from the hydrothermal fluid with a change in the oxidation state of iron towards reducing conditions. Boron and sodium were also added at the contacts of veins in the form of metasomatic tourmaline and albite. Pyrite is most directly related to the occurrence of gold and formed after muscovite and ankerite. Quartz-calcite-chlorite veins crosscut and replace earlier formed alteration minerals.

***Surface Stop Descriptions:***

The San Antonio Mine Unit is exposed at several localities along the north shore of Rice Lake near the mine plant.

locality a: San Antonio Mine Site (ask permission of owners)

A large outcrop of the SAM Unit is exposed at the headframe of the Mine. The rock here is relatively uniform in composition and fine grained. Local zones containing white-weathering 2 to 5 mm spheroids are observable near the southeastern corner of the headframe. These are granophyric quartz-albite intergrowths that are diagnostic of the leucogabbro in the upper part of the unit. The preservation of epidote and actinolite in these rocks indicates that they are not strongly carbonatized even though they are located up-plunge from major orebodies.

locality b: SAM Unit at town beach

A knoll-like outcrop of the SAM Unit occurs at the Bissett town beach. Although the metagabbro here is relatively featureless, a northeasterly striking feldspar porphyry dyke is exposed in the western part of the outcrop. Such dykes are relatively common in the mine and cut across the SAM Unit in an east-northeast direction. They are carbonatized in the vicinity of ore.

locality c: Gabrielle Shaft southeast of the town curling rink along the lakeshore

A stamp mill and historic plaque marks the site of the original Gabrielle discovery shaft (since backfilled). This was the first gold mill in Manitoba and was brought into the area in 1912 after the 1911 discovery. This locality is of historical interest because the veins and carbonate alteration present here are representative of the "stockwork" style of mineralization. Although this was apparently the first style of mineralization discovered at Rice Lake, its economic importance (larger, wider orebodies) was not realized at the San Antonio Mine until the mid-1930's when the 26 and 36 veins were discovered.

locality d: Mineralization in outcrop 150 m west of c at shoreline (ask permission of owners)

The small low outcrop along the shoreline illustrates small scale examples of the main types of mineralization within the San Antonio Mine Unit. In the western part of the outcrop is an east-northeast striking and moderate northerly dipping shear zone which is representative of the 16-type vein structures. Note the local strong foliation. In the eastern part of the outcrop is a small-scale example of a quartz-albite stockwork zone. Note the local strong bleaching of the host (albite-ankerite-sericite alteration).

***Underground Stop Descriptions:***

Access to the San Antonio Mine is only by permission of the current owners, Rea Gold Ltd. Although much of the current development at San Antonio is dedicated to deeper levels, good representative exposures of the host rocks, structure, ore styles and alteration remain on upper levels such as No. 7 (Fig. 37).

On the 7th level, as on many others in the mine, one approaches the SAM Unit from the footwall side. The footwall rocks belong to the Hare's Island formation and are commonly strongly carbonatized and foliated for a 50 to 100 m interval adjacent to the sill. As a result they form the beige to salmon pink "footwall sericite schist" (note that this rock also occurs locally in the hangingwall of the sill but is much thinner). The southern, footwall contact of the SAM Unit is commonly a sharp and distinct colour boundary from pink to dark green rocks. Note that the melagabbro of the SAM Unit is also strongly carbonatized as well but this is not as visible owing to the larger amount of carbonate that can be formed in it prior to "saturation" (i.e. complete destruction of Fe, Mg, Ca silicates) compared to the more felsic rocks of the Hare's Island formation. To the north of the footwall contact the 701 crosscut branches into three parts. The left branch leads to the 738 Stockwork zone which is now an open stope. The branch straight ahead (716 Drift) follows the famous No. 16 vein which is well exposed in a raise a few metres to the left of here. The right branch (710 cross-cut) leads to several other shear veins similar in style and orientation to No. 16 (706, 708), to weak stockwork type mineralization (704 and 729) and to examples of both late SE- and SW-dipping faults. Carbonate-albite alteration is strong in the vicinity of veins and mafic to intermediate dykes can be observed to cut the SAM Unit at several locations.

Return to Highway 304 and proceed west from the centre of Bissett for approximately 1.5 km passing the Vanson Road on your right. Continue west past this sideroad for to an open area which marks the western firebreak. Turn left (south) onto a poorly marked bush road (drivable in dry weather) and proceed approximately 200 m southward to the first outcrop ridge ( Fig. 38)

**Stop III-4: Overturned Limb of San Antonio Formation**

These outcrops occur along strike from similar ones on the southwest shore of Rice Lake (Fig. 35) and represent overturned strata of the San Antonio Formation which unconformably overlies the host sequence at the San Antonio Mine (Fig. 36). This contact of the San Antonio Formation is not exposed but has been observed in drill core to be moderately sheared (see Stops III-5, 6).

***Stop Description:***

The cross-bedded coarse quartzose arenite at these outcrops is typical of the Formation elsewhere. Here the beds generally strike northwest and dip 60 degrees

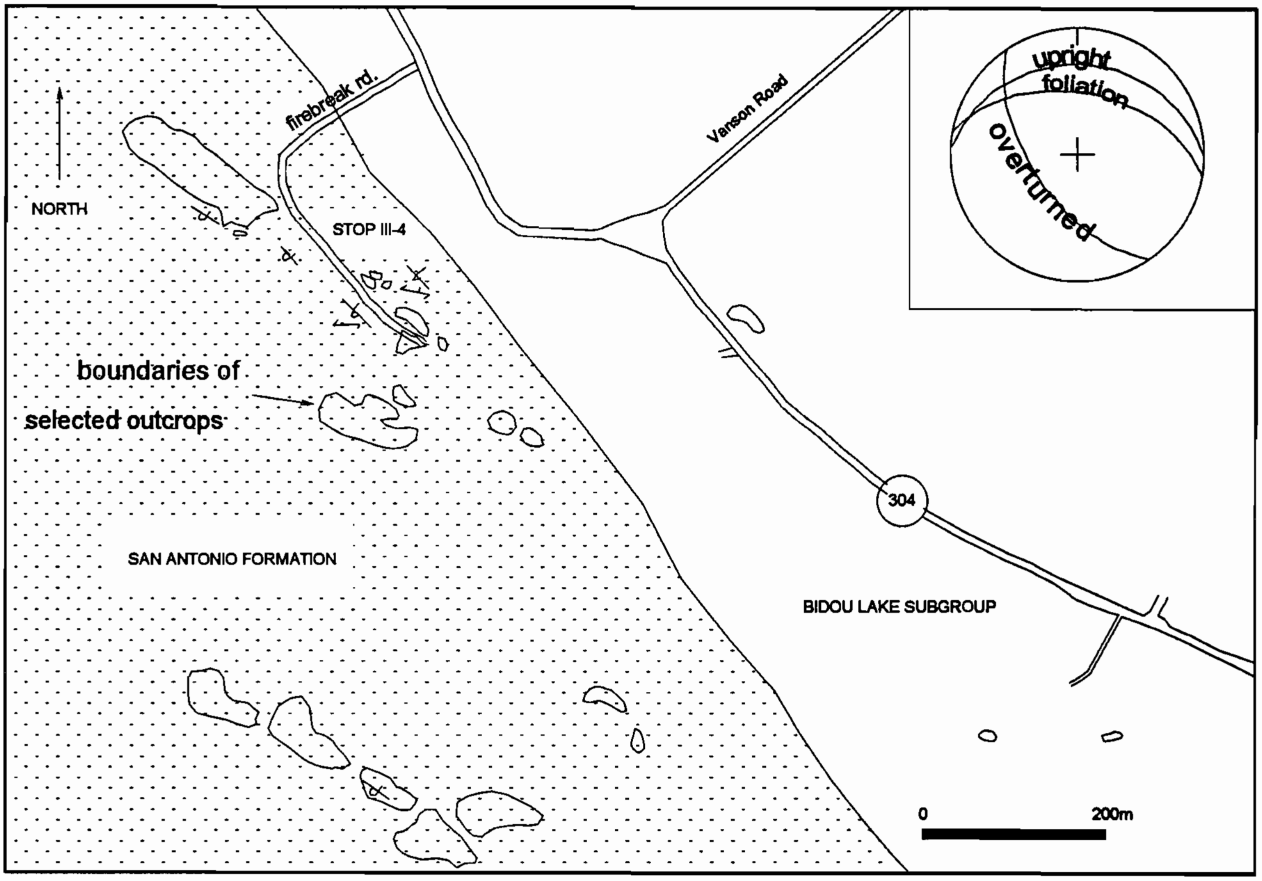



Figure 38: Geology of an overturned panel of rocks of the San Antonio Formation at the west end of Rice Lake.

northeast but face downward to the southwest on the basis of morphology of cross-beds. A prominent east-west cleavage cuts the beds at several localities and locally can be observed to cut an older weaker cleavage that is closer to the bedding orientation. One Interpretation of the structure here is that these exposures occur on the overturned northern limb of a northwest plunging reclined syncline.

Return to highway and proceed west to intersection with Quesnel (Caribou) Lake Road. Turn left on the Quesnel Lake Road and proceed southward. At a distance of approximately 5.5 km a sideroad takes off to the right to the Packsack gold deposit but continue on the Caribou Lake Road for an additional 1.8 km to a series of exposures at a bend in the road near the southwest corner of Red Rice Lake.

**Stop III-5: Nonconformity at base of San Antonio Formation in contact with tonalite (Optional)**

At this locality (Fig. 39), the conglomeratic base of the San Antonio Formation overlaying tonalite (belonging to the pluton southwest of Bissett) is exposed. These exposures are similar to the classical erosional unconformity on the tonalite pluton exposed 10 km west of Bissett (Stockwell, 1938, 1945; Davies, 1963).

***Stop Description:***

From northeast to southwest the following lithologies are encountered:

1. Polymictic conglomerate with boulders of tonalite and layered quartz arenites (re-deposited tonalite regolith found elsewhere at the base of the SAF).
2. Conglomerate with round and subangular tonalite boulders, locally (at one of the peeled locations) conglomerate layers with basaltic clasts.
3. Similar to 2 but essentially monomictic tonalite boulder conglomerate; clasts are subangular to rounded; some clasts are brecciated. Local pink granitic and quartz clasts are evidence that this is a conglomerate; otherwise this location could be interpreted as brecciated tonalite.
4. A large outcrop extending to the south shore of Red Rice Lake exposes highly brecciated and quartz veined tonalite. The contact between units 3 and 4 (above) is exposed(?)in a bleached section.

Return northward along the Quesnel Lake Road for approximately 500 metres and park in a clearing on the east side at the intersection with a bush road leading to the east. Follow the bush road eastward for approximately 500 metres, turn to the north-northwest and proceed approximately 500 m through the bush to a low outcrop (among the trees.

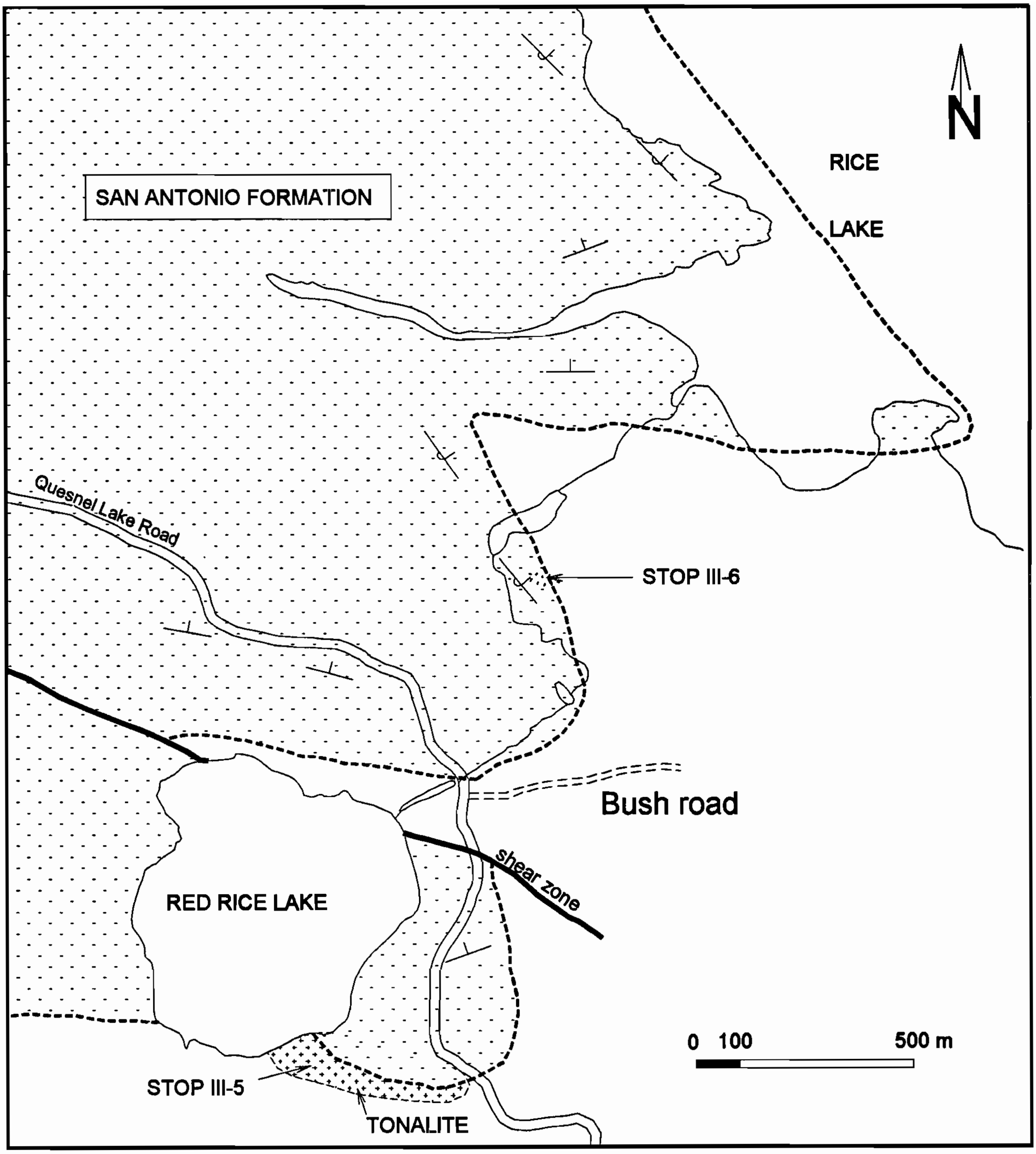



Figure 39: Sketch of the geology between Rice Lake and Red Rice Lake showing the distribution of rocks of the San Antonio Formation.

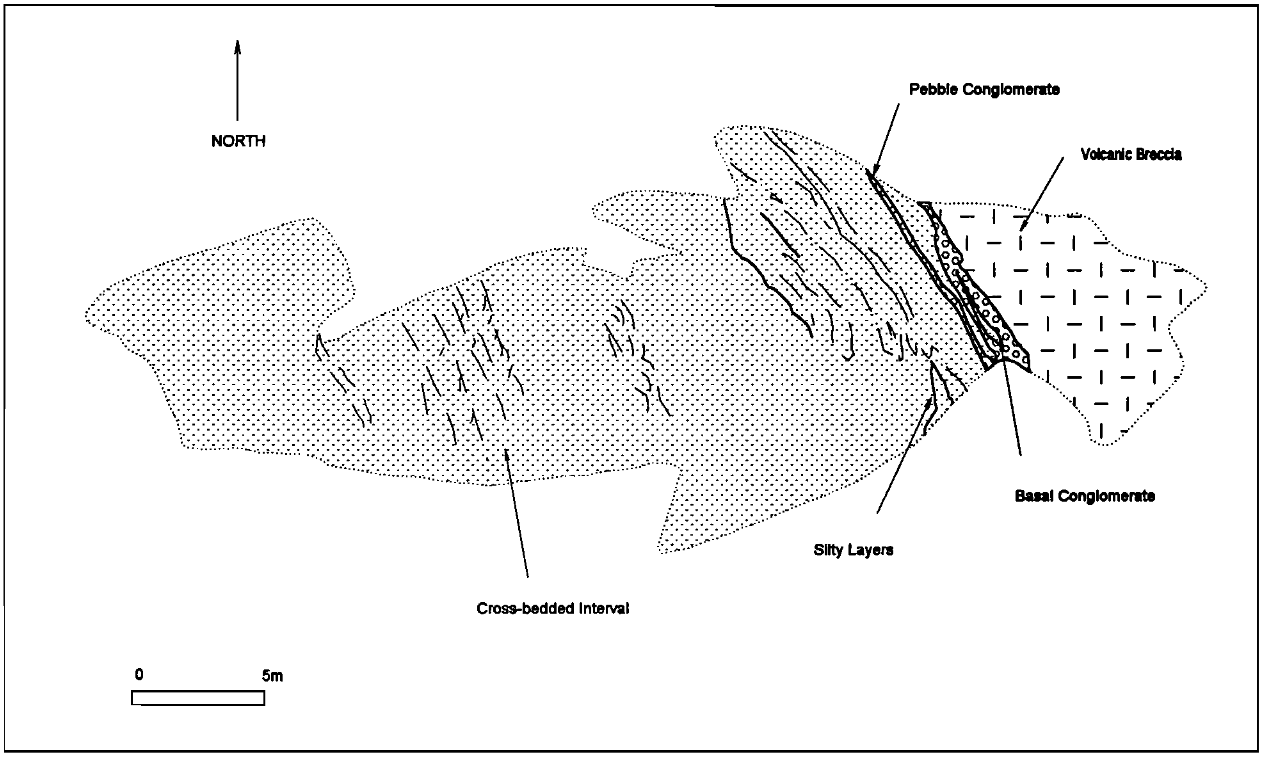



Figure 40: Geological sketch of an outcrop showing the unconformable contact between intermediate volcanic rocks of the Bidou Lake Subgroup and the overlying conglomerate and sandstone of the San Antonio Formation.

**Stop III-6: Unconformity at base of San Antonio Formation**

Stockwell (1938) interpreted an unconformable to nonconformable lower contact between the San Antonio Formation and Rice Lake Group volcanic rocks and coeval intrusions respectively (Fig. 39). At many localities the lower contact is sheared where exposed but an intact contact exists in this outcrop 600 m southeast of Rice Lake and 650 m northeast of Red Rice Lake.

***Stop Description:***

The outcrop is approximately 40 x 20 metres and is elongate in an east-west direction (Fig. 40). At the east end foliated, feldspar-phyric tuff breccia composed of one- to 20-cm clasts is exposed. Two northwesterly striking foliations intersect in a moderate plunging northerly trending lineation. The base of the overlying San Antonio Formation is marked by a one- to two-metre thick conglomerate bed containing mainly local debris but rare ovoid two- to five- mm quartz granules as well as elongate sericitic clasts and sericitic quartz sandstone. The basal conglomerate (regolith ?) is separated from an overlying 15 cm-thick pebble conglomerate bed by approximately one metre of quartz sandstone. Overlying this thin conglomerate is quartz sandstone with local thin siltstone layers containing possible ripple marks. At one location near the southern edge of the outcrop the silty beds are warped into a gentle NW trending open fold which is transected by an east-west (S3?) cleavage. The western part of the outcrop is composed of coarse- to fine-grained cross-bedded quartzose arenite that is typical of the San Antonio formation elsewhere in the region. One- to two-mm pyrite cubes are widely distributed in the first three metres of this sandstone unit.

- END OF FIELD TRIP -

## MINING HISTORY

The following summary has been compiled mainly from information contained in Tuba and Ostry (1994), Minton (1982), Cole (1938) as well as from press articles. It is included here for the general interest of users of the field guide.

### Manigotagan Area

1881: Gold was discovered on Black Island (Minton, 1982), shaft was sunk.

1885-86: Gold was discovered on the south side of Hole River close to its mouth (Minton). A tunnel was driven 50 feet into the rock, some test pits.

**Lotus**
1924: Lotus (33 km NW of Bissett) 1924-35 trenching, pitting drilling. 1946-54 trenching.
1978-81 drilling. 1982 short production.
Production (1982) 8 287 tonnes at 4.56 g/t (0.13 oz/ton) Au.
Reserves (1981) 18 140 t grading 10.29 g/t(0.30 oz/ton) Au.

### Bissett Area

**San Antonio Mine**
1910-11: Discovery of gold at Rice Lake in 1911(Gabrielle property) (Cole, 1938); or "a few days after Christmas 1910" (Minton). (Background: In Febr. 1911 Duncan Twohearts sent some samples to Arthur Quesnel at Manigotagan who gave them to E.A. Pelletier an RCMP inspector and prospector. He panned them and one had gold. In March he went to Twohearts' camp at Turtle Lake and then both went to Rice Lake. Twoheart led Pelletier to a projection on the Lake on March 6, where the sample had come from. The pair made a big fire. The heat chipped the rocks along the shore and disclosed quartz veins and mineralization. Pelletier chipped on the quartz and finally freed gold about the size of a small pea. He staked a claim, the first in the Rice lake area, and named it in honor of a lady friend (after Minton)).

1911: the San Antonio claim was staked by A. Desautels and assigned to E.A. Pelletier.

1912: E.S. Moore (GSC) surveyed Rice Lake area and his report generated much prospecting (Minton).

1912 (August): Pelletier erected a stamp mill on the northwest shore of Rice Lake, at a location presently in front of the Newshams' house. The mill had been brought up Lake Winnipeg to Manigotagan, across 28 portages to Rice Lake. A small amount of ore was taken from the original shaft and crushed by hand before entering the mill. This was the first gold milled in Manitoba.

1927: San Antonio Mines sink No 1 and No 2 shafts (Cole, 1938).

1928: No. 1 completed down to 50m with 305 m of lateral work on the 46 m level. No. 2 had reached 187 m with over 1220 m of drifting and cross cutting on 4 levels.

1929-30: Winze 1, inclined 60° was sunk from the 183 m level at a point 139 m northeast of No. 2 shaft with stations at the 260 and 290 m levels.

1933: San Antonio started milling May 1st, 150 tons per day in August. No. 3 shaft (main production, 3 compartments) was started.

1934: San Antonio paid first dividend, 5 cents a share, milling increased to 170 tons/day. In 1934 Gabrielle Mine also sinks shaft to 400 foot level and in1935 sells its property to San Antonio Gold Mines Ltd.

1935-36: Milling at San Antonio increased to 275 tons/day. 1936 milling increased to 325 tons/day. In 1936 a 547 m cross cut to the Gabrielle workings was completed.

1938-40: No. 3 shaft was completed to 498 m in 1938. It is connected on the 366, 412, and 458 m levels to winze 2 sunk in 1937 from the 320 to the 473 m level. In 1939, No. 3 winze ( a 3 compartment internal shaft) was begun at a point 275 m northeast of the No. 3 shaft on the 456 m level, completed in 1940 to 763 m, opening up 6 new levels at 46 m intervals.

1947: No. 4 winze, located 275 m east of No. 3 winze was sunk from the 16th level 732 m to 1256 m below surface with 10 levels, the deepest (26th) at 1179 m.
In 1960 a 5th winze was completed, located on the adjoining leased property of Forty-Four Mines Ltd.. It extends from the 26th level for 372 m, to 1546 m below surface.

1968: Production ceased due to fire in main hoist and low gold prices. Company was placed in receivership and its assets purchased by 3 of the former directors. Ore reserves estimated at 186 490 tonnes grading over 8.23g/tonne (0.24 oz/ton) gold. Independent consultant estimates that deep drilling would show 1 800 000 tonnes grading 10.63 g/tonne (0.31 oz).

1972: Chemalloy Minerals Ltd. took out a 60-day option to do work. Option not exercised.

1980-84: Brinco and Forty-Four Mines conducted a 7 month feasibility study. It confirmed mineable reserves of 725 680 tonnes with average grade of 6.51 g/tonne (0.19 oz/ton) gold. Work was done to access levels down to 1586 m. In 1981 a $13 million program was started. A 408 tonne/day concentrator was build to replace the one destroyed by fire in 1968. The mine re-opened in January 1982 designed to produce 684 kg gold from the upper levels only. Production reached 49.76 kg by July 1982. Grades of ore only reached 4.8 g/tonne, so operations were terminated in May, 1983. In 1983 Lathwell Resources Ltd. negotiated an option agreement with Brinco. Exploration drilling during 1983 intersected the 97 stockwork with 9 holes. Average thickness below 33 level was 3.45 m averaging 9.26 g/tonne (200 000 tonnes of ore). In 1984 a D shaft ore reserve between the 26 and 36 levels was estimated as 1 203 161 tonnes averaging 7.89g/tonne. Drill holes confirmed the presence of several new stockworks (parallel 97 veins) on the 33 level. However Lathwell dropped the option after phase I exploration work late in 1984.

1985 (November) to 1987: The San Antonio property was optioned by San Antonio Resources, jointly owned by Inco Ltd., Quest Resources and private investors. A 6640 m underground drilling program was carried out that defined a "mineral resource" of 420 000 oz or 13 063 kg gold. In 1987 Kilborn-Cassiar confirms mineable reserves of 1,469,690 tons grading 0.208oz/ton with operating costs of US $322/oz

1989: Early in the year Cassiar (Kilborn) estimates 1.23 million tons at an average grade of 0.223 oz/ton mineable reserves. Cost US $230/oz for the first 3 years, capital cost $11.2 million for extending the A shaft 900ft to the 16th level and deepening the D shaft to access the ore below the 26th level. Later in 1989 Rea Gold acquires San Antonio from Cassiar Mining. Estimated mineable ore below the 26th level was 1.2 million tons grading 0.22 oz/ton and 301,400 tons grading 0.192 oz above the 26th level. Capital cost was estimated at $18.8 million, operating cost at $78.53/ton.

1993-present: In 1993 Rea Gold begins a pre-feasibility study involving underground drilling in 1994. In 1994 Rea Gold begins engineering study to complete feasibility study. Projected production 60 000-70 000 oz/year, cost US$250/oz. Capital cost to mine 1000 tons/day is $30 million. Mineable reserves >400 000 oz.

In 1995 after an underground exploration drilling program in 1994 estimated 1.95 million tons grading 0.197 o.p.t., subsequent recalculations arrive at nearly 3 million tons grading 0.275 o.p.t. Capital cost for bringing the mine back into production is estimated at $30.3 million. Operating costs $61.22 per ton or $US 242 per ounce of gold. Milling 1000t.p.d. upgraded within 2 years. During this period operating revenue of $5.6 million from processing of development ore.

Gold production at San Antonio:

| | | |
|---|---|---|
| 1932-68 | 41,519 kg (1,334,892 oz.) | |
| 1982 estimate | 344 kg | 11,050 oz. |
| 1983 estimate | 137 kg | 4,393 oz. |

Siver production:

1932-68 5,978.2 kg

**Sannorm Mine** (Hunter Group or Normandy)
1934: The Hunter Group was staked by several people. In 1934 it was assigned to Normandy Mines Ltd. Two deposits were opned up in 1934. Property inactive until 1944 when claims were a 21 leases were assigned to the Hunter Group and Sannorm Mines Ltd took over, magnetic surveys and diamond drilling started.
1947: Sangold Mines Ltd. to the north was purchased. A 2 level shaft (at 125 fft intervals) was sunk but work was suspended in 1948.
1952: Consolidated Sannorm Mines Ltd. took over. Geophysical surveys between 1961 and 1971, drilling 1974, 1978, 1986-1989.
No production.
Reserves (1989) 177 460 t grading 4.18g/t (o.12 oz/ton) Au including 106 000 t grading 5.42 g/t gold to a depth of 150 m.

**Gold Field, Wingold**
1913-15: 5 shallow shafts are sunk, 12-31 m deep; a small stamp mill operated for a brief time on Wingold shaft/mine, produced one brick from Chicamon claim near Gold Lake. 100ft shaft was sunk on Big Four in 1914, 50 feet of drifting; Gold Cup (60 ft. shaft, possibly 2 shafts), part of Wingold Group.

1934-36 underground work, Gold Fields shaft deepened to 91 m with 3 levels.
Reserves (1935) 6535 t grading 13.95 g/t (0.41 oz/ton) gold, 6 349 t grading 7.20 g/t Au in a surface dump.

**Emperor-Gold Standard**
1912-17: 40 ft shaft on Emperor claim; 100 ft. shaft on Gold Standard (formerly Independence)- some drifting,
properties sold to Forty-Four Mines.

**Gold Pan, Gold Seal**
1915: A 300 m shaft as sunk and short levels run from it; a mill was built. Mine closed 1916.
1917: Gold Pan Mine Ltd. produced $1400 from two shafts. Arthur Quesnel described that were the vein crossed a diabase dyke, spectacular free gold was extracted and samples were exhibited all over the country. Work continued until 1946-47 (Minton).
1980: drilling
1982: installation of small mill and flotation circuit.
Production (1919-1924) 7.49 kg of Au.
Reserves unknown.

**Vanson Mine**
1926: (Syndicate No.9,10 staked by Aronowitch and Bubis; shaft sunk in 1926 or 27. In 1932 Vanson Gold Mines Ltd. was formed and a 25 ton mill was installed in 1933 and started working. This mill proved unsatisfactory and was replaced by a 2-stamo mill with capacity of 18 tons per day. In 1935 a four-level shaft was completed, but only the

225 and 475 level-foot levels were developed. Equipment was converted from steam to electric and a company town was built. Operations ceased in 1935. Geophysical surveys in 1968, 1970 and 1971. ESL Resources Canada sampled in 1981.
No information on past production or reserves.

**Eva**
1921: 18 m shaft was sunk.
1950 drilling, 1970,71 geophysical surveys, 1979-81 feasibility study, 1981-82 drilling.
Reserves (1981) 15 964 t grading 6.17 g/t (o.18 oz/ton) Au.

**Packsack Mine**
1917: staked as Moncalm claim, 4 km SW of Bissett.
1935: Packsack Mines Ltd. bought property and in 1936 sank a shaft down to 525 ft.
Lack of financing terminated project in 1937.
1940: Gods Lake Gold Mines gained control, but after much drilling and underground development the mine was closed down again in 1940. Open End Mines was processing stockpiled ore afterwards.
1985: small crusher installed and open cut and shaft sinking.
Production(1936-37) development ore stockpiled (1985) small (unknown) amount of gold obtained.
Reserves (1937) 21 800 t at 12.36 g/t (O.36 oz/ton) and 4 536 t at 5.83 g/t (o.17 oz/ton) gold. (1979) 272 155 t grading 10.3 g/t (o.30 oz/ton)

**Wolf Prospect** (Fox-Prime)
1920: pitting.
1949-59: 47 drill holes
1981: drilling.
Reserves (1981) Fox vein: probable reserves 1 807 t grading 6.86 g/t (0.20 oz/ton), possible reserves 12 228 t grading 6.86 g/t; West Fox vein prob. reserves 910 t grading 16.8 g/t (o.49 oz/ton) Au possible reserves are 5 080 t grading 16.8 g/t: prime vein possible reserves 2993 t grading 25.71 g/t (0.75 oz/ton) Au.

**Rita No. 1** (Independence)
1934-37: pitting, trenching, 9 m shaft was sunk.
1964: drilling
1970-71: geophysical surveys, 1973 drilling
1983: geophysical surveys, soil geochem.
Reserves (1938) 2 585 t grading 25.4 g/t (0.74 oz/ton) Au.

**Moose**
1914-16: pitting, trenching; 2 shafts sunk (7.6 and 30.5 m deep),
1936-43: drilling, 1961-62 drilling, 1980 drilling.
Reserves (1986) mine muck samples range 4.9 g/t to 21.6 g/t. (1914-16) 16 780 t grading 34.29 g/t (1.0 oz/ton) Au.

**Gold Lake**
1920: 2 shafts sunk, 6 and 15 m; pitting, trenching.
1935-36: drilling, 1 shaft deepened to 107 m, drifting and crosscutting;
1953 underground exploration, drilling,
1984 drilling.
Production :none
Reserves (1934) 79x1.7 m grading 14.4 g/t (0.42 oz/ton) Au

**Ranger**
1914: 59 ft shaft sunk
1934: drilling
1981: prospecting.
Reserve (1981) 1787 t at 13.7g/t

## Long Lake - Stormy Lake Area

**Central Manitoba Mine**
1925-26: Surface and underground development on the Kitchener group (later Central Manitoba Mines) (Cole, 1938)
1927: Mill of 150 ton/day was erected and started operation at Central Manitoba Mines (Cole, 1938).
Kitchener Mine producing from 1927 to 1937. Others to follow were Tene, Growler and Hope (and Rogers shaft?) mines next to Kichener, operated by Central Manitoba from 1932 to 1937. 1977 trenching; 1981 geophysical surveys; 1982 surface material is milled in Bissett; 1984 drilling.
Production (1927-37) 4 287 kg (or 160 000 oz JS)of Au was produced. (1982) 437 t were processed, but recovery unknown.
Reserves unknown.

**Ogama-Rockland**
1924-25: trenching;
1941: 36 m deep Ogama shaft sunk, deepened to 239 m in 1946-47.
1948: 2 shafts sunk on Rockland vein.
1948-51: Ogama shaft deepened to 314 m and Rockland to 83 m. Production interrupted from 1942-48 , ceased in 1951.
1968, 1973: drilling
1981-82: geophysical surveys, 1984,87 drilling.
Production(1942-43 and 48-51) 50,000 oz (1 555 kg) Au.
Reserves (1950) No. 4 vein - 30,137 t grading 11.66 g/t (0.34 oz/ton) gold

**Onondaga**
1923-24: Onondaga claim staked, 31 m shaft sunk and five-stamp mill installed (Cole, 1938).
1949-50: shaft dewatering and drilling.

1981 geophysical surveys.
1984: drilling.
Production (1933-34) 0.933 kg (30 oz) of gold.
Reserves unknown.

**Elora**
1922: Two-stamp mill installed at Elora Fractional claim, Long Lake, 26 km SE of Bissett (Cole, 1938).
1928 : drilling.
1981 geophysical surveys. 1984 drilling.
Production (1922) 113 t were milled which produced 3.21 kg (104.1 oz) of Au.

**Macketta**
1934: sampling on Halfway Lake, 25 km SE of Bissett;
1938-39: drilling, shaft sunk, drifting;
1963: geophysical surveys;
1978-81, 1986: trenching
1987-88: drilling. No production.
Reserves (1987) 68 000 t grading 4.46 g/t (0. 13 oz/ton) Au.
Contact between Rice Lake volcanics and Ross River tonalite.

**Valley Vein,**
1920-23: 2 shafts sunk (7.6 and 10 m);
1934: drilling,
1945: 10 m shaft deepened to 82 m;
1963 drilling;
1981 geophysical surveys, 1984 drilling.
No production, reserves unknown.

**Eldorado**
1927: Development work (Cole, 1938)

**Gunnar Mine**
1933-36: Diamond drilling at Gunnar Property, 35 km SE of Bissett. 1934 development work: 2 shafts sunk to 305 and 380 m. 1935 mill construction, in operation in 1936.
1937-41: pays its first dividend. Main shaft sunk to 625 m. Operated until 1941.
Processing of mine tailings.
1980 geophysical surveys. 1984 geophysical surveys.
Production (1934-41) 3 101.4 kg of Au was produced. (1979) 0.1 kg of Au.

**Oro Grande-Solo Mines**
1924-26: Development work at Oro Grande-Solo claims, Central Manitoba area (Cole, 1938), 34 km SE of Bissett. 43 m (Solo) shaft sunk, 15 m (Oro Grande) shaft sunk.1928 both shafts deepened.

1932-34 milling commenced in 1932; in 1933 Oro Grande shaft deepened to 78 m and connected to Solo shaft on the 38 m level; new mill installed.
1936-40 operations renewed.
1962 drilling and geophysical surveys.
1984 geophysical surveys.
Production (1932-34) 8.85 kg gold, (1938-40) 156.15 kg of gold.
Reserves (1985) 29 290 t grading 19.29g/t (0.30 oz/ton) between the 150 m level and surface.

**Mirage**
1924: staked
1928-29: 9 m shaft was sunk, trenching and pitting;
1978-81: trenching
1986-87: 2 $km^2$ overburden removal by Esso Resources Canada.

**Mandalay**
1919: staked by O.J. Quesnel.
1934-36: trenching and pitting; 15 m deep shaft,1936 drilling.
1980: sampling; 1984 geophysical and geochemical surveys.

**Tut**
trenching and pitting;
1994 geophysical surveys

## Gem Lake Area

**Diana Mine**
1925-26: Gold discoveries near Gem Lake and Slate Lake (Cole, 1938)
1928-38: Gem Lake mine (Bon), 51 km SE of Bissett, 236 m shaft sunk with 6 levels.
1932: Gem Lake mine milling ore.
1933: Gem Lake Mines bankrupt, Diana Gold Mines takes over.
1967-68: trenching.
1974-77 geophysical surveys, sampling of tailings.
Production (1928-32) 16.95 kg of Au. (1934-36) 199.79 kg of Au. (1937-38) 15.83 kg of Au, (1940-41) 3.02 kg of Au.
Reserves (1976) tailings 27 000 to 45 000 t grading 4,25 g/t. (0.124 oz/ton)

## Wallace Lake Area

**Jeep**
1934: staked
1946: transferred to Jeep Gold Mines Ltd. a subsidiary of San Antonio Mines Ltd.

1947-50: shaft sunk, underground exploration, crosscutting and drifting. Ore grade in 1947 26.5g/t to 64.07 g/t. In 1948 it averaged 27.29 g/t. in 1950 shaft deepened to 180 m with levels at 135 and 175 m.
1958-59 surface exploration.
1973: geophysical surveys, drilling; intention to develop an open pit.
1980 geophysical survey, feasibility study for a 180 tonnes/day mill.
Production (1947-50) 16 319 tonnes were milled producing 432 kg (13 889 oz) of Au.
Reserves unknown

**Conley**
1932: staked
1933-36: 10 pits (to shallow shafts) were dug, drilling.
1958 exploration activity.
1965 drilling for Ag, Au, Cu, Zn, Pb in graphitic slate/argillite, interlayered with silicified limestone.

**Gatlan**
1932: staked; trenching, shaft sinking
1934: drilling
1950: drilling

**Cryderman Mine** (Little Pal claim)
1925: staked
1926: Victoria Syndicate option and work on Cryderman property (Cole, 1938). In 1926 Mining Corporation of Canada sank a 260 ft shaft and 656 ft and 232 ft of drifting on the 125 ft and 250 ft level.
1928: Cryderman Mines Ltd. took over. No work until 1932, when shaft was dewatered, a 40 ton mill and a 100 ton mill were erected, but work stopped again at the end of 1932.
1936: drilling
1958: surface sampling
Production (1931-32) 11.60 kg of gold.
Reserves (1931) 67 m by 7.6 m that grades 17.83 g/t. (1959) 79.9 m by 1.0 m that grades 19.2 g/t (0.56 Oz/ton) Au

**Moore Lake**
1988: geophysical surveys, drilling

## Wanipigow River - Little Beaver Lake Area

**Luleo**
1915: staked
1915-19: shaft sunk 3 500 ft NW of Little Beaver Lake, stamp mill, shut down in 1919.
1921-25: Selkirk Gold Mining Co. took over; its subsidiary, American Development Co.

replaced the mill, extended the shaft to over 525 ft. and did extensive development work on 5 levels. Mine shut down in 1925.
1927-28: Selkirk Mines Ltd. did electromagnetic surveys and drilling in 1927 and 1928. Average grade too low.
1934: Poundmaker Gold Mines Ltd. acquired the claims. Drilling;
1938: a new, hydroelectric mill capable of handling 100 tons per day was constructed, but lack of financing finished the venture in 1942. Several new owners tried to make a going: Jacknife Gold Mines Ltd. Jacobus Mining Co. Ltd. H. Barry, P.E. Beament (1956)(Minton).
1968, 70, 71:Magnetic surveys
1980-83: Production from muck pile in 1980 and 1982-83.
Production 1923-24: 12.4 kg; 1980: 0.9 kg; 1982-83: 6.7 kg (2 093 t)
Reserves unknown.

**Grand Central**
1928: Grand Central (Gold) Mine (Lakeshore claim) on the north shore of Wanipigow Lake. Staked by E. Bonus. Some pits and trenches in 1929.
1933: the Walsh brothers hand-sank a shaft to 107 feet and moved a 5-stamp mill to the property. Operation ceased in 1933 with 300 tons of ore milled which produced 0.93 kg (30 oz.) of Au.
1964, 68, 70, 71: Geophysical surveys
1982: muck pile sampled. 1986 assessment.
Production 300 tons yielded 0.93 kg of Au. (Reserves unknown)

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