GS-26 GEOCHEMICAL SAMPLING OF THE BIDOU LAKE SUBGROUP OF THE RICE LAKE GREENSTONE BELT

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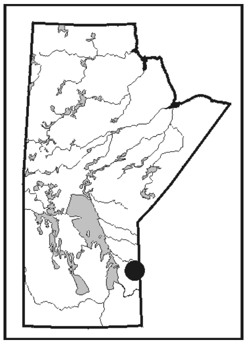

SUMMARY

During a 2 1/2 week field program, a representative suite of 63 least altered samples of volcanic and intrusive rocks was collected from the ca. 2.73 Ga Bidou Lake Subgroup of the Rice Lake greenstone belt. These samples will be analyzed by neutron activation and ICP-MS methods to provide high precision trace and REE element analyses that will permit geochemical characterization of Bidou Lake Subgroup volcanic rocks. The geochemistry of these rocks will be reported in the 1999 Report of Activities.

Geological observations made while collecting geochemical samples are given at the end of this report. They indicate that some important elements of the geological history of the Rice Lake area still remain to be resolved despite overall excellent mapping of this greenstone belt.

INTRODUCTION

The Rice Lake greenstone belt and its equivalent in Ontario, the Red Lake greenstone belt, are important Archean lode gold mining areas (Figure GS-26-1). The Rice Lake greenstone belt, with nearly two million ounces (approximately 60 tonnes) of past gold production (Poulsen et al., 1996), has been mapped in detail (Stockwell, 1938; Stockwell and Lord, 1939; Davies, 1950, 1953, 1963). More recent efforts have been focussed on: 1) broader geological setting and synthesis of the belt (references in McRitchie and Weber, 1971); 2) mineral inventory (Theyer and Yamada, 1989; Theyer and Ferreira, 1990; Theyer, 1991, 1994a,b); 3) relationships between gold-bearing structures and regional generations of deformation (Poulsen et al., 1994, 1996); and 4) geochronological studies (Turek et al., 1989; Turek and Weber, 1991; Poulsen et al., 1994, 1996; Davis, Royal Ontario Museum, unpublished data, 1994).

Recent discovery of older (ca. 3.0-2.85 Ga) Mesoarchean volcanic rocks at Wallace and Garner lakes that do not belong to the dominant (ca. 2.73-2.71 Ga) Neoarchean volcanic rocks of the remainder of the Rice Lake greenstone belt (Figure GS-26-2) suggest that supracrustal rocks of this belt may be composed of several distinctive "tectonic assemblages" (Poulsen et al., 1996). This is comparable to subdivisions proposed by Stott and Corfu (1991) for the Red Lake greenstone belt and other areas in the Uchi subprovince (Figure GS-26-1).

Current geological programs in the Rice Lake greenstone belt are being conducted jointly by Manitoba Energy and Mines (MEM) and the Geological Survey of Canada (GSC). Objectives of this work is to: 1) map and characterize the newly discovered Mesoarchean assemblages on Wallace Lake (Sasseville (McGill University) and Tomlinson (GSC)) and Garner Lake (Corkery (MEM) and Tomlinson (GSC)); 2) elucidate the chemostratigraphy of the Neoarchean assemblages using modern high precision trace element geochemical techniques (Bailes, this report); 3) determine boundary relationships between the Mesoarchean and Nesoarchean assemblages; 4) produce a new 1:100 000 scale compilation of the geology of the Rice Lake greenstone belt; and 5) examine the tectonic and metallogenic setting of mineral deposits (mainly lode gold) in light of new geological concepts that arise from these programs.

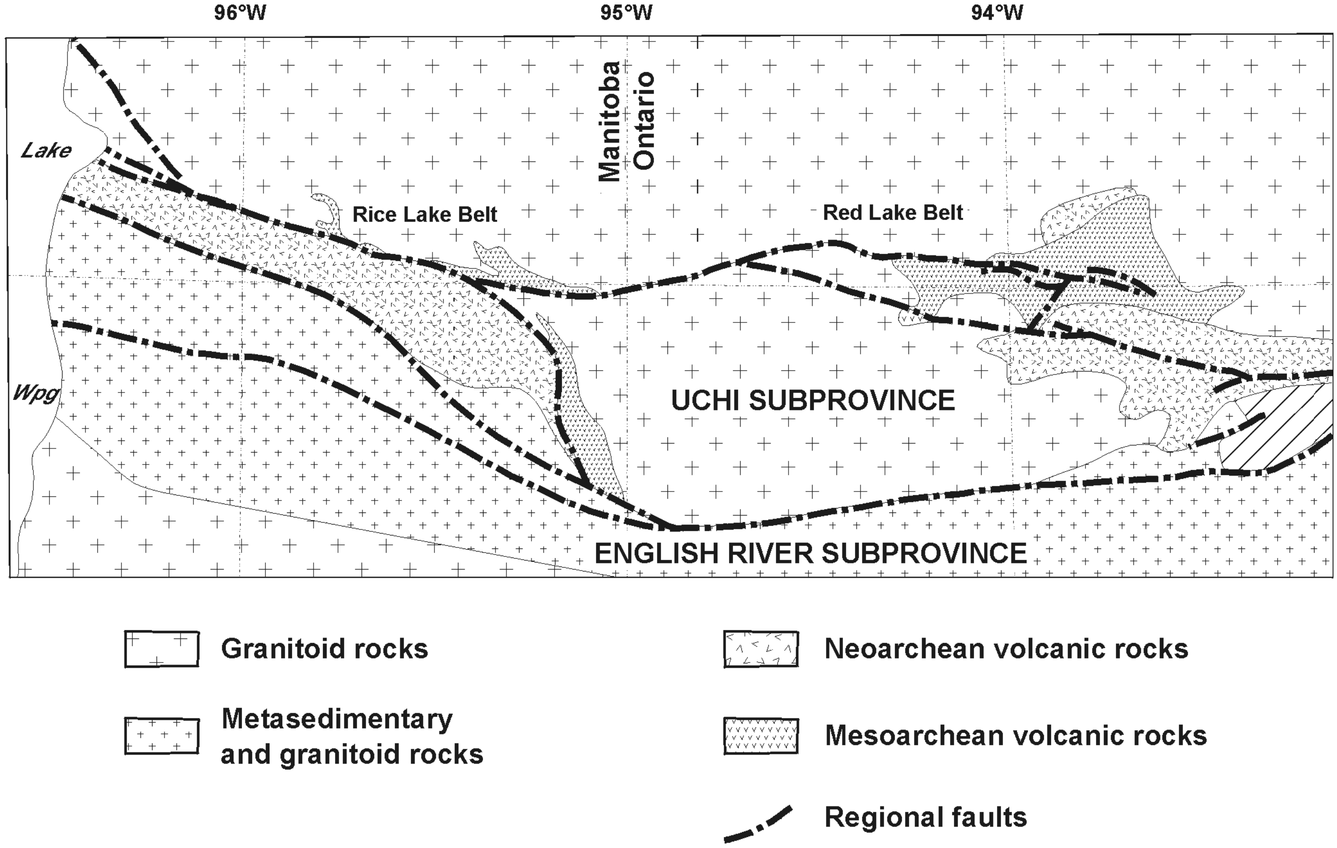

Figure GS-26-1: Setting of the Rice Lake greenstone belt in the western part of the Superior Province (from Poulsen et al., 1996)

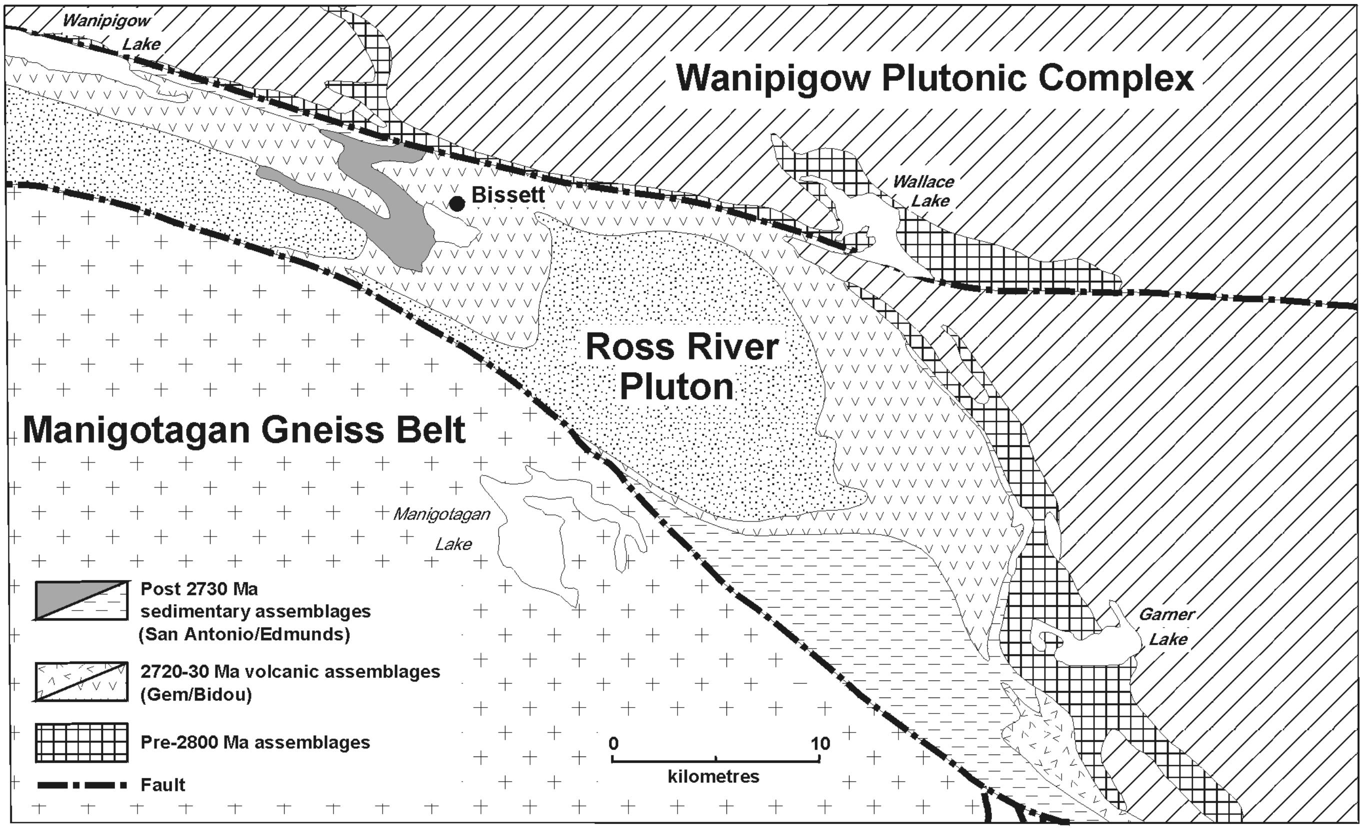

Figure GS-26-2: Interpreted lithotectonic assemblages that compose the Rice Lake greenstone belt (after Poulsen et al., 1996)

This contribution outlines the results of a 2 1/2 week program of geochemical sampling and geological investigations of the Bidou Lake Subgroup, part of the (ca. 2.73-2.71 Ga) Neoarchean volcanic rocks of the Rice Lake greenstone belt.

GEOLOGY OF THE BIDOU LAKE SUBGROUP

Existing geological maps for the Rice Lake greenstone belt, particularly the 2.73-2.71 Ga supracrustal rocks, are high quality and generally do not require upgrading. However, much of the mapping was completed prior to 1975 and predates modern volcanological, geochemical, geochronological and lithotectonic approaches to unravelling the geology of Precambrian 'greenstone' belts (e.g., Dimroth et al., 1979; Bailes and Syme, 1989; Stott and Corfu, 1991; Stern et al., 1995; Lucas et al., 1996). The objective of field work undertaken in 1998 was to sample and examine the 2.73-2.71 Ga Rice Lake Group. This project focussed on the ca. 2.73 Ga Bidou Lake Subgroup of the Rice Lake Group (Weber, 1971b) with T. Corkery responsible for the slightly younger ca. 2.71 Ga volcanic rocks of the Gem Lake Subgroup. Sampling and examination of the Bidou Lake Subgroup was concentrated in two areas where these rocks outcrop most prominently: 1) the Wadhope-Stormy Lake area east of the large synvolcanic 2727.6 ± 8 Ma (Turek et al., 1989) Ross River Pluton; and 2) the Bissett area west of the Ross River Pluton (Figure GS-26-2).

Wadhope-Stormy Lake area

The Wadhope-Stormy Lake area was mapped in detail by Stockwell and Lord (1939), Weber (1971b), Seneshen (1990) and Brommecker (1991). Much of this mapping followed forest fires that provided exceptionally clean exposures and, consequently, unit subdivisions and facing directions for the Wadhope-Stormy Lake area are well defined. The over 3 km thick section of supracrustal rocks in this area are exposed in a large antiformal structure west of Beresford Lake where Campbell (1971), using the excellent mapping of Stockwell and Lord (1939), subdivided the sequence into a number of formations. This subdivision of units, for which Campbell (1971) provided descriptions of type localities, is still used today (see Figure GS-26-3) with only the addition of the Manigotagan Lake formation, formerly part of the Narrows formation, by Seneshen and Owens (1985).

The lower 1.6 km of the supracrustal section, starting at the core of the anticline east of Beresford Lake, consists of a series of texturally distinct basalt formations characterized by low vesicle content and only minor epidote (seafloor?) alteration (Unamed basalt, Tinney Lake Formation, Gunnar Lake Formation). In this lower 1.6 km of the section the basalt formations are seperated by units of well bedded, mafic to intermediate volcaniclastic rocks (Stovel Lake Formation, Dove Lake Formation; see Campbell, 1971). Pillows in the basalt units and turbidite bed forms in the mafic to intermediate volcaniclastic units indicate a subaqueous environment of deposition.

From 1.6 to 3.3 km, the Wadhope-Stormy Lake section (Figure GS-26-3) comprises a series of massive to well bedded felsic to intermediate volcaniclastic units (Stormy Lake Formation, Narrows Formation, Manigotagan River Formation), a dramatic departure from the mafic- and flow-dominated lower part of the sequence. The Stormy Lake Formation consists of a basal volcanic conglomerate overlain by immature volcanic sandstone with local tuff, iron formation/chert and discontinuous basalt flows (Campbell, 1971). The Narrows Formation consists of crystal-rich felsic volcaniclastic rocks and heterolithologic/monolithologic breccia that have been interpreted to be largely subaqueously-deposited pyroclastic, secondary pyroclastic and debris flow rocks (Weber, 1971b). Seneshen and Owens (1985) describe a gradational boundary between the Narrows Formation and the overlying Manigotagan River Formation, with the Manigotagan River Formation consisting dominantly of epiclastic, crystal-rich, reworked felsic detritus, but locally containing volumetrically minor, massive and pillowed basalt flows. Bed forms in the Stormy Lake, Narrows and Manigotagan River formations are indicative of deposition by subaqueous sediment gravity flows, including turbidity currents, which along with minor intercalations of pillowed basalt flows is consistent with a subaqueous environment of deposition. This section was only briefly examined and sampled during the 1998 field program but there is evidence of rounding of fragments in these formations that suggests subaerial reworking of detritus prior to incorporation into these dominantly subaqueously deposited rocks. The general upward increase of quartz content and reworked epiclastic detritus in this section, the local presence of granitic and quartz-feldspar porphyritic hypabyssal clasts, and intercalation with direct products of both mafic and felsic volcanism (flows) suggest that this part of the Wadhope-Stormy Lake section involved construction and unroofing of a

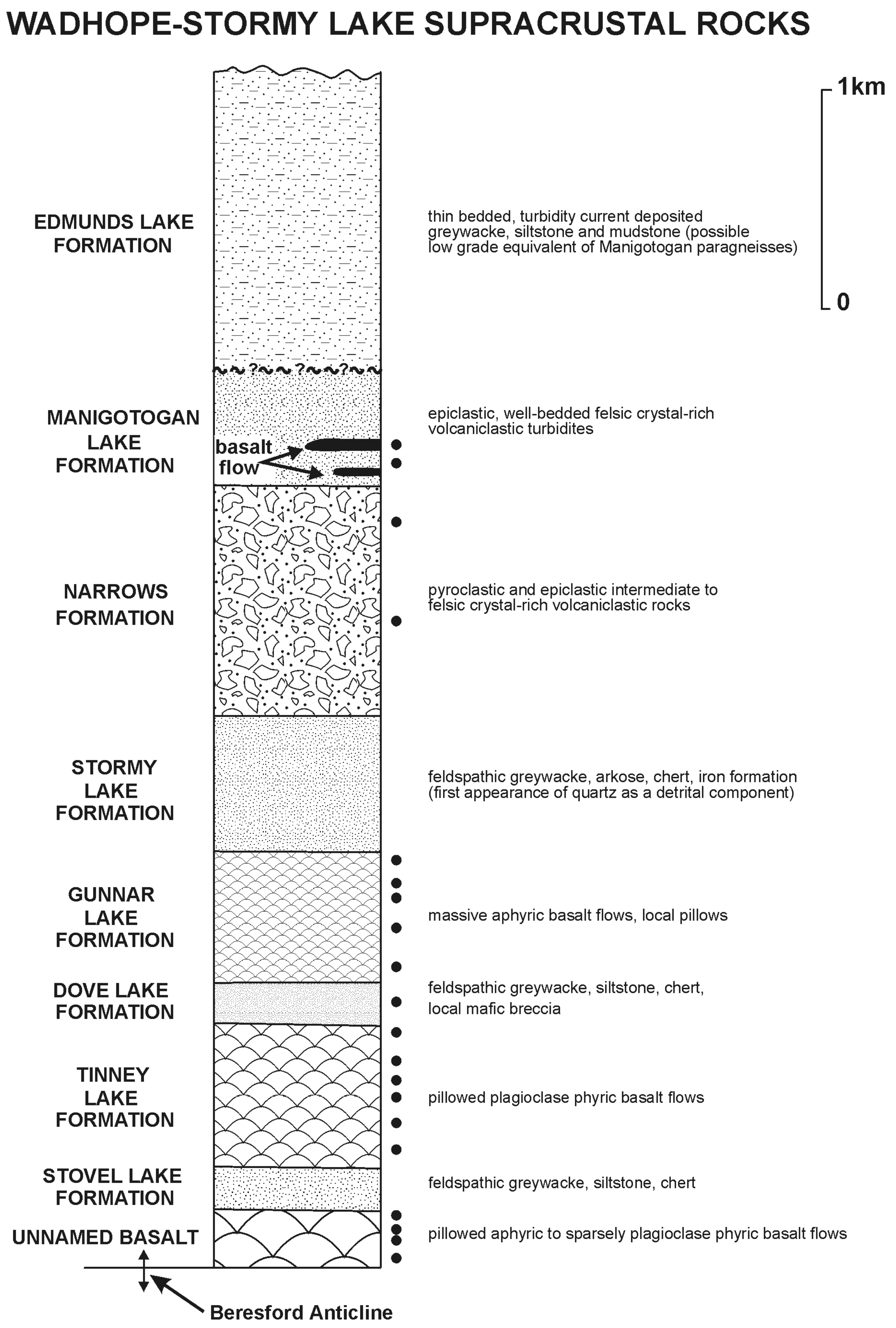

Figure GS-26-3: Section showing major lithological subdivisions in the Bidou Lake Subgroup in the Wadhope-Stormy Lake area. Unit names from Campbell (1971) and Seneshen and Owens (1985). Dots indicate stratigraphic position of geochemical sample sites.

felsic to intermediate volcanic edifice and related subvolcanic intrusions (Seneshen, 1990).

The overlying Edmunds Lake Formation consists of thin-bedded turbidites composed of greywacke, siltstone, mudstone and minor conglomerate. These sediments display a much more uniform grain size and a thinner more continuous bedding than underlying formations, as well as an absence of intercalated volcanic flows (Campbell, 1971). Campbell suggested that these sediments could be less highly metamorphosed equivalents of paragneisses of the Manigotagan gneiss belt and, as such, they may be seperated from other rocks of this section by a major fault and not be part of a structurally intact section. The thickness of the Edmunds Lake Formation is unknown.

Bissett area

The Bissett area has been mapped by Stockwell (1938) and Davies (1953, 1963). Part of Stockwell's area was burned at the time he undertook his mapping. However, most of the Bissett area was and still is dominated by moss and lichen covered outcrops. As a result, recognition of unit boundaries and facing directions are typically not well defined or constrained. This is particularily true of the area mapped by Davies (1953) south of Rice Lake. An additional problem is that most of the Bissett Lake area consists of heterolithologic felsic to intermediate volcaniclastic rocks, most likely the products of deposition by subaqueous debris flows. Acquiring facing directions and identifying meaningful unit boundaries in such units is difficult at the best of times and is almost impossible in areas with poor exposure.

At Bissett, the Bidou Lake Subgroup is continuously exposed between the 'greenstone-bounding' Manigotagan River Fault to the south and the Wanipigow Fault to the north. Examination of these rocks, in 1998, from the south shore of Rice Lake north to the Wanipigow Fault indicates that this suite of rocks is all north-facing (not folded as indicated by Weber (1971a)) and dominantly comprises intermediate to felsic epiclastic and pyroclastic volcaniclastic rocks, with units corresponding closely to those identified by Stockwell (1938), Ames (1988) and Tirshman (1986). Field work, in 1998, south of Rice Lake to the Manigotagan River Fault has not identified any facing directions and has confirmed the subdivision of units identified by Davies (1953). There is no way of knowing whether the section south of Rice Lake is folded, although comparisons to the Bidou Lake Subgroup east of the Ross River Pluton suggests that folding south of Rice Lake is likely. This is also confirmed by the presence of south-facing volcanic strata south of the east end of Wanipigow Lake (discussed below). A composite section (not necessarily a stratigraphic section) through the Bidou Lake Subgroup at Bissett is shown in Figure GS-26-4, with the Normandy Lake Fault corresponding approximately with the south shore of Rice Lake. North of the Normandy Lake Fault the section shown in Figure GS-26-4 is upright (tops north) and unfolded. South of the Normandy Lake Fault facing directions are not directly known but, because volcanic rocks on strike to the west (south of Wanipogow Lake) top south, it is possible that this part of the section in Figure GS-26-4 may be a structural repetition.

The 3.3 km section (Figure GS-26-4) of Bidou Lake Subgroup at Bissett is dominated by felsic to intermediate volcaniclastic rocks that are comparable in overall character to the upper, dominantly felsic, volcaniclastic suite (Stormy Lake Formation, Narrows Formation, Manigotagan River Formation) in the Wadhope-Stormy Lake area. Volcaniclastic rocks in the Bissett section have heterolithologic fragment populations and clasts that were rounded prior to deposition. In large clean exposures, in the vicinity of the new tailings pond for the San Antonio Mine, heterolithologic volcaniclastic breccia typical of the Bissett section are crudely bedded, matrix-supported, and normally to reverse size graded; these beds are interpreted as debris flow deposits. Local pillowed basalt flows, rhyolite flows and felsic pyroclastic flows in the sequence indicate that deposition of the volcaniclastic units was contemporaeous with volcanism. Features displayed by these volcaniclastic rocks is consistent with derivation from a subaerially exposed felsic to intermediate volcanic terrane that included ongoing volcanism. Bed forms (e.g., normal size grading, rip ups) in volcaniclastic rocks and local intercalated pillowed basalt flows suggest a subaqueous depositional environment that was dominated by downslope sediment gravity flows and redeposition of the subaerially transported detritus.

SAMPLING PROCEDURES AND OBJECTIVES

Sampling of the Rice Lake greenstone belt has been undertaken because high precision, low cost geochemical analytical procedures (e.g., ICP-MS) were not available during earlier mapping and geological investigations. The 1998 field program was designed primarily to collect a representative suite of volcanic rocks in the Wadhope-Stormy Lake and Bissett areas. The purpose is to characterize the trace and rare earth element geochemistry of the suite in order to identify the tectonic environment of volcanism and to aid correlation between the Wadhope-Stormy Lake area and the less well understood section at Bissett.

Samples from the Bidou Lake Subgroup were collected from all the major units in the Wadhope-Stormy Lake and Bissett sections. They were taken from mesoscopically least-altered rocks encountered in these sections. Samples were trimmed to remove weathered surfaces, fractures and veins from rocks, and to avoid visible alteration or significant amygdale populations.

The stratigraphic position of sample sites in the Wadhope-Stormy Lake and Bissett sections are plotted for reference in Figures GS-26-3 & 4; 20 samples of supracrustal rocks were collected in the Wadhope-Stormy Lake area and 24 in the Bissett area. In addition 4 samples of late intrusive rocks, 6 basalt samples from the Wallace-Beresford Lake area and 2 samples from cobbles in the younger San Antonio Formation were collected. Sampling was targeted on basalt units as they provide the most information about paleotectonic environment of volcanism. Due to the preponderance of felsic volcaniclastic rocks these units too were sampled where feasible.

MISCELLANEOUS OBSERVATIONS FROM 1998 FIELD PROGRAM

Although the primary objective of the 1998 field program was to collect a representative suite of volcanic rock samples for geochemistry, additional miscellaneous geological observations were made:

1) Volcanic rocks of the Bidou Lake Subgroup were deposited in a subaqueous environment. Rocks higher in the sequence were deposited by fluidized sediment gravity flows of detritus derived from subaerial unroofing of felsic volcanic and plutonic (synvolcanic?) rocks (see also Campbell, 1971; Weber, 1971a; Seneshen, 1990; Poulsen et al., 1996).

2) Bidou Lake Subgroup volcanic rocks exposed on Rice Lake and north to the Wanipigow Fault in the Bissett area are monoclinal and top to the north (i.e., they are not folded as indicated on earlier maps (e.g., Weber, 1971a)).

3) Bidou Lake Subgroup volcanic rocks exposed south of Highway 304 at the east end of Wanipigow Lake are monoclinal and top to the south. They comprise felsic volcaniclastic rocks that most closely resemble rocks exposed north of the Bissett townsite and referred to by Poulsen et al. (1996) as the Round Lake volcanics (Figure GS-26-4). They are heterolithologic, matrix supported volcanic conglomerates characterized by plagioclase-phyric andesite and dacite pebbles and cobbles that were subrounded, probably in a subaerial environment, prior to deposition. The conglomerate beds are intercalated with intermediate to felsic volcaniclastic turbidites and pillowed andesite flows that indicate a subaqueous environment of deposition. This section differs from that observed north of Bissett as the volcaniclastic rocks are thinner bedded and finer grained, and contain andesite flows. A distinctive plagioclase-phyric pillowed basalt at the base of the Wanipigow section may be the lateral facies equivalent of plagioclase-phyric volcaniclastic rocks (Townsite volcanics; Figure GS-26-4) that outcrop prominently in the Bissett townsite. Repetition of the south-facing equivalents of the Round Lake volcanics in the section south of Wanipigow Lake indicates the presence of a tight, east-trending, anticlinal structure that must lie north of Highway 304 in the Wanipigow Lake area and south of Rice Lake in the Bissett area.

4) Rocks between Wallace and Bennett lakes that were previously mapped by McRitchie (1971) as being sedimentary were examined at three localities. At these localities the 'sediments' are in fact tectonites rather than sedimentary rocks. In two localities, just north of the granite body exposed along the road into Wallace Lake, the laminated rocks are clearly highly deformed, pillowed, basalt flows. At a locality along highway 304, laminated felsic rocks are deformed granitic rocks, gradational into less deformed granites to the south and north. These

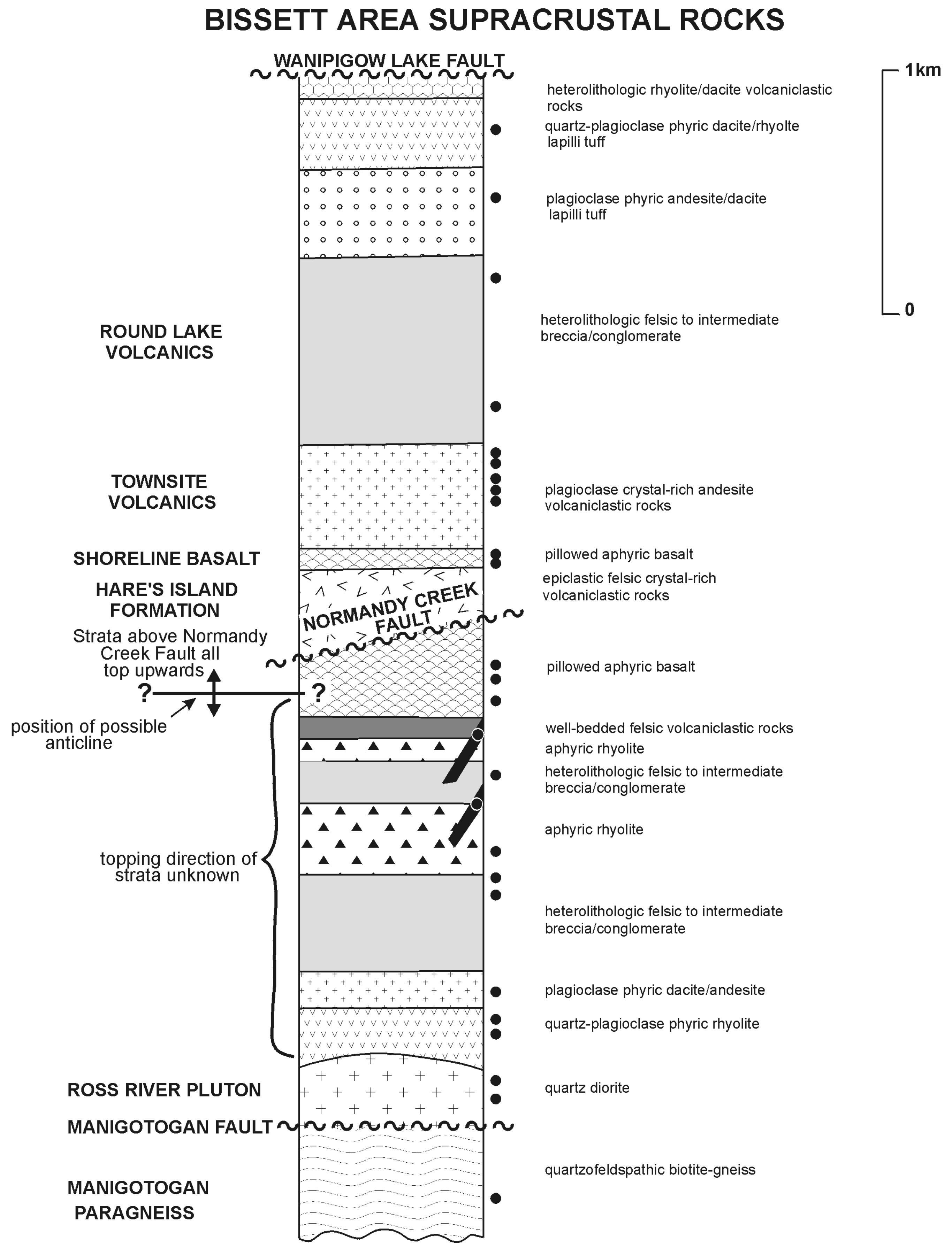

Figure GS-26-4: Section showing major lithological components in the Bidou Lake Subgroup in the Bissett area. Informal units names from McRitchie and Weber (1971) and Poulsen et al. (1996). Dots indicate stratigraphic position of geochemical sample sites.

preliminary findings suggest that some and perhaps many rocks mapped as sedimentary between Wallace and Bennett lakes, as well as equivalents to the southeast, should be re-examined to determine whether or not they are true sediments. These rocks define the contact between pre-2.80 Ga rocks (Mesoarchean) on Wallace and Garner lakes and the dominant 2.73-2.71 Ga (Nesoarchean) rocks of the Rice Lake greenstone belt, so the implication is that these domains may have been structurally juxtaposed.

5) Granitic rocks adjacent to a prominent topographic lineament on the south side of Siderock Lake display abundant ankerite veins in fractures generated by brittle deformation. The implication is that this lineament and others like it may be late brittle structures. Since these lineaments have been used to help define the location of the regionally important Wanipigow Fault, the question is whether these late brittle structures (lineaments) are the 'total' expression of the Wanipigow Fault or whether they are simply late, brittle-stage deformation on a longer-lived zone that included ductile deformation. The latter seems more likely, as Poulsen et al. (1996) report prominent phyllonite and mylonite zones spatially associated with the Wanipigow Fault.

6) San Antonio Formation lithic arenites and conglomerate not only lie unconformably upon older volcanic rocks of the Bidou Lake Subgroup (McRitchie and Weber, 1971), but postdate an episode of previously unrecognized pre-San Antonio deformation. Evidence for this lies in foliated cobbles of volcanic rocks in the conglomerate and foliated xenoliths of volcanic rocks in granitic boulders. This generation of foliation is not present in either the sandstone matrix or in the contained granitic cobbles and boulders, and is oriented in random directions in the cobbles and pebbles of volcanic rocks in the conglomerate. The underlying granitic pluton (Figure GS-26-2), which was included in the same unit as the subvolcanic Ross River pluton (Weber, 1971a), is not subvolcanic as it postdates deformation of the Bidou Lake Subgroup volcanic rocks. This deformational history also indicates a possible explanation for the apparent abrupt termination of post-San Antonio folds in underlying volcanic rocks. To accomplish this, pre-San Antonio deformation need only to have placed the Bidou Lake Subgroup formations at a high angle to the subsequent depositional plane of the unconformably overlying San Antonio Formation. Thus, post-San Antonio subhorizontal shortening only flattened (i.e. did not fold) steeply inclined formations of the Bidou Lake Subgroup, whereas it openly folded flat-lying bedding in the overlying San Antonio Formation.

7) The Normandy Creek Fault, recognized by Ames (1988) and Poulsen et al. (1996), likely cuts through the San Antonio Formation, as rocks previously assigned to the Bidou Lake Subgroup on the southwest shoreline of Rice Lake are actually highly foliated San Antonio Formation conglomerates. These foliated conglomerates are on strike with the Normandy Creek Fault and indicate that this fault cuts and offsets the contact of the San Antonio Formation with the underlying Bidou Lake Subgroup.

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