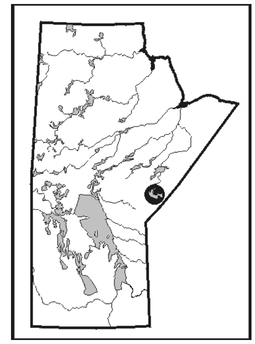
GS-18 GEOLOGICAL INVESTIGATION IN THE ISLAND LAKE GREENSTONE BELT, NORTHWESTERN SUPERIOR PROVINCE, MANITOBA (PARTS OF NTS 53E/15 & 16)

by S. Lin, H.D.M. Cameron, E.C. Syme and F. Corfu[1]



Lin, S., Cameron, H.D.M., Syme, E.C. and Corfu, F. 1998: Geological investigation in the Island Lake greenstone belt, northwestern Superior Province, Manitoba (parts of NTS 53E/15 & 16); **in** Manitoba Energy and Mines, Geological Services, Report of Activities, 1998, p. 78-87.

SUMMARY

Mapping in the Island Lake greenstone belt has resulted in a better understanding of the stratigraphy and structure of the belt. It shows that: 1) the Hayes River Group can be divided into four lithologically distinct, shear zone-bounded panels; 2) the lithology and depositional environment of the sedimentary rocks at the base of the Island Lake Group vary significantly from locality to locality, from subaerial to subaqueous; and 3) the Bella Lake pluton, a major pluton in the area, intrudes, instead of being unconformably overlain by, the Island Lake Group. Mapping also elucidated the geometry and kinematics of three major shear zones in the belt, the Savage Island, Harper Island and Whiteway Channel shear zones, and their significance in the interpretation of the geology of the greenstone belt. Two distinct events of gold mineralization have been recognized, both related to shear zones.

INTRODUCTION

The Island Lake greenstone belt is one of the largest greenstone belts in the northwestern Superior Province of Manitoba (Fig. GS-18-1). A structural study of the greenstone belt was begun in 1997 and continued in 1998 to better understand its geological evolution. This study is one of Manitoba Energy and Mines' Northern Superior projects and part of the Western Superior NATMAP project.

The Island Lake greenstone belt has been mapped at the scale of 1:50 000 by Godard (1963a, b) and at a scale of 1:20 000 by Neale (1981), Neale and Weber (1981), McGregor and Weber (1982), Neale et al. (1982), Weber et al. (1982a), Gilbert et al. (1982, 1983) and Gilbert (1984a, 1985a, b). The geological setting of mineral occurrences in the area have been described by Theyer (in press, and references therein) and Lin and Cameron (1997).

The purpose of this study is to improve our understanding of the Island Lake area through detailed structural mapping, as well as geochemical and geochronological studies. Mapping in 1997-98 was mainly concentrated in the eastern part of the belt, in NTS 53E/16 (Fig. GS-18-2), and this report is mainly concerned with this area unless otherwise indicated. Reconnaissance work was also carried out in NTS 53E/15 (Fig. GS-18-2) to observe critical relationships and to prepare for mapping in 1999.

GENERAL GEOLOGY AND STRATIGRAPHY

Results of the current mapping that pertain to the general geology and stratigraphy of the Island Lake greenstone belt are summarized in this section. The structural geology of the belt is discussed in a subsequent section of the report.

The rocks of the Island Lake greenstone belt have been traditionally divided into two groups, the Hayes River Group and the unconformably overlying Island Lake Group. The Hayes River Group consists of mafic volcanic rocks (and spatially associated gabbro intrusions), subordinate intermediate and felsic volcanic rocks, and volcanogenic sedimentary rocks. A Hayes River Group dacite in the western part of the belt has yielded a U-Pb zircon age of 2861 ±12 Ma (Stevenson and Turek, 1992). The Island Lake Group consists of conglomerate, sandstone and turbidite. The supracrustal rocks are intruded by granitoids that are between ~2890 to ~2700 Ma in age (Turek et al., 1986; Stevenson and Turek, 1992).

Hayes River Group

The Hayes River Group can be divided into four lithological panels by three major shear zones: 1) the Savage Island shear zone in the south (Weber et al., 1982b); 2) the Harper Island shear zone in the north; and 3) the Whiteway Channel shear zone near the northern edge of the map area (Fig. GS-18-3). Planned geochemical and geochronological

[1] Royal Ontario Museum, Toronto, Ontario M5S 2C6

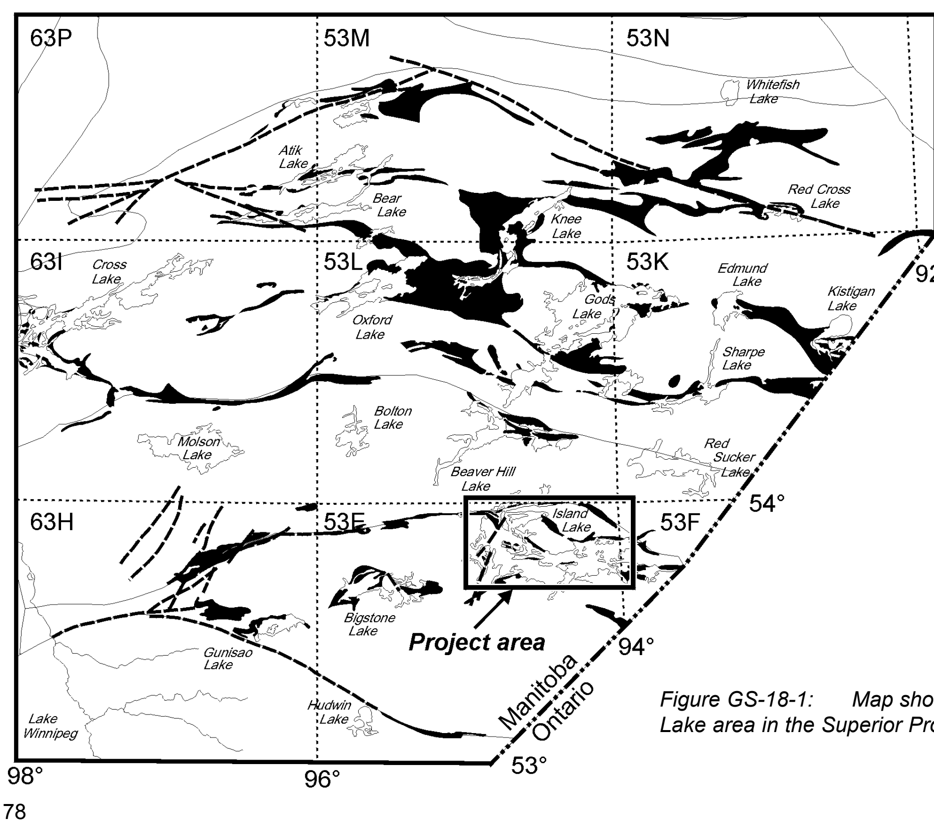


Figure GS-18-1: Map showing the location of the Island Lake area in the Superior Province of Manitoba.

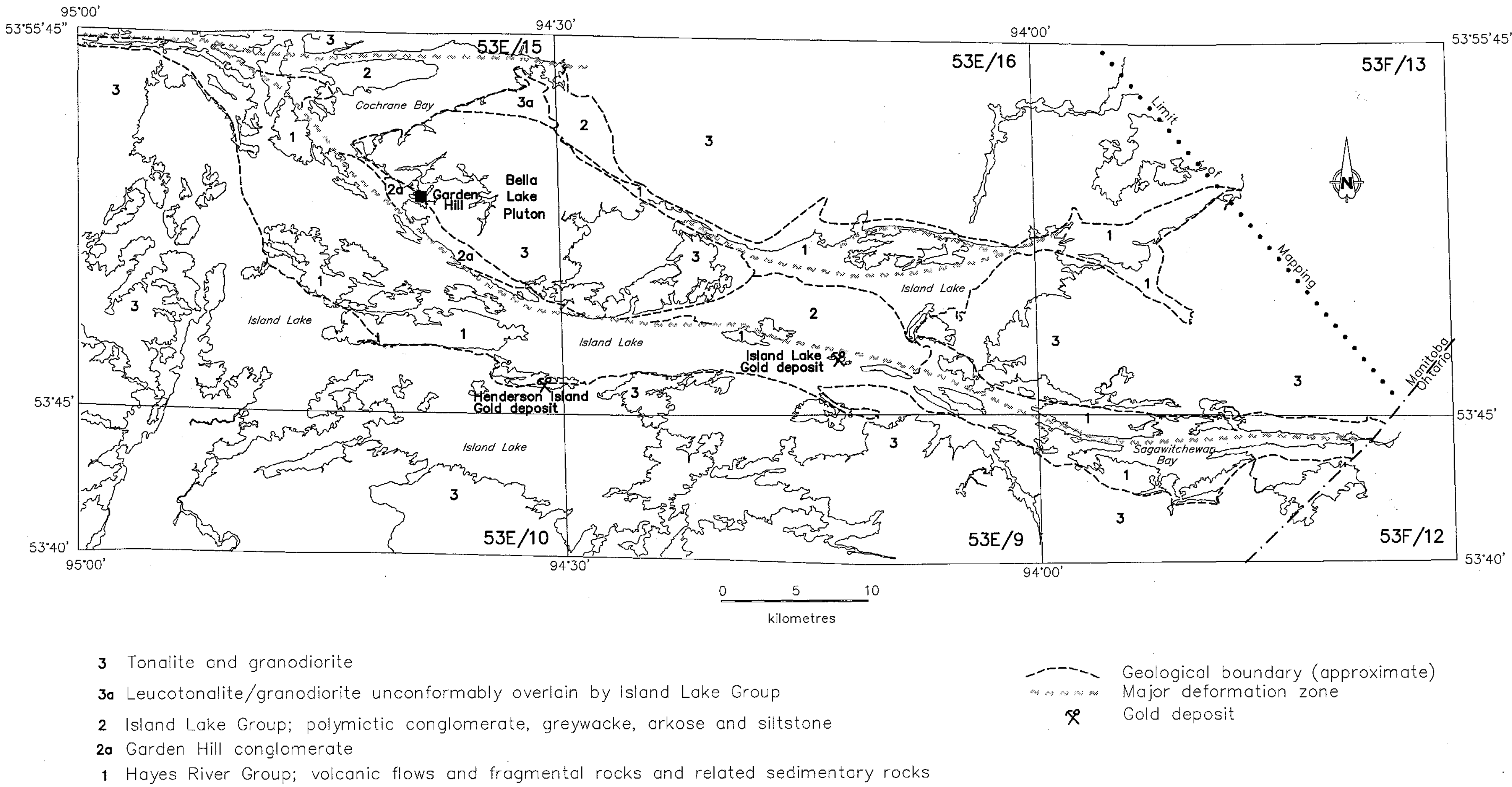


Figure GS-18-2: Simplified map of the Island Lake greenstone belt.

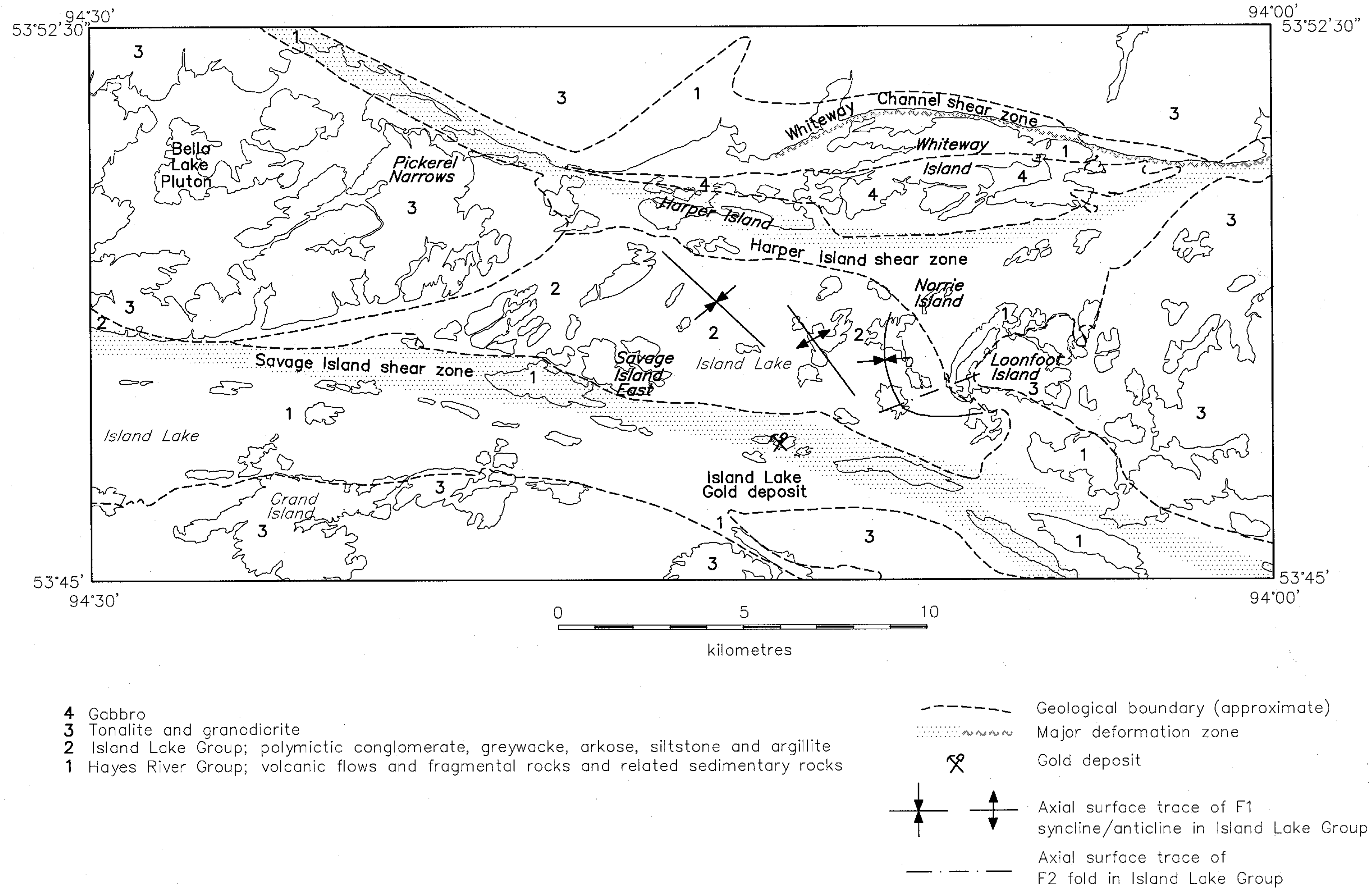


Figure GS-18-3: Simplified map of the eastern Island Lake greenstone belt.

work will be used to define the petrogenesis and age of rocks in these distinct, shear zone-bounded panels.

The panel south of the Savage Island shear zone consists of mafic, intermediate and felsic volcanic rocks and volcanogenic sedimentary rocks, generally metamorphosed to amphibolite facies. Small gabbro bodies are spatially associated with the mafic volcanic rocks. Rocks in this panel are generally strongly deformed (see below) and primary structures are rarely preserved.

The panel between the Savage Island and the Harper Island shear zones consists of pillow basalt with very minor mafic and ultramafic intrusions. The pillow basalt can be subdivided into two suites: 1) in the northwest, near Harper Island, a very dark to black coloured suite that contains abundant epidote veins and domains; and 2) in the east, near Loonfoot Island, a pale-green suite that does not contain epidote.

The panel between the Harper Island shear zone and the Whiteway Channel shear zone is composed of pillow basalt and minor sedimentary rocks. These rocks are intruded by a large (~8 x 2 km) gabbro-quartz diorite body at Whiteway Island.

The panel to the north of the Whiteway Channel shear zone consists of amphibolite grade mafic to ultramafic rocks, including a pillowed ultramafic flow.

Island Lake Group

The lithology and depositional environment of the sedimentary rocks at the base of the Island Lake Group vary significantly from locality to locality (Fig. GS-18-4). At the southern shore of Cochrane Bay (Fig. GS-18-2), the group unconformably overlies tonalite-granodiorite (Weber et al., 1982b); the unconformity and regolith are both well exposed. The regolith consists of blocks of tonalite-granodiorite and quartz in a blue quartz eye-rich matrix. It grades, in ascending stratigraphic order, into polymictic conglomerate, sandstone and greenish wacke-siltstone (mudstone) turbidites.

In the Norrie Island area (Fig. GS-18-3), the Island Lake Group unconformably overlies Hayes River Group pillowed basalt. The unconformity is well exposed at the southern end of Norrie Island (see Gilbert, 1984b). As at Cochrane Bay, the regolith at the unconformity grades into polymictic conglomerate, grey to slightly reddish cross-bedded sandstone and greenish wacke-siltstone (mudstone) turbidites, in ascending stratigraphic order.

In the Savage Island East area (Fig. GS-18-3), the stratigraphically lowest lithology exposed is a turbidite consisting of sandstone and black shale (Fig. GS-18-5). The sandstone contains abundant large (up to 4 mm) blue quartz grains that are similar to those in the regolith described above at the south shore of Cochrane Bay. At the south edge of Savage Island East (Fig. GS-18-6), this turbidite grades into an overlying thin layer of turbiditic sandstone (with similar quartz eyes) that in turn grades into a thin layer of pebbly conglomerate with quartz-rich sandstone matrix, and finally into polymictic cobble conglomerate. The polymictic conglomerate in turn grades upwards into grey to slightly reddish cross-bedded sandstone. These cross-bedded sandstones are succeeded by greenish wacke-siltstone-mudstone turbidites. Inasmuch as the polymictic conglomerate here is unambiguously part of the Island Lake Group, we interpret the conformably underlying turbidite as also part of the group. The turbidite is stratigraphically correlative with the regolith at Cochrane Bay and possibly with the regolith at the southern end of Norrie Island. These relations indicate that, during the initial deposition of the Island Lake Group, the depositional environment was subaerial in the (present day) east and west, but subaqueous in the centre. In other words, the western and eastern parts of the area were elevated above sea level before the central part. The implications of this observation for the geological evolution of the Island Lake greenstone belt, especially the tectonic setting of the Island Lake Group, will be a focus of further study.

The turbidite at Savage Island East described above can be traced westwards to the Garden Hill area (Fig. GS-18-2). At Garden Hill, it is conformably overlain by a polymictic conglomerate (Garden Hill conglomerate of Weber et al., 1982b; unit 2a in Fig. GS-18-2). Weber et al. (1982b) assumed that the turbidite was part of the Hayes River Group, and thus concluded that the conglomerate belonged to the same Group. The relationship we established at Savage Island East demonstrates

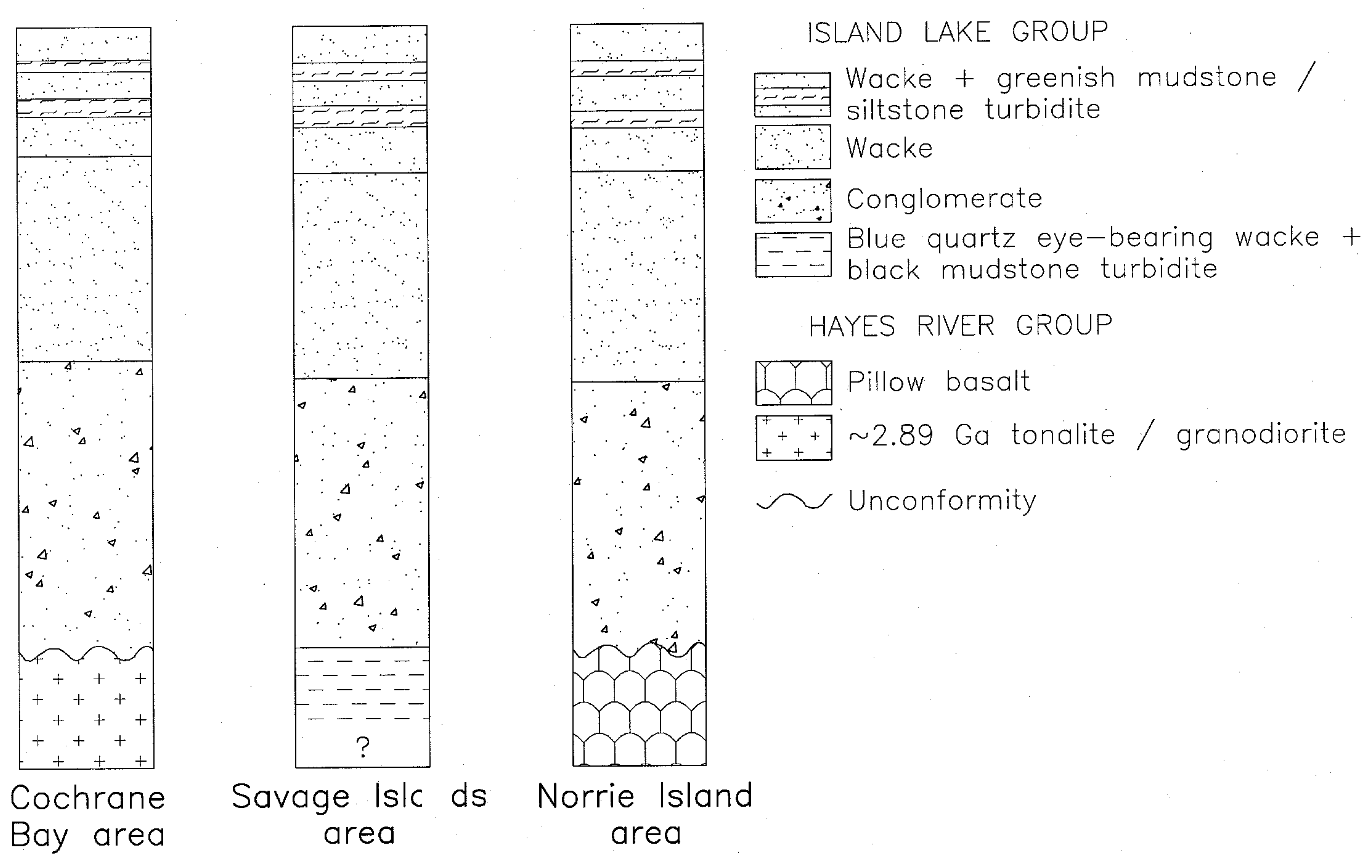


Figure GS-18-4: Schematic stratigraphic sections through the Island Lake Group showing the lateral variation in lithology (and depositional environment) of the sedimentary rocks at the base of the group.

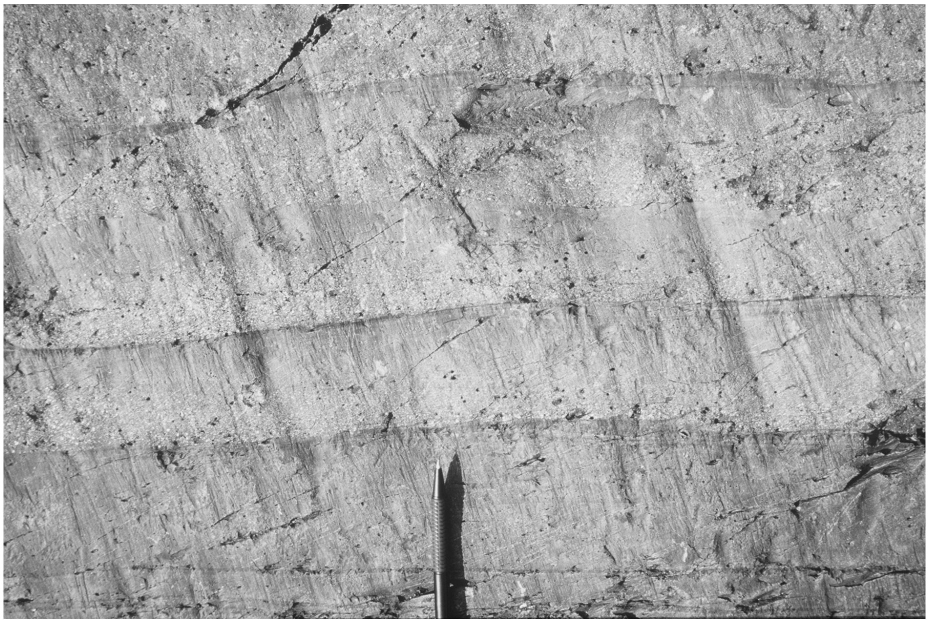


Figure GS-18-5: Turbidite at the base of the Island Lake Group.

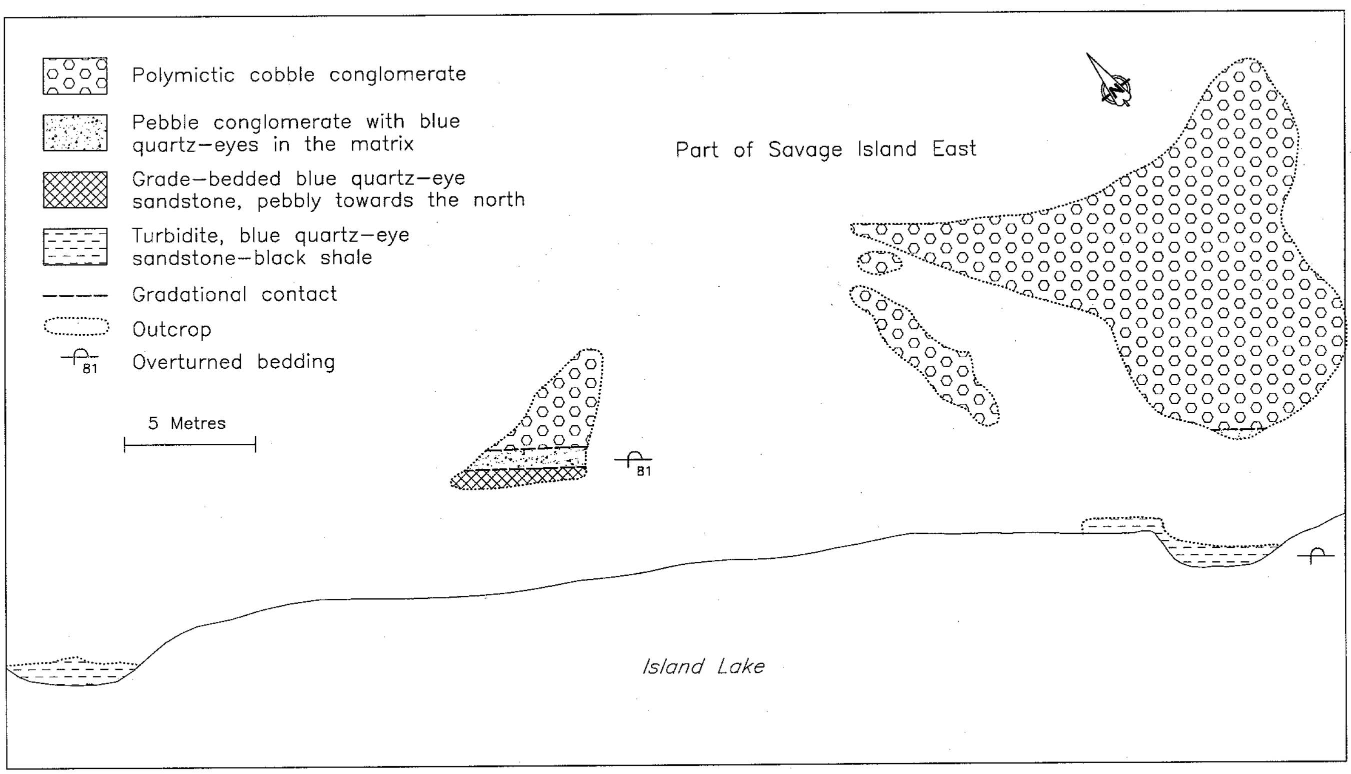


Figure GS-18-6: Sketch of outcrops at the south edge of Savage Island East, showing the stratigraphy near the base of the Island Lake Group.

that both the turbidite and the conglomerate are clearly part of the Island Lake Group. This is consistent with the observation that the conglomerate can be traced into lithologically identical Island Lake Group conglomerate in the eastern Island Lake and Cochrane Bay areas (Fig. GS-18-2). These relationships indicate that the Island Lake Group is continuous in the Island Lake area and was deposited in a single basin. The group is intruded by the Bella Lake pluton (see below), which separates the western and eastern outcrop areas and erroneously lends the appearance of two separate basins.

Bella Lake pluton

The Bella Lake pluton (~28 x 11 km; Fig. GS-18-2) consists of massive hornblende tonalite with characteristic pale-green plagioclase. Weber et al. (1982b) interpreted that the pluton to predate the Island Lake Group, based on the observation that at the southeastern shore of Cochrane Bay a conglomerate unconformably overlies granitoids, as described above. Although the existence of the unconformity was confirmed during the current study, we determined that the granitoids at the unconformity locality are different from those typical of the Bella Lake pluton. In fact, at most localities where the contact is exposed, granitoid rocks intrude the Island Lake Group. Accordingly, we suggest that the term Bella Lake pluton be reserved for the hornblende tonalite that intrudes, and thus is younger than, the Island Lake Group. The areally restricted granitoids (unit 3a in Fig. GS-18-2) unconformably overlain by the Island Lake Group are clearly a remnant of an older plutonic suite and cannot be included in the Bella Lake pluton *sensu stricto*.

The older granitoids (unit 3a) at southeastern Cochrane Bay include two distinct lithologies. One, a massive leucotonalite with bluish quartz, has yielded a U-Pb zircon age of 2886 ±15 Ma (Turek et al., 1986). Blue quartz eyes in the regolith at southeastern Cochrane Bay and in the turbidite near the base of the Island Lake Group at Savage Island East were most likely derived from this pluton. The other granitoid lithology is a strongly foliated granodiorite. The foliation in this rock was formed before the deposition of the Island Lake Group because the regolith at the unconformable contact with the granodiorite contains blocks of foliated granodiorite. Clasts of foliated granitoids are common in the conglomerate of the Island Lake Group.

Turek et al. (1986) interpreted the Hayes River Group to be partly older than ca. 2886 Ma because they assumed that the dated (ca. 2886 Ma) leucotonalite was part of the Bella Lake pluton that intrudes the Hayes River Group. This interpretation should be reevaluated because we cannot be sure that the dated leucotonalite does, in fact, intrude the Hayes River Group.

The younger, post-Island Lake Group hornblende tonalite of the Bella Lake pluton was traced from near Harper Island, in the east, to the south shore of Cochrane Bay, close to the location of the unconformity described above. In the east, this pluton cuts bedding in Island Lake Group conglomerate and interlayered sandstone (Fig. GS-18-7a). At the south shore of Cochrane Bay, the pluton intrudes Island Lake Group greenish sandstone-siltstone and interlayered conglomerate (Fig. GS-18-7b).

a)

b)

Figure GS-18-7: (a) Intrusive contact between the Bella Lake pluton (on the left) and the Island Lake Group (on the right) at eastern Island Lake. Note that the pluton cuts the bedding in the sediments. (b) Intrusive contact between the Bella Lake pluton and the Island Lake Group on western Island Lake, south shore of Cochrane Bay.

STRUCTURE

The Hayes River Group and Island Lake Group experienced multiple generations of deformation. The former experienced at least one more generation of deformation than the latter. Clasts with predepositional tectonic fabrics are very common in the conglomerate of the Island Lake Group, including mylonite clasts with S-C fabric (Fig. GS-18-8).

Shear zones

The most significant structures in the area are the three shear zones mentioned previously: the Savage Island, Harper Island and Whiteway Channel shear zones (Fig. GS-18-3). The northern and southern contacts of the Island Lake Group are also sheared. North of the Whiteway Channel shear zone and south of the Savage Island shear zone rocks typically are strongly deformed and mostly contain amphibolite facies mineral assemblages. Rocks between these two shear zones are only locally strongly deformed and primary features, such as pillow structures, graded and cross bedding, are well preserved. These rocks contain greenschist facies mineral assemblages.

In the strongly deformed amphibolite facies rocks south of the Savage Island shear zone, a foliation and lineation are well developed. The foliation strikes easterly to east-southeasterly and dips steeply. The lineations plunge steeply. The foliation is axial planar to locally preserved isoclinal folds and is defined by amphibolite facies minerals (e.g., hornblende). The deformation is thus interpreted to have occurred under amphibolite facies conditions. In this area, different lithologies occur in narrow zones that follow different chains of islands. The contacts between the different lithological units, although not exposed, are likely sheared.

The Savage Island shear zone is a large-scale structure that extends for over 40 km from Sagawitchwan Bay to Garden Hill, and probably further west (Weber et al., 1982b; Figs. GS-18-2 and 3). Near this shear zone, the foliation in the amphibolite facies rocks described above is folded and a new axial planar foliation is developed (Fig. GS-18-9a). The new foliation is defined by greenschist facies mineral assemblages. Near the margin of the shear zone, the earlier, higher grade, foliation is clearly recognizable (Fig. GS-18-9a); however, in most of the shear zone, the deformation is extremely strong, the earlier foliation is transposed and obliterated (Fig. GS-18-9b), and mylonite or phyllonite is well developed. The new foliation strikes easterly to east-southeasterly and dips steeply, and the lineations plunged steeply east. Shear sense indicators indicate south-over-north dip slip with dextral strike-slip component (Fig. GS-18-10). The dip slip component explains the observation, described above, that the metamorphic grade is higher to the south than to the north of the shear zone.

The easterly-trending Harper Island shear zone has been traced from Pickerel Narrows, in the northwest, to the east of Whiteway Island (Fig. GS-18-3). Rocks in the shear zone are strongly deformed with well developed foliation and lineations (Fig. GS-18-11a). The foliation strikes easterly and dips steeply, and the lineations plunge steeply. Dextral shear sense indicators are well developed on the horizontal surfaces (Fig. GS-18-11b). This structural association indicates that the shear zone is most likely a dextral transpression zone.

The Whiteway Channel shear zone strikes approximately easterly and dips steeply. The shear zone follows the channel and is exposed sporadically along the shoreline. It merges with the Harper Island shear zone towards the east (Fig. GS-18-3). Mineral assemblages in mylonites suggest that deformation occurred under greenschist facies conditions. The lineations in this shear zone also plunge steeply, and the movement along the shear zone is north-over-south dip slip and explains the observation that the rocks to the north contain higher grade mineral assemblages than those to the south.

Folds

Folds are common in the Island Lake greenstone belt. Outcrop scale folds are mainly associated with shear zones where rocks are strongly foliated and the foliation is commonly folded. Macroscopic scale folds are also common. Their relationship with the shear zones, if any, is not clear. Outcrop scale folds parasitic to the macroscopic folds are rare, and the presence of the macroscopic folds are mainly indicated by younging direction reversal and local bedding-cleavage relationship reversal.

Two generations of macroscopic folding are recognized in the Island Lake Group (Fig. GS-18-3). The earlier generation (F_1) is very tight to isoclinal and is indicated by younging direction reversal. No axial planar cleavage is associated with this folding. The second generation folds (F_2) are open and warp the axial planes of F_1 folds. They have a well developed axial planar cleavage, particularly in siltstone and mudstone in the tops of turbidite beds (Fig. GS-18-12). The cleavage cuts across both limbs of the F_1 folds and the bedding-cleavage relationship reverses across the hinge of the F_2 folds.

IMPLICATIONS FOR GOLD MINERALIZATION

It has long been recognized that gold mineralization is commonly associated with shear zones. At Island Lake, two distinct gold mineralization events have been distinguished: 1) an earlier one that took place during deformation along ductile shear zones parallel to the dominant planar fabrics in the greenstone belt; and 2) a later one that occurs in ductile-brittle shear zones that cut across the dominant planar fabric in the greenstone belt.

The Island Lake gold deposit and numerous other gold occurrences (Theyer, in press) are spatially associated with the Savage Island shear zone. This shear zone is parallel to the major structural trend in the greenstone belt. Rocks in the shear zone are pervasively altered (carbonization and pyritization), and the gold is associated with quartz

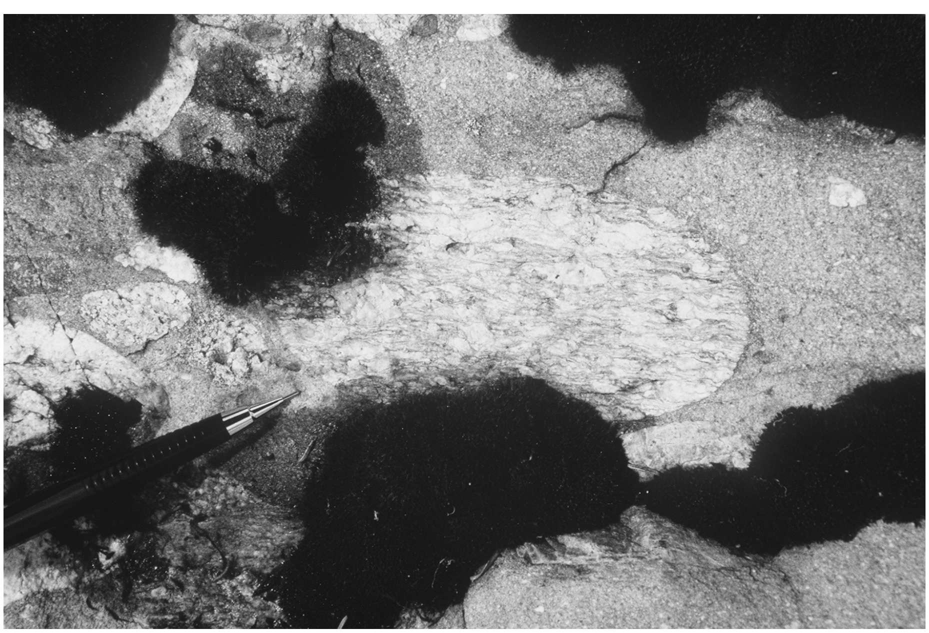


Figure GS-18-8: Clast of mylonite in Island Lake Group conglomerate, eastern Island Lake.

a)

b)

Figure GS-18-9: (a) Earlier foliation overprinted by a later foliation at the margin of the Savage Island shear zone. (b) In the shear zone the earlier foliation is transposed into the new foliation.

Figure GS-18-10: Shear bands in mylonite of the Savage Island shear zone, indicating a dextral shearing component. The outcrop surface dips moderately to the east. Right side is east.

a)

Figure GS-18-11: (a) Strongly deformed pillow basalt and felsic dykes in the Harper Island shear zone. (b) Deformed gabbro in the Harper Island shear zone with dextral shear sense indicators.

b)

veins. Field observations show that emplacement of at least some of the quartz veins was syn-deformational.

Lin and Cameron (1997) describe the structural setting of Au-bearing quartz veins at the Henderson (High Rock) Island gold deposit. Gold-bearing quartz veins are controlled by a dextral ductile-brittle fault. The fault, associated mineralized quartz veins, and a mineralized alteration zone are late features that are perpendicular to the main structures in the Island Lake greenstone belt.

ACKNOWLEDGMENTS

The authors would like to thank Alan Bailes for comments and suggestions on the manuscript, and Chris Farmer and Keith Muir for field assistance.

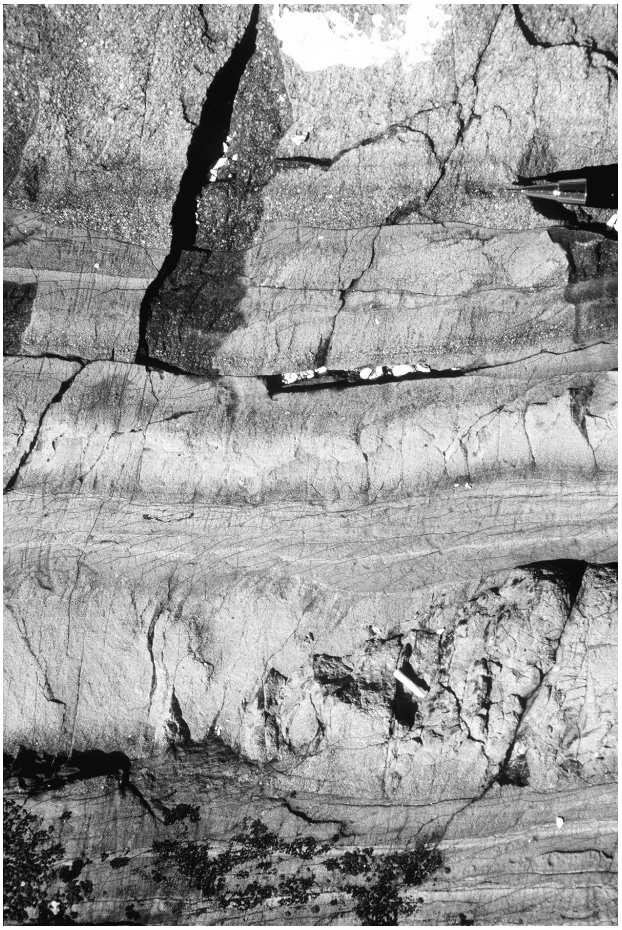


Figure GS-18-12: Cleavage in turbidite of the Island Lake Group related to the second generation of folding (F_2) in the group.

REFERENCES

Gilbert, H.P.

1984a: Loonfoot Island; Manitoba Energy and Mines, Preliminary map 1984I-1, 1:20 000.

1984b: Island Lake project; **in** Manitoba Energy and Mines, Mineral Resources Division, Report of Activities, 1984, p. 120-125.

1985a: Loonfoot Island; Manitoba Energy and Mines, Preliminary map 1985I-3, 1:20 000.

1985b: Island Lake; Manitoba Energy and Mines, Preliminary map 1985I-3, 1:20 000.

Gilbert, H.P., Neale, K.L., Weber, W., Corkery, M.T. and McGregor, C.R.

1982: Island Lake; Manitoba Energy and Mines, Preliminary map 1982I-4, 1:20 000.

1983: Island Lake; Manitoba Energy and Mines, Preliminary map 1983I-1, 1:20 000.

Godard, J.D.

1963a: Island Lake; Manitoba Mines and Natural Resources, Mines Branch, Map 59-3A, 1:63,360.

1963b: Island Lake; Manitoba Mines and Natural Resources, Mines Branch, Map 59-3B, 1:63,360.

Lin, S. and Cameron, H.D.M.

1997: Structural setting of the Au-bearing quartz veins at the Henderson Island gold deposit (Ministik Mine), Island Lake, Manitoba; **in** Manitoba Energy and Mines, Mineral Division, Report of Activities, 1997, p. 6-12.

McGregor, C.R. and Weber, W.

1982: St. Therea Point; Manitoba Energy and Mines, Preliminary map 1982I-3, 1:20 000.

Neale, K.L.

1981: Island Lake-Sinclair-Savage Islands; Manitoba Energy and Mines, Preliminary map 1981I-2, 1:20 000.

Neale. K.L. and Weber, W.

1981: Island Lake - Cochrane Bay; Manitoba Energy and Mines, Preliminary map 1981I-1, 1:20 000.

Neale. K.L., Weber, W., and McGregor

1982: Garden Hill; Manitoba Energy and Mines, Preliminary map 1982I-2, 1:20 000.

Stevenson, R.K. and Turek, A.

1992: An isotope study of the Island Lake Greenstone Belt, Manitoba: crustal evolution and progressive carbonization in the late Archean; Canadian Journal of Earth Sciences, v. 29, p. 2200-2210.

Theyer, P.

in press: Mineral Deposits and Occurrences in the Island Lake Area, NTS 53E/15, 53E/16, 53F/13, 53E/10, 53E/9, 53E/12; Manitoba Energy and Mines Mineral Deposit Series Report No. 32.

Turek, A., Carson, T.M., Smith, P.E., van Schmus, W.R., and Weber, W.

1986: U-Pb zircon ages from the Island Lake greenstone belt, Manitoba; Canadian Journal of Earth Sciences, v. 23, p. 92-101.

Weber, W., McGregor, C.R., and Neale, K.L.

1982a: Waasagomach May; Manitoba Energy and Mines, Preliminary map 1982I-1, 1:20 000.

Weber, W., Gilbert, H.P., Neale, K.L. and McGregor, C.R.

1982b: Island Lake Project; **in** Manitoba Energy and Mines, Mineral Resources Division, Report of Activities, 1982, p. 34-43.