GS-17 GEOLOGY AND GEOCHRONOLOGY OF THE ISLAND LAKE GREENSTONE BELT, NORTHWESTERN SUPERIOR PROVINCE

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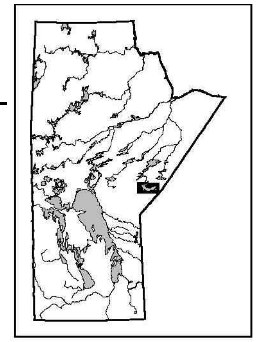

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SUMMARY

The Island Lake greenstone belt is composed of volcanic and volcanogenic sedimentary rocks of the Hayes River Group and sedimentary rocks of the Island Lake Group, all of which are intruded by various plutons. Field mapping and geochronological work in 2001 demonstrated that 1) the Hayes River Group in the western portion of the belt can be divided into lithologically and chronologically distinct structural panels that are correlated with those previously defined in the eastern portion of the belt; 2) there exists a distinct ca. 2728 Ma volcanic unit in the belt; and 3) the Island Lake Group is unconformable on the Bella Lake pluton. The mapping also led to a better definition of the location and nature of the Savage Island Shear Zone in the western part of the belt and the kinematics of the Chapin Bay Shear Zone in the area.

INTRODUCTION

The Island Lake greenstone belt is one of the largest greenstone belts in the northwestern Superior Province. The purpose of this study is to improve the understanding of the depositional, structural and tectonic evolution of this greenstone belt. To this end, an eight-week field-mapping and sampling program was conducted during the summer of 2001, following a one-week field-sampling program in 2000. Seven samples collected in 2000 have been dated at the Jack Satterly Laboratory of the Royal Ontario Museum. Preliminary results of these studies are summarized in this paper.

The Island Lake greenstone belt was mapped at a scale of 1:63 360 by Godard (1963a, 1963b), 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, 1982b), Gilbert et al. (1982, 1983) and Gilbert (1984, 1985a, 1985b). An isotope study was carried out by Stevenson and Turek (1992), and U-Pb geochronology studies were done by Turek et al. (1986) and Corfu and Lin (2000). The geology of mineral occurrences has been described by Theyer (1998), Lin and Cameron (1997), and Lin and Corfu (in press). The current study is, in part, a continuation of work started by Lin et al. (1998) and Corfu and Lin (2000).

GENERAL GEOLOGY

The Island Lake greenstone belt is composed of volcanic and volcanogenic sedimentary rocks mapped as the Hayes River Group (HRG; Weber et al., 1982b) and the younger sedimentary rocks of the Island Lake Group (ILG), all of which are intruded by various plutons. The ca. 2744 Ma Bella Lake pluton (Corfu and Lin, 2000) occupies the central portion of the area and divides the belt into eastern and western portions (Fig. GS-17-1). Lin et al. (1998) were mostly concerned with the eastern portion, whereas the present mapping is focussed on the western portion, particularly the Cochrane Bay area.

Structural Panels and the Hayes River Group (HRG)

The term Hayes River 'Group' has traditionally been applied to all volcanic and volcanogenic sedimentary rocks in this greenstone belt. However, the geochronology of Corfu and Lin (2000) and new preliminary data presented in this report indicate that the Hayes River 'Group' in fact includes supracrustal rocks of three different ages, and that these chronologically different rocks occur in different structural panels (Lin et al., 1998; this study). It is clear that use of the term Hayes River 'Group' must be re-evaluated for all of the volcanic rocks in this greenstone belt. Nevertheless, no new subdivision has been made, and the term Hayes River Group (or HRG) is used in this report for all supracrustal rocks older than the ILG.

Lin et al. (1998) have divided the eastern portion of the belt into four lithologically, chronologically and geochemically distinct structural panels, separated by the Whiteway Channel Shear Zone, the Harper Island Shear Zone and the Savage Island Shear Zone (Fig. GS-17-1). The panel south of the Savage Island Shear Zone (panel I) contains metamorphosed mafic, intermediate and felsic volcanic and volcanogenic sedimentary rocks. Two dacite samples from this panel yielded identical zircon ages of ca. 2852 Ma (Corfu and Lin, 2000), and detrital zircons from a sedimentary rock yielded ages between ca. 2858 and ca. 2847 Ma (Corfu and Lin, 2000). The HRG in the panel between the Savage Island and Harper Island shear zones (panel II) consists mainly of pillowed basalt and related mafic and ultramafic intrusive rocks. A quartz-phyric felsic tuff was discovered in this panel in 2001 and will be dated to directly constrain the age of the panel. The panel between the Harper Island and Whiteway Channel shear zones (panel III) consists of pillow basalt and minor volcanogenic sedimentary rocks. A gabbroic intrusion in this panel yielded a zircon age of 2807 ± 1 Ma (Corfu and Lin, 2000), and all three detrital zircon grains

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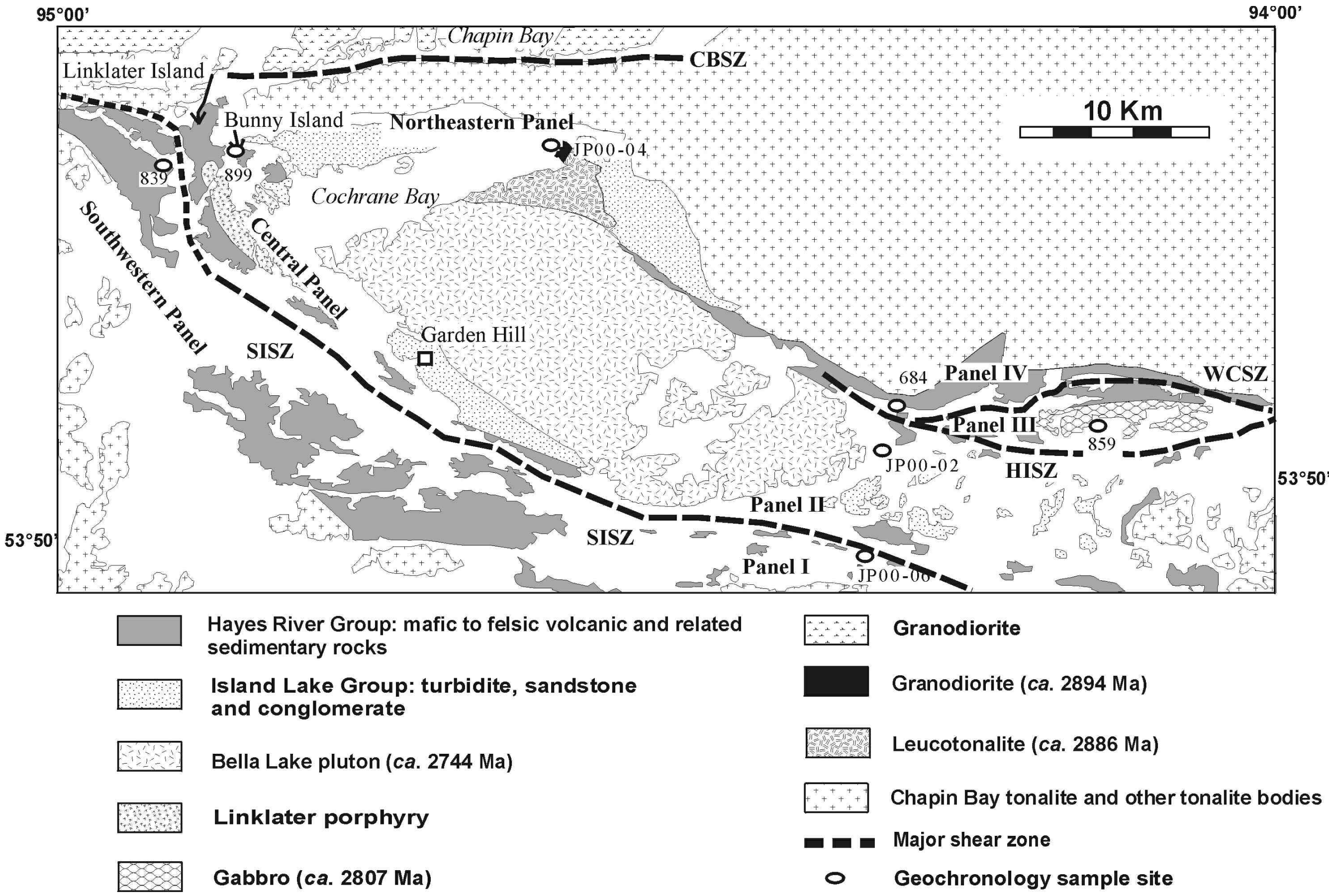

Figure GS-17-1: Simplified geology of the Island Lake greenstone belt.

dated so far from a sedimentary rock yielded essentially identical ages of ca. 2897 Ma (sample 859, this study). The panel north of the Whiteway Channel Shear Zone (panel IV) consists of amphibolite-grade mafic and ultramafic volcanic rocks. No material suitable for U-Pb dating has been found in this panel.

In the western portion of the belt, mapping in 2001 has led to the recognition of three lithologically and chronologically distinct structural panels: the southwestern, central and northeastern panels (Fig. GS-17-1). The southwestern panel occurs to the southwest of the Savage Island Shear Zone, contains pillowed and massive basalt, felsic volcanic rocks and volcanogenic sedimentary rocks, and can be traced unambiguously into panel I in the eastern portion of the belt. A dacite sample from the southwestern panel, collected west of Linklater Island, has yielded a zircon age of 2852 ± 1 Ma (sample 839, this study). The northeastern panel is exposed in the eastern part of Cochrane Bay and consists of sedimentary rocks, an older leucotonalite unit and an older granodiorite unit. The leucotonalite has a zircon age of 2886 ± 15 Ma (Turek et al., 1986), and the granodiorite has a zircon age of 2894 ± 1 Ma (sample JP00-04, this study). We tentatively correlate this panel with panel III in the eastern portion of the greenstone belt, based on similar zircon ages and the fact that the two panels are approximately along strike.

The central panel occurs in the Bunny Island area (Fig. GS-17-1) and contains pillowed and massive basalt, and related felsic volcanic rocks and subvolcanic porphyry. The felsic volcanic rock yielded a zircon age of ca. 2728 Ma (sample 899, this study). This panel is thus distinctly younger than the southwestern panel (or panel I in the east). Field mapping shows that this panel has sheared contacts with the Linklater porphyry and the Island Lake Group (Fig. GS-17-1). We suspect that this panel can be correlated with panel II in the east, based on similar lithological association and similar location relative to other panels. Additional geochronological and geochemical work (especially geochronological work on the newly discovered felsic tuff in panel II) will help to test this correlation.

Island Lake Group (ILG)

The Island Lake Group (ILG) unconformably overlies the Hayes River Group and is composed of conglomerate, sandstone and turbidite sequences. Detrital zircon work by Corfu and Lin (2000) on two wacke samples from the upper part of the sequence shows that this part of the sequence is younger than ca. 2712 Ma. However, the lower part of the sequence was believed to be intruded by the ca. 2744 Ma Bella Lake Pluton (Lin et al., 1998; Corfu and Lin, 2000); if correct, this indicates that the ILG was deposited over an extended period of time. During the summer of 2001, a critical outcrop was cleaned and re-examined. The results called the intrusive relationship into serious doubt and instead indicate an unconformable relationship between the ILG and the pluton (Fig. GS-17-2). To test this important relationship, a wacke sample was collected near the contact at this outcrop for detrital zircon analysis. The youngest zircon dated so far has an age of ca. 2717 Ma (sample JP00-02, this study), younger than the Bella Lake pluton and thus supporting the unconformable relationship. The ILG is intruded by a ca. 2699 Ma porphyry (the Horseshoe Island porphyry in the Cochrane Bay area; Turek et al., 1986). The age of sedimentation of the ILG is thus constrained between ca. 2712 Ma and ca. 2699 Ma.

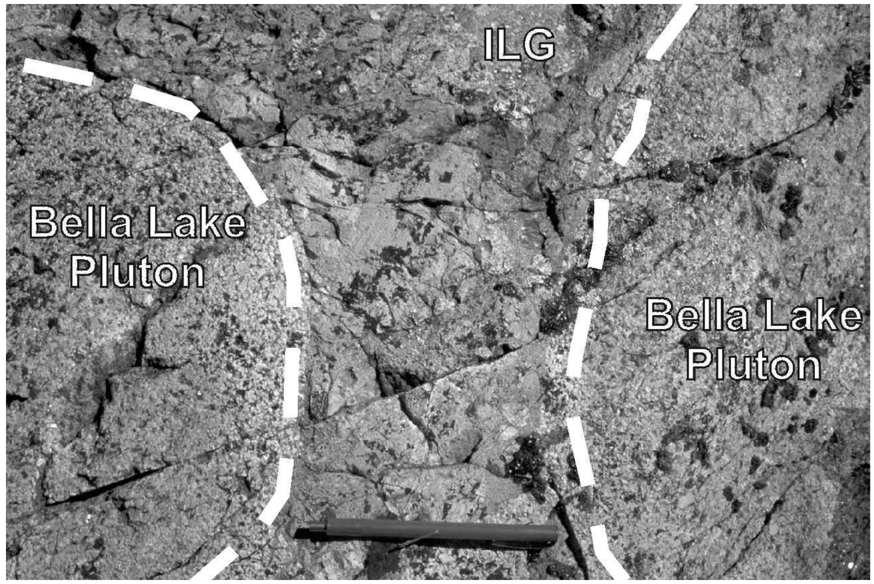

Figure GS-17-2: Unconformable relationship between the Bella Lake pluton and the Island Lake Group in the eastern part of the map area. The Island Lake Group infills a scour in the Bella Lake pluton.

STRUCTURE

The Island Lake greenstone belt has undergone multiple generations of deformation that have produced at least four distinct shear zones: the Whiteway Channel, Harper Island, Savage Island and Chapin Bay shear zones (Fig. GS-17-1). The structure in the eastern portion of the belt was described by Lin et al. (1998). Here we are mainly concerned with the structure in the western portion.

Savage Island Shear Zone (Western Segment)

The Savage Island Shear Zone is a major shear zone that trends east-southeast to southeast across the map area. It was previously well defined in the east (Lin et al., 1998) and mapping in the summer of 2001 helped to better define it in the west. It was traced with confidence from southeast of the town of Garden Hill to southwest of Linklater Island, and separates the ca. 2852 Ma southern panel from the ca. 2728 Ma central panel (Fig. GS-17-1). In this area, both a sedimentary unit (most likely of Hayes River Group) and a gabbroic unit are sheared (Fig. GS-17-3). The foliation in the shear zone strikes west-northwest and dips moderately to steeply southwest. The lineation plunges moderately to the southeast. South of the town of Garden Hill, a late crenulation transposes an early northwest-trending foliation into a west-trending, steeply dipping foliation. Shear-sense indicators (boudinaged quartz veins and rotated porphyroclasts) show both sinistral and dextral movement, suggesting that the shear zone has a complicated deformation history.

Chapin Bay Shear Zone

Field mapping shows an extensive (approx. 1 km wide and at least 30 km long) shear zone, the Chapin Bay Shear Zone, that trends east-west along the northern edge of the western portion of the map area. This shear zone strongly deforms the Chapin Bay tonalite, a granodiorite unit north of the Chapin Bay tonalite and a small (approx. 5 km by 300 m) sediment sliver, consisting mainly of conglomeratic rocks, situated between these two units (Fig. GS-17-4). Foliation in the shear zone strikes west and dips steeply to the north to vertically. Lineation varies from plunging shallowly (approx. 30°) east in the margins of the shear zone to plunging moderately (approx. 60–80°) east in the centre of the shear zone. Field observations indicate a sinistral strike-slip component and north-over-south dip-slip component along the shear zone. An S/C fabric and rotated plagioclase porphyroclasts are well developed in a deformed tonalite in the shear zone and indicate sinistral shearing (Fig. GS-17-5).

Timing of Deformation Events

A major objective of this project is to place geochronological constraints on the timing of deformation in this greenstone

Figure GS-17-3: Foliated gabbro in the Savage Island Shear Zone. Foliation in gabbro is parallel to the dashed line in the photo.

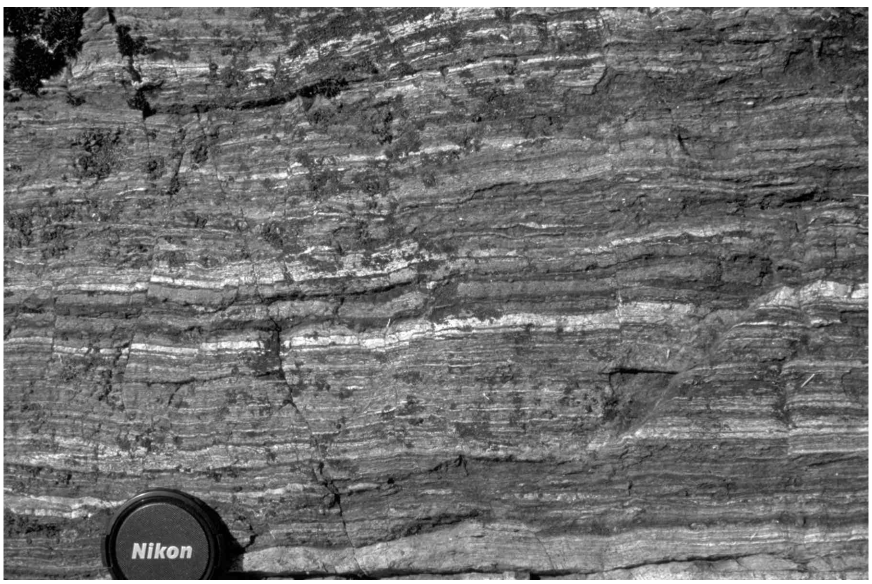

Figure GS-17-4: Strongly deformed conglomerate unit in the Chapin Bay Shear Zone. This unit can be traced laterally into areas where the clasts are rounded and less deformed.

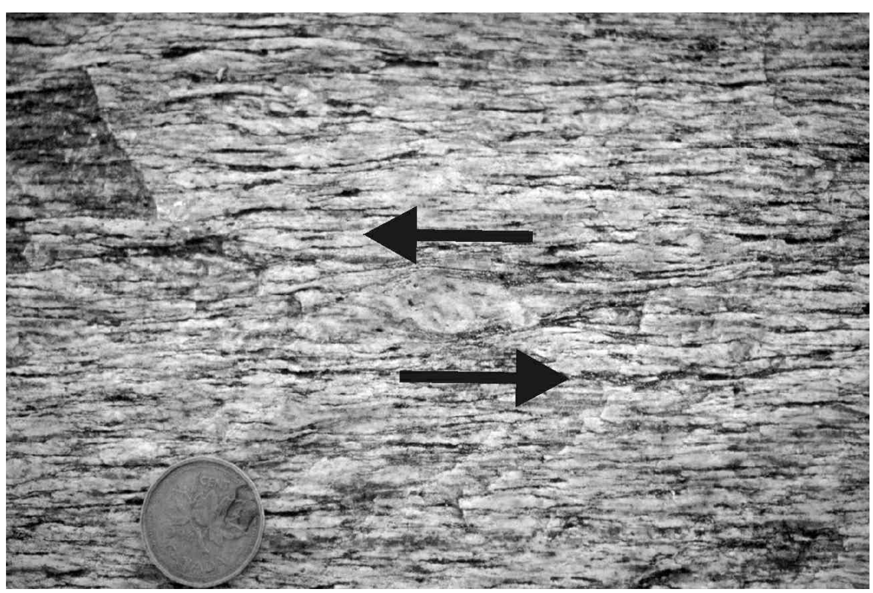

Figure GS-17-5: Sheared porphyroclasts and mylonitic texture of the Chapin Bay Shear Zone in the Chapin Bay tonalite. Asymmetric tails indicate sinistral movement.

belt. So far, two dykes from the eastern portion of the greenstone belt have been successfully dated for this purpose. In the Harper Island Shear Zone, an approximately 15 m wide late syntectonic tonalite dyke has yielded a zircon age of 2722 ± 1.2 Ma (sample 684, this study). The dyke is weakly foliated and contains xenoliths of more strongly foliated mafic volcanic rocks. South of the Savage Island Shear Zone in panel I, a postkinematic quartz-porphyry dyke yielded a preliminary zircon age of 2723 ± 1.8 Ma (sample JP00-06, this study). The latter dyke is unfoliated and cuts a strong foliation in deformed mafic volcanic rocks (Fig. GS-17-6). Detailed work by Lin et al. (1998) showed that this foliation predates the Savage Island Shear Zone.

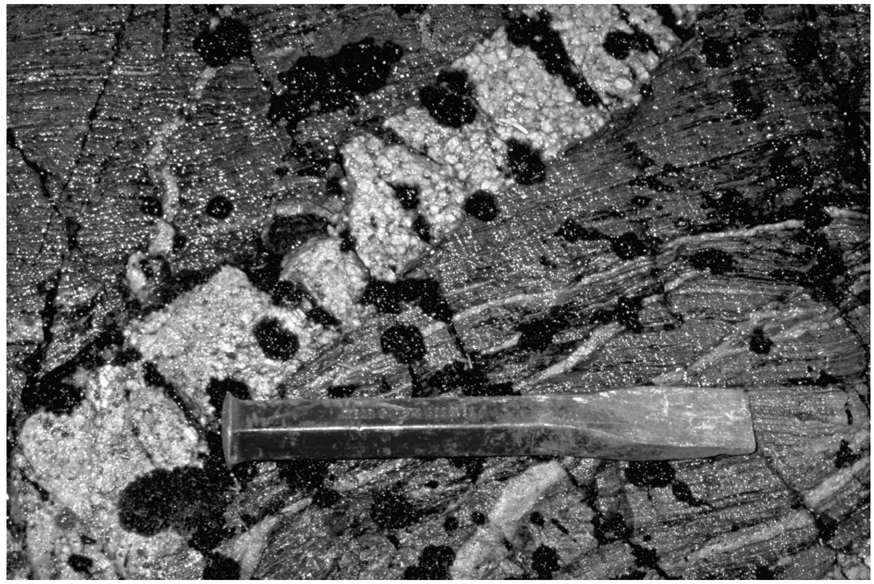

Figure GS-17-6: Coarse-grained felsic dyke cutting foliation in strongly deformed mafic volcanic rocks.

CONCLUSIONS AND FUTURE WORK

The Hayes River Group within the Island Lake greenstone belt can be divided into lithologically and geochronologically distinct structural panels that can be correlated across the entire belt. The central panel in the west consists of distinct volcanic rocks that are ca. 2728 Ma in age, much younger than other dated rocks of the Hayes River Group. The use of the term Hayes River Group for all volcanic and volcanogenic rocks in this greenstone belt needs to be re-evaluated. The Island Lake Group is confirmed to have an unconformable contact with the Bella Lake pluton.

The western segment of the Savage Island Shear Zone is kinematically complicated and shows evidence for both dextral and sinistral shearing. The Chapin Bay Shear Zone is an extensive structure along the northern edge of the western part of the map area and has experienced strong deformation with a sinistral strike-slip component and a north-over-south dip-slip component.

To further constrain the geological evolution of the Island Lake greenstone belt, additional U-Pb analyses will be done at the Jack Satterly Laboratory of the Royal Ontario Museum. Geochemical analyses, including Sm-Nd work, are also planned to help characterize the different panels and test the correlation of the panels from east to west. Detailed microstructural work will be conducted on samples taken this summer. In particular, work will be done to determine the sequence of movements on the western segment of the Savage Island Shear Zone and to confirm the sense of shear along the Chapin Bay Shear Zone.

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REFERENCES

Corfu, F. and Lin, S. 2000: Geology and U-Pb geochronology of the Island Lake greenstone belt, northwestern Superior Province, Manitoba; Canadian Journal of Earth Sciences, v. 37, p. 1275–1286.

Gilbert, H.P. 1984: Loonfoot Island; Manitoba Energy and Mines, Mineral Resources, Preliminary Map 1984I-1, scale 1:20 000.

Gilbert, H.P. 1985a: Loonfoot Island; Manitoba Energy and Mines, Geological Services/Mines Branch, Preliminary Map 1985I-3, scale 1:20 000.

Gilbert, H.P. 1985b: Island Lake; Manitoba Energy and Mines, Geological Services/Mines Branch, Preliminary Map 1985I-3, scale 1:20 000.

Gilbert, H.P., Neale, K.L., Weber, W., Corkery, M.T. and McGregor, C.R. 1982: Island Lake; Manitoba Department of Energy and Mines, Mineral Resources Division, Preliminary Map 1982I-4, scale 1:20 000.

Gilbert, H.P., Neale, K.L., Weber, W., Corkery, M.T. and McGregor, C.R. 1983: Island Lake; Manitoba Department of Energy and Mines, Mineral Resources Division, Preliminary Map 1983I-1, scale 1:20 000.

Godard, J.D. 1963a: Island Lake; Manitoba Department of Mines and Natural Resources, Mines Branch, Map 59-3A, scale 1: 63 360.

Godard, J.D. 1963b: Island Lake; Manitoba Department of Mines and Natural Resources, Mines Branch, Map 59-3B, scale 1: 63 360.

Lin, S. and Corfu, F. in press. Structural setting and geochronology of auriferous quartz veins at the High Rock Island gold deposit, northwestern Superior Province; Economic Geology.

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* Report of Activities 1997, Manitoba Energy and Mines, Geological Services, p. 6–12.

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

McGregor, C.R. and Weber, W. 1982: St. Theresa Point; Manitoba Department of Energy and Mines, Mineral Resources Division, Preliminary Map 1982I-3, scale 1: 20 000.

Neale, K.L. 1981: Island Lake–Sinclair–Savage Islands; Manitoba Department of Energy and Mines, Mineral Resources Division, Preliminary Map 1981I-2, scale 1:20 000.

Neale, K.L. and Weber, W. 1981: Island Lake–Cochrane Bay; Manitoba Department of Energy and Mines, Mineral Resources Division, Preliminary Map 1981I-1, scale 1:20 000.

Neale, K.L., Weber, W. and McGregor C.R. 1982: Garden Hill; Manitoba Department of Energy and Mines, Mineral Resources Division, Preliminary Map 1982I-2, scale 1:20 000.

Stevenson, R.K. and Turek, A. 1992: An isotope study of the Island Lake Greenstone Belt, Manitoba: crustal evolution and progressive cratonization in the late Archean; Canadian Journal of Earth Sciences, v. 29, p. 2200–2210.

Theyer, P. 1998: 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, Geological Services, Mineral Deposits 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 Bay; Manitoba Department of Energy and Mines, Mineral Resources Division, Preliminary Map 1982I-1, scale 1:20 000.

Weber, W., Gilbert, H.P., McGregor, C.R. and Neale, K.L. 1982b: Island Lake Project; *in* Report of Activities 1982, Manitoba Energy and Mines, Mineral Resources Division, p. 34–43.